CALIFORNIA SPINY LOBSTER FISHERY MANAGEMENT PLAN

April, 2016

FINAL

California Department of Fish and Wildlife

Marine Region

Executive Summary

The California Spiny Lobster (CA lobster) is an important natural resource managed by the state of California for over 100 years. The species supports a valuable commercial fishery and a significant recreational fishery. CA lobsters also act as important keystone predators within the southern California nearshore ecosystem. The commercial fishery in California extends from Point Conception south to the U.S.-Mexico border, and accounted for approximately 430.9 metric tons (mt) (950,000 pounds) in ex-vessel landings and $18.2 million in ex-vessel value during the 2014-15 fishing season. The California recreational fishery ranges from Central San Luis Obispo County south to the U.S.-Mexico border, and is estimated to contribute between $33-$40 million in consumer spending to the California economy each year.

The 2011 California Department of Fish and Wildlife (CDFW) stock assessment indicates that the CA lobster stock is stable under the current management measures. The current minimum size limit allows many lobsters to reproduce for one to two years before reaching the legal size limit. The seasonal closure (March-October) protects individuals from harvest during the sensitive spawning period of the species. The limited-entry nature of the commercial fishery restricts the number of commercial participants.

A substantial increase in average landing price ($/pound) has occurred within the commercial fishery during recent years. Around the same time, overall commercial trap effort as measured by the amount of trap pulls recorded on CDFW-issued daily lobster fishing logs has also increased. The increase in commercial fishing effort has raised questions about the long-term sustainability of the fishery, the negative consequences on the fishing grounds and associated ecosystems from increased gear usage, and the economic health of the commercial fishery.

The recent rise in commercial effort is also accompanied by changes in the dynamics of the recreational fishery. The recreational sector has traditionally been dominated by divers, but in the early 2000s, the popularity of boat-based hoop nets began to rise. Starting in 2008, recreational lobster fishermen were required by CDFW to record their daily fishing activity and catch on standardized report cards.

Report card sales have increased over the last seven years, suggesting that participation has increased. However, card sales do not necessarily reflect actual fishing effort or catch. Report card return rates have steadily increased since the program was first implemented due to proactive CDFW effort to educate the public and the establishment of a non-reporting fee in 2013. Based on the returned cards, CDFW estimates that recreational fishermen harvested 26% of the total catch (commercial + recreational) during 2014-15 fishing season. As return rate continues to improve from new public outreach and reporting requirements, CDFW will be better able to estimate recreational effort and catch.

In 2012, the state implemented a set of new marine protected areas (MPAs) under the **Marine Life Protection Act** (MLPA) in southern California. The 50 MPAs and two special closures in this region are designed to serve a myriad of objectives including conservation of valuable fishery resources. These MPAs create safe zones for species such as CA lobsters to reproduce without fishing pressure, but at the same time shift and compress fishing effort to the remaining non-MPA areas.

Marine Life Protection Act (MLPA) - The MLPA, enacted in 1999, required the California Department of Fish and Wildlife to develop a Marine Life Protection Program, including a Master Plan for a network of Marine Protected Areas (MPAs) within state waters. The network of MPAs includes an improved State Marine Reserve (complete no-take areas) component and other classifications of MPAs (State Marine Parks and State Marine Conservation Areas). The goals of the MLPA are varied and include protecting portions of ecosystems in a variety of habitats, preserving biodiversity, and helping to sustain and protect populations of fished species.

In light of the dynamic nature of the fisheries, it is important for CDFW to adopt a cohesive management strategy for CA lobster. Accordingly, a key provision of this Fishery Management Plan (FMP) is a harvest control rule (HCR) for CA lobster. The HCR serves as the foundation for managing the fishery in the future as well as the primary mechanism to prevent, detect, and recover from overfishing as required by the **Marine Life Management Act** (MLMA). The HCR is a type of adaptive management framework that identifies potential conservation problems and prescribes appropriate management responses. It consists of three parts: 1) reference points, 2) a control rule toolbox, and 3) a control rule matrix. Reference points are the metrics used to gauge the status of the fishery. The three CA lobster reference points are: 1) Catch, 2) **Catch Per Unit Effort** (CPUE), and 3) **Spawning Potential Ratio** (SPR):

REFERENCE POINT	THRESHOLD	RATIONALE
Catch	$\frac{average\ catch\ for\ 3\ most\ recent\ seasons}{average\ catch\ for\ 10\ most\ recent\ seasons} \leq 0.9$	Identifies possible change in stock stability, particularly growth overfishing
CPUE	$\frac{CPUE\ for\ 3\ most\ recent\ seasons}{CPUE\ for\ 10\ most\ recent\ seasons} \leq 0.9$	Identifies potential adverse changes in the fishery, mainly economic overfishing
SPR	$SPR_{CURRENT} \leq SPR(Average\ 2000\text{-}2008)$	Detects biological sustainability, particularly recruitment overfishing

The reference points incorporate important information regarding the fisheries such as the effects of fishing and MPAs. New information is interpreted in relation to prescribed reference point thresholds that signal when changes within the fishery may warrant management responses. Once these changes are detected within the fishery, resource managers have flexibility to choose the appropriate management response from a toolbox of eight management tools. These consist of: 1) Change commercial trap limit, 2) Change recreational bag limit, 3) Establish a Total Allowable Catch (TAC), 4) Implement district closures, 5) Change season length, 6) Change minimum size limit, 7) Implement a maximum size, and 8) Establish a sex selective fishery (Male-only fishery or female-specific size restrictions). The control rule matrix links specific reference point results to the appropriate management response.

Marine Life Management Act (MLMA)- The Marine Life Management Act (MLMA), which became California law January 1, 1999, established goals of conserving entire ecosystems, recognizing non-consumptive values, sustainability, habitat conservation, restoring depressed fisheries, limiting bycatch, and recognizing fishing communities.
Catch Per Unit Effort (CPUE) - The rate at which fish are caught; typically a number or weight of fish captured per unit of effort. Units of effort can be assigned many ways, including the time spent fishing (hours or days), the amount of fishing gear deployed (number of vessels, traps, nets, etc.), the number of times that fishing gear is deployed and retrieved (e.g., net hauls, trap pulls), or a combination of these estimates. Because it is difficult and expensive to scientifically measure the number of fish in an area (abundance), CPUE is often used as an index for the relative abundance of organisms across time or space. For CA lobster, CPUE is typically defined as the number of legal (or sublegal-sized) lobsters per trap pull for the commercial fishery, and number of legal lobsters retained per fishing trip for the recreational fishery. Effort is most often described in terms of trap pulls, total traps, and number of active permits for the commercial fishery, and number of fishing trips for the recreational fishery.
Spawning potential ratio (SPR) – A ratio of the number of eggs produced during the lifetime of an average female in a fished population to the number of eggs produced during the lifetime of an average female in an unfished population; used to characterize the amount of impact fishing has on a population's ability to reproduce.
Lobster Advisory Committee – A committee composed of representatives from the recreational fishery, the commercial fishery, environmental interest groups, scientific experts, non-consumptive recreational interest groups, and federal resource managers. The committee was responsible for providing crucial constituent inputs during the drafting process of this FMP, in part through a consensus recommendation.

The scientific foundation for the HCR underwent an independent, external peer review (see Appendix VII and VII). In particular, reviewers focused on the choice of reference points, the model used to calculate SPR, and the decision to manage CA lobster as a single stock. The primary changes to the previous draft of this FMP in response to peer review include:

- A von Bertalanffy growth model was used to describe lobster age at a given size within the model used to calculate SPR.
- Catch and CPUE reference points were made more sensitive by setting the threshold levels at 0.9 rather than 0.8.
- Expanded discussion of possible reference points and associated models was added to the FMP along with increased explanation of the selected approach.
- Information on regional differences within the stock was added and better understanding of these differences was highlighted as an information need.

This FMP also describes various management tools considered during the stakeholder **Lobster Advisory Committee** (LAC) process. The LAC reached consensus on several regulatory recommendations that will assist future fishery management. These recommendations include, but are not limited to: 1) Commercial permit-based trap limit, 2) Tail clipping or hole punching of recreationally caught CA lobsters, 3) An additional grace period for commercial fishermen to deploy traps before the season and an additional period to retrieve traps after the season, 4) Changing the opening time for the recreational season, 5) Restrictions on mechanical pullers for the recreational fishery, 6) Allowance to carry SCUBA gear on commercial vessels, 7) Requirement to mark recreational hoop net floats, 8) Clarifying regulatory language on the take of lobster by hand, and 9) Increased soak time for commercial traps.

CDFW currently collects substantial fishery-dependent data on CA lobster through commercial logbooks, landing receipts, recreational lobster report cards, creel sampling, and at-sea sampling. However, better information on the species stock distribution, ecological role, and life history (e.g., movement, **recruitment**, reproduction, mortality) would allow CDFW to improve its future management activities. Pursuant to the MLMA mandates, CDFW will continue to work with its constituents to improve research and monitoring efforts in order to better maintain sustainable CA lobster populations and associated fisheries.

Recruitment - The process, event, or rate by which individuals enter new life stages or segments of a population. *Larval recruitment* refers to the process or event by which larvae of marine species exit the planktonic life stage. *Fishery recruitment* (or, recruitment to the fishery) refers to the moment that an animal becomes vulnerable to capture in a fishery – usually because it has attained some minimum size or age for harvest.

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Acknowledgements

The California spiny lobster FMP is the result of collaboration among many individuals and organizations. We would first like to thank all the Lobster Advisory Committee (LAC) members and particularly the constituent representatives for their many contributions and cooperative attitude throughout the process. The LAC volunteered a great deal of time and provided input that helped the FMP to represent the varied knowledge, interests, and values of its members. The Sacramento State University Center for Collaborative Policy served the essential role of impartial facilitator of the LAC meetings and assisted with development of the LAC process. We thank Dr. Richard Parrish, Dr. Matthew Kay, and Dr. Yong Chen for providing modeling expertise that was critical for the development of sound reference points for assessing the status of the stock. We thank the Sea Grant Collaborative at-Sea Sampling Program (CAPS) and in particular Dr. Carrie Culver for openly sharing their data which was valuable in many ways throughout the writing of the FMP. Retired Marine Region staff members who dedicated many years to the lobster resource and fishery participants include Kristine Barsky, Dr. Douglas Nielson, and Kai Lampson. Independent peer review greatly improved the FMP and we thank the organizers of that effort, Ocean Science Trust, and the scientific experts including Dr. John Field, Dr. Michelle Comeau, Dr. Robert Muller and Dr. Pete Raimondi. Finally, the Ocean Protection Council provided the necessary funding to support the processes and contractors noted above and the California Wildlife Foundation served as funds administrator.

Acronyms

CA lobster – California spiny lobster, *Panulirus interruptus*
CalCOFI – California Cooperative Oceanic Fisheries Investigations
CASP – Sea Grant Collaborative At-Sea Sampling Program
CC – Climate Change
CCR – California Code of Regulations
CDFW – California Department of Fish and Wildlife
CL – Carapace length
CFR – Collaborative Fisheries Research
CPUE – Catch per Unit Effort
EFI – Essential Fishery Information
FGC – California Fish and Game Code
FMP – Fishery Management Plan
GHG – Green House Gas
HCR – Harvest Control Rules
ITQ – Individual Transferrable Quota
LAC – Lobster Advisory Committee
LFMP – California Spiny Lobster Fishery Management Plan
Max LS – Maximum Legal Size
MEY – Maximum Economic Yield
Min LS – Minimum Legal Size
MLMA – Marine Life Management Act
MLPA – Marine Life Protection Act
MPA – Marine Protected Areas
MSE – Management Strategy Evaluation Model
MSY – Maximum Sustainable Yield
SAM – Size at Maturity
SCB – Southern California Bight
SPR – Spawning Potential Ratio
SST – Sea Surface Temperature
TAC – Total Allowable Catch
YPR – Yield per Recruit

1. Introduction

The Marine Life Management Act (MLMA) establishes a policy for the State to ensure the conservation and **sustainable** use of California's living marine resources (FGC § 7050(b)). The MLMA states that Fishery Management Plans (FMP) "shall form the primary basis for managing California's sport and commercial marine fisheries" (FGC § 7072). FMPs are documents that consolidate available information under the statutorily prescribed frameworks (FGC §§ 7072, 7075, 7080-7088); their contents and any subsequent amendments form the basis for all **fishery** management decisions. The California Department of Fish and Wildlife (CDFW) is responsible for drafting FMPs and presenting them to the California Fish and Game Commission (Commission). FMPs become effective upon adoption by the Commission through a public process. Implementation is done through a separate Commission rulemaking process, and the implementing regulations are codified in Title 14 of the California Code of Regulations. This FMP is developed for the California spiny lobster (*Panulirus interruptus*; CA lobster) in U.S. waters.

1.1 The Goal of the FMP

The goal of this FMP is to formalize a management strategy that can respond effectively to changes in the CA lobster fisheries pursuant to the tenets of the MLMA. CA lobsters have long supported major **commercial** and **recreational fisheries**, and the species plays a key role in maintaining the health of the southern California kelp forest **ecosystem**. This ecosystem is important to a number of non-consumptive users such as divers, eco-tourists, researchers, educators, and the conservation community.

To achieve responsive and effective management, this fishery must be adaptable and sustainable. This FMP uses an **adaptive management** framework (Holling et al., 1978; Walters and Hilborn, 1978) based on a harvest control rule (Section 4.3). Section 90.1 of the Fish and Game Code (FGC) defines adaptive management as "a policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning."

1.2 Efforts Leading Up to the FMP – The Lobster Advisory Committee

This FMP incorporates input from the Lobster Advisory Committee (LAC). The LAC was formed in early 2012 following a call by CDFW for volunteers to represent various public stakeholder groups. The purpose of the LAC is to involve constituent representatives with the development of this FMP. The LAC provided guidance on FMP objectives and end-products as well as ideas for management options that addressed the key issues put forth by members of the public. The LAC consists of representatives from the marine science community, the recreational fishing sector, commercial fishing sector, the non-consumptive recreational sector, the environmental

Sustainable, Sustainable use, and Sustainability - With regard to a marine fishery, means both of the following: 1) continuous replenishment of resources, taking into account fluctuations; and 2) securing the highest possible present and long-term social and economic benefits, maintaining biological diversity, and managing fisheries in a way that does not exceed **optimum yield**. See also FGC § 7050(b).
Fishery - Fishing for, harvesting, or catching one or more populations of marine fish or marine plants that may be treated as a unit for purposes of conservation and management that are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics.
Commercial fishery - Describes a group of enterprises and individuals as well as their actions associated with fishing for certain species with the intent of selling the catch.
Recreational fishery - Describes a fishery associated with taking of any fish for any purpose other than profit.
Ecosystem - The physical and climatic features and all the living and dead organisms in an area that are interrelated in the transfer of matter and energy, which together produce and maintain a characteristic type of biological community. Ecosystems can range in size.

community, and the federal government.

A total of nine LAC meetings occurred between June 2012 and September 2013. All meetings were open to the public, and public input was encouraged. Meeting announcements were posted on the CDFW website, and the public was encouraged to sign up for the Lobster FMP news email service. Meeting summaries as well as various background documents are available on the CDFW website (www.wildlife.ca.gov/Conservation/ Marine/Lobster-FMP). The LAC reached consensus on several management recommendations for CDFW and the Commission (Section 4.4.5, Appendix II, and Appendix IX).

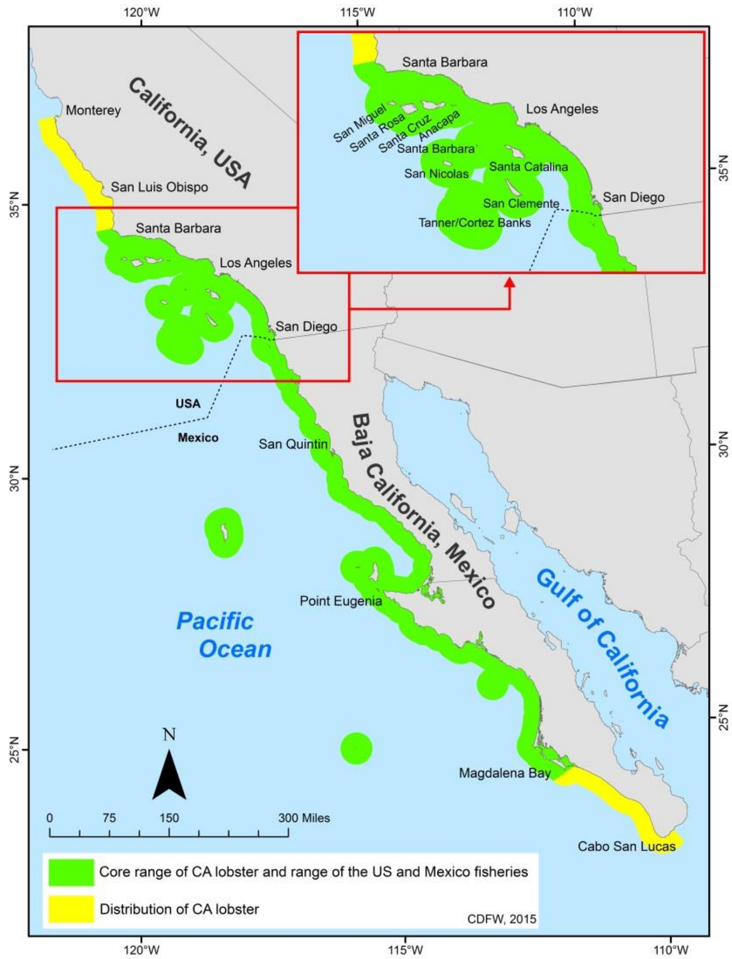

Figure 1-1: Geographic range of CA lobster (*P. interruptus*).
***A 20mi buffer from the coast was used to indicate the approximate range of the species, and does not represent fine-scale distribution**

2. Background of the Fishery

CA lobsters have been fished since the 1800s. U.S. fishermen target CA lobsters primarily from Point Conception south to the U.S. – Mexico border, and off southern California islands and banks (Barsky, 2001; Figure 1-1). Some fishing takes place north of Point Conception, but as of 2013 effort has not been significant. The commercial and recreational fisheries run from early October to mid-March, with the recreational fishery starting 4 days earlier than the commercial fishery (FGC § 8251; 14 CCR § 29.90). This results in a 24 week commercial fishing season and a 24.5 week recreational fishing season.

Stock assessment - An evaluation of the status of a stock, including past and current stock levels and information to help guide future harvest. Assessments may integrate many different biological data, including growth rates of fish, mortality rates, age at first reproduction, fecundity, size classes present in the catch, and selectivity of fishing gear.
Population – All the individuals of a species that live in the same geographic area. A population may contain several discrete breeding groups or stocks.
Harvest rate (u) - The percentage of legally harvestable individuals in a population that are removed each year due to fishing.
Stock - A group of fish of the same species in a given management area. A single stock may be comprised of multiple populations or be a portion of a single larger population.

A 2011 **stock assessment** suggested that the post-2000 CA lobster **population** is at a sustainable level where surplus production provides the majority of the harvestable CA lobster each season (Neilson, 2011). This conclusion was based mostly on consistency in the size of captured lobsters, **harvest rates**, catch totals, and level of fishing effort since 2000.

Biological sustainability of the **stock** is attributed to multiple factors. Chief among them is likely the minimum legal size for the CA lobster fisheries, which is larger than the size at which individuals reach sexual maturity (Section 3.3). The number of sublegal-size lobsters caught by commercial fishermen has increased in recent years, which suggests that the current size limit is effective, and that a sizable number of sublegal-size lobsters are present in the wild and contributing to reproduction (Neilson, 2011).

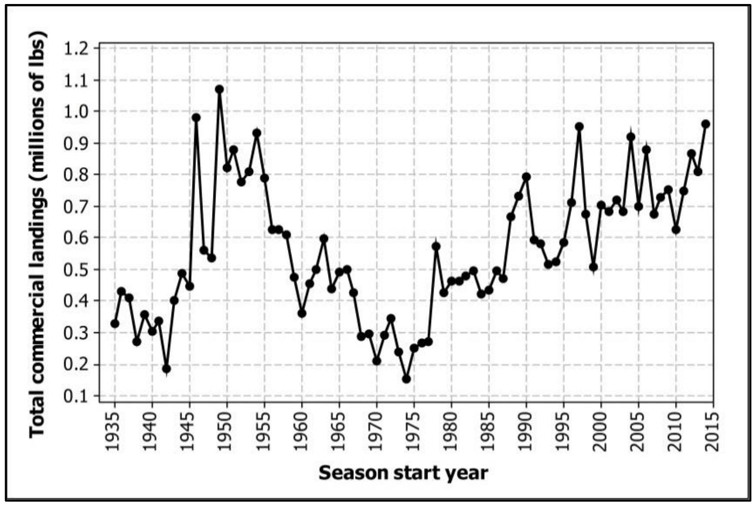

Figure 2-1: Commercial CA lobster (*P. interruptus*) landings from the 1936-37 to 2014-15 fishing seasons.

2.1 Commercial Fishery History and Description

The commercial CA lobster fishery can be characterized by several distinct periods. Commercial landings peaked at an all-time high of 485 mt (1.07 million pounds) during the 1949-50 fishing season, and declined to a record low of 69 mt (152,000 pounds) during the 1974-75 fishing season (Figure 2-1). The reason for this decline was thought to have been the illegal take of sublegal-size adults, and was corrected by the introduction of escape ports in 1976, which allowed sublegal-size individuals to exit

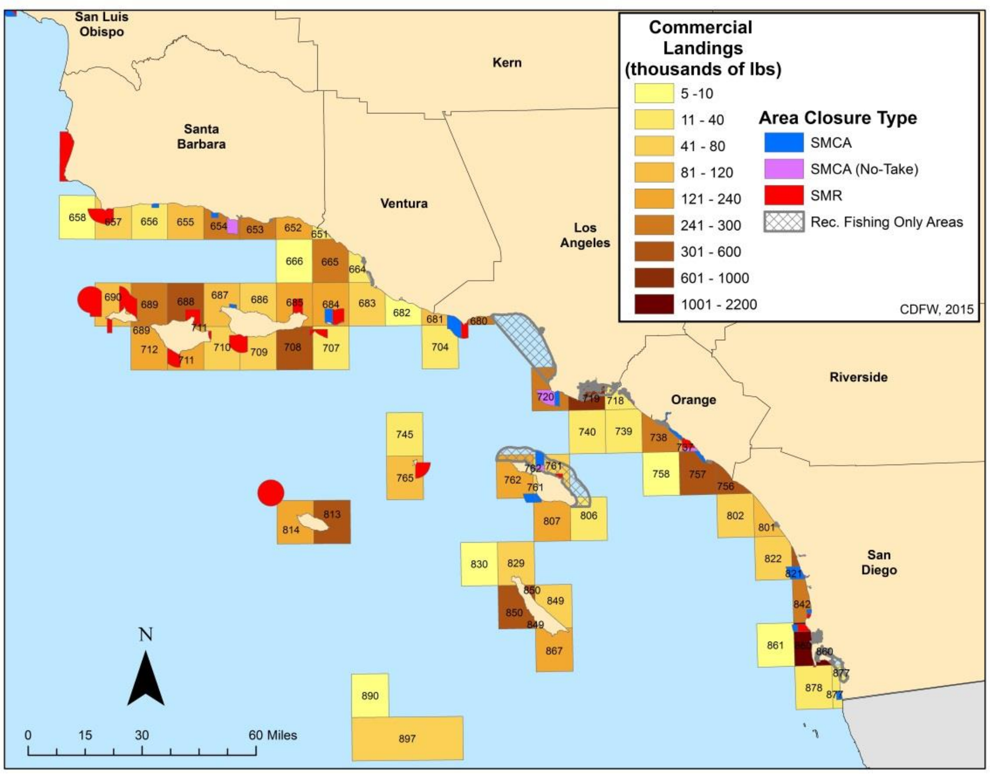

Figure 2-2: Commercial CA lobster (*P. interruptus*) landings by CDFW commercial fishing block between 2000-2014 fishing seasons overlayed with MPAs and recreational-only fishing areas.
***SMCA = State Marine Conservation Area**
****SMR = State Marine Reserve**

traps (Barsky, 2001). After 1976, the harvest increased and was stable for approximately a decade. Landings then showed further increases but volatility until the 2000-01 fishing season, when 319 mt (702,000 pounds) were landed. Since 2000, **landings** have fluctuated within a relatively narrow range, exceeding 300 mt (661,000 pounds) each season. Figure 2-2 provides a snap shot of CA lobster landings based on commercial fishing blocks between 2000 and 2013 along with marine protected areas (some of which prohibit the take of CA lobster). Since 2000, the number of active commercial participants has remained relatively consistent between 145 and 160.

Figure 2-3: CA lobster (*P. interruptus*) commercial fishing trap.

Commercial fishermen use wire box-like traps deployed from boats to catch CA lobsters (Figure 2-3). Properly placed and serviced traps do not generally cause significant physical disturbance to the environment (Eno et al., 2001). Traps are usually deployed in less than 31 m (100 ft) of water, but some are deployed as deep as approximately 93 m (300 ft). According to a 2013 CDFW commercial fishery survey, fishermen generally operate 75 to 1,000 traps each season, with a median of 300 traps. California law requires fishermen to service (pull and clean) each deployed trap at least once every 96 hours, weather conditions permitting (FGC § 9004).

Traps - Generally, a wire basket or cage used for trapping certain types of organisms.
Landings - The number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the points where fish are brought to shore. Note that landings, catch, and harvest define different things.

Commercial landings tend to be distributed evenly between San Diego County, Los Angeles/Orange Counties, and Santa Barbara/ Ventura Counties. However habitat area and fishing effort are not equally distributed. For example, in the last 10 years 20-30% of all trap pulls and a similar proportion of the total catch can be attributed to the single fishing block at Point Loma, San Diego. In general, 80% of a season's catch is landed within the first half of the commercial season by mid-January. The majority of CA lobsters landed by the commercial fishery have reached legal size within the last year, although larger lobsters are still landed (Neilson, 2011).

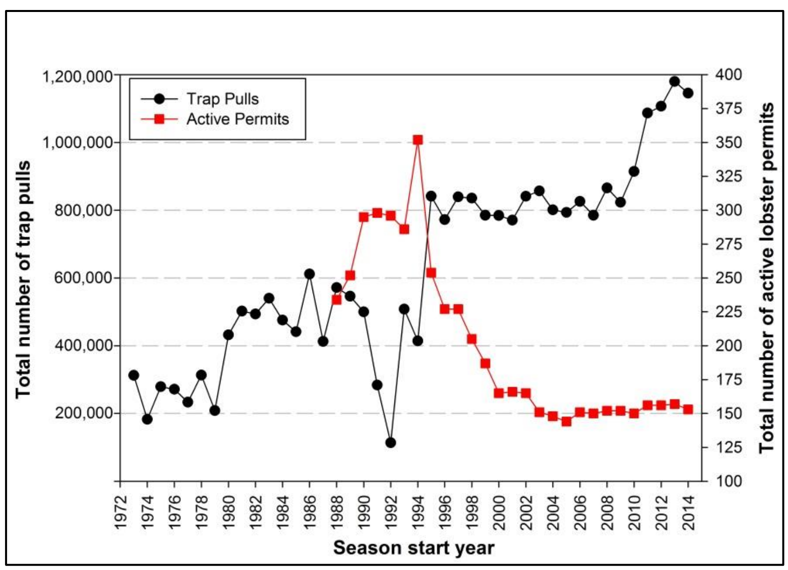

Figure 2-4: Total commercial trap pulls for CA lobster *(P. interruptus)* by year (black) compared to total number of active fishermen by year (red).

*Active Permits defined as individuals who made at least one landing during a particular fishing season

Commercial fishing effort (i.e., number of trap pulls) has been increasing in recent years despite an overall decrease in the number of active fishermen since the late

1990s (Figure 2-4). Between 1995 and 2009, the annual total trap pulls of the commercial fleet hovered near 800,000 pulls. In 2012, the number increased to just over 1.1 million pulls, despite the number of active fishermen remaining stable at about 150 individuals since 2003. This effort increase could be driven by several factors. Permit transferability adopted in 2005 can create considerable debt for new entrants into the fishery. Transferable lobster operator permits sold for approximately $75-100K in the 2010s on the private market. This estimate is based on online permit exchange (e.g., http://www.permitmaster.com) and is consistent with testimonies from commercial fishermen during the Commission's Marine Resources Committee meetings. It is reasonable to expect the owners of this debt would have incentive to fish harder than unindebted permit holders.

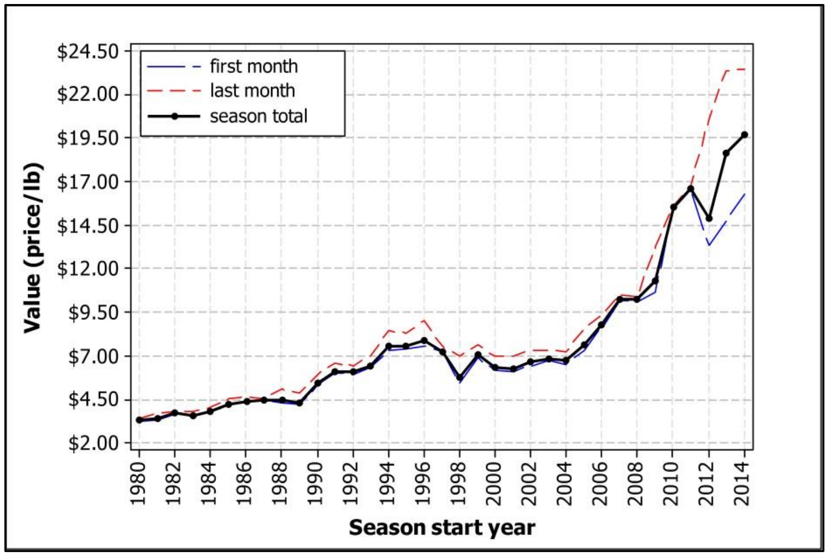

Figure 2-5: Mean commercial CA lobster (*P. interruptus*) landings value (price/pound (lb)) by fishing season. Lines indicate the total season, beginning (Sept+Oct) and ending (Feb+Mar) average value.

> **Ex-vessel price/Ex-vessel value -** The value of fish at first sale by fishermen at the dock, distinguished from wholesale or retail value.
> **Yield per recruit (YPR) -** A theoretical value that describes the yield to a fishery that is contributed by a given number of recruits (usually a single recruit).

Furthermore, some longtime permit holders who formerly contributed little effort to the fishery are becoming increasingly active because of the rapidly rising ex-vessel price of CA lobster in recent years. The average landing price of CA lobster has consistently increased over each season since the early 1990s (Figure 2-5). In the 2014-15 fishing season the fishery hit a record average seasonal landing price of $19.67/pound. The average landing price ($/pound) of CA lobster increased by approximately $8/pound between the 1980-81 and 2009-10 fishing seasons as domestic demand slowly grew. However, the average price increased by the same amount in just 5 years between the 2009-10 fishing season and the 2014-15 fishing season, as foreign markets expanded and export demand grew (Figure 2-5). Total **ex-vessel value** increased gradually between the late 1960s and 1990s, after which the value increased at a much faster rate and reached a record high of $18.7 million in the 2014-15 fishing season (Figure 2-6).

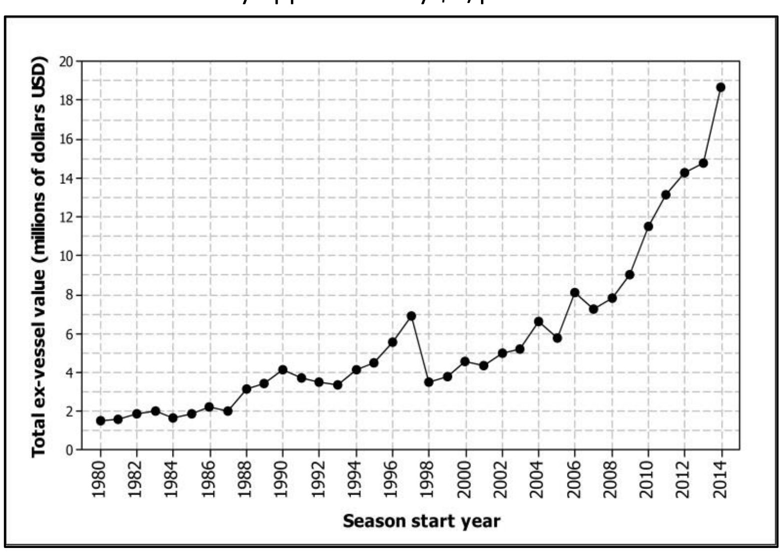

Figure 2-6: Total ex-vessel value of the CA lobster (*P. interruptus*) fishery from 1980 to 2014.

Figure 2-7 shows the cumulative percentage contribution of fishermen, ranked from highest to lowest catch, to the total catch of the fishery in the 2013-14 fishing season. If all fishermen land similar levels of catch, the cumulative catch will be a straight line. Here the slope is curved, which means that differences exist with some fishermen landing more than others. Furthermore, the curve is very gradual with no significant break, suggesting there is high competition within the fishery, and a fisherman can easily trade place with those immediately before or after him/her from one season to the next. However, this graph does not show the difference in operational costs between fishermen; a more efficient fisherman (e.g., loses less traps or running a more efficient boat) may generate more profit than a more highly ranked competitor.

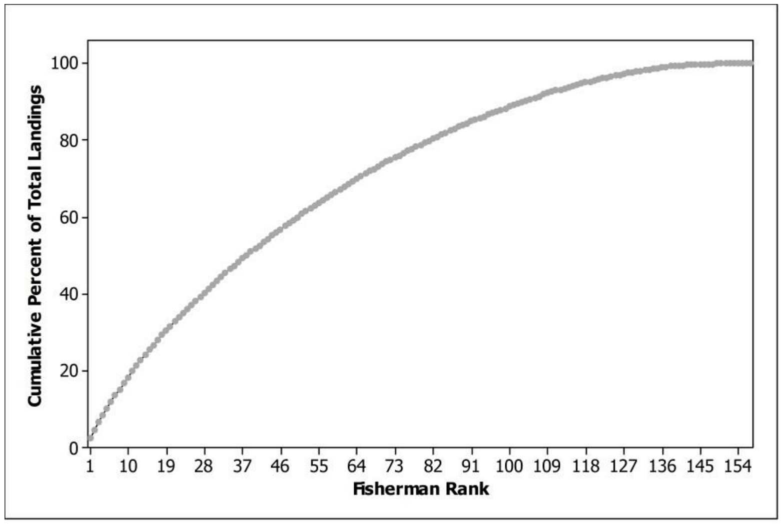

Figure 2-7: The cumulative percent contribution of fishermen to the 2013-14 CA lobster (*P. interruptus*) fishing season landings.
***The graph starts with the fisherman with the highest landings and incrementally adds the landings of the next highest-landing fisherman until all active fishermen are accounted for.**

High effort in the commercial fishery may present challenges to sustainability when it results in a high harvest rate. Instantaneous harvest rate (Section 4.1) in the San Diego region is estimated to be higher than Santa Barbara. For CA lobster, however, **yield per recruit** (YPR) increases very little when harvest rates are increased beyond a certain point, leading to **economic overfishing** (Kay, 2011; Section 4.1). This scenario is nearly universal among the world's lobster fisheries (Gardner et al., 2013). The economic inefficiency of high harvest rates is accompanied by other challenges to California's MLMA objectives (Section 4.1). These include a lower spawning potential, diminished non-consumptive user experiences, and greater risk of undesired ecological interactions (e.g., bycatch, lost gear, ghost fishing).

2.2 Recreational Fishery History and Description

The recreational fishery targets CA lobster using **hoop nets** (Figure 2-8) or by hand when diving (**SCUBA** or skin diving). Historically, diving has been more prevalent than hoop netting. Eighty percent of the interviewees in a 1992 CDFW recreational **creel survey** were composed of divers, with hoop netters accounting for 20%. This pattern has since changed with 80% of the recreational interviewees hoop netting in the more recent 2007 CDFW recreational creel survey.

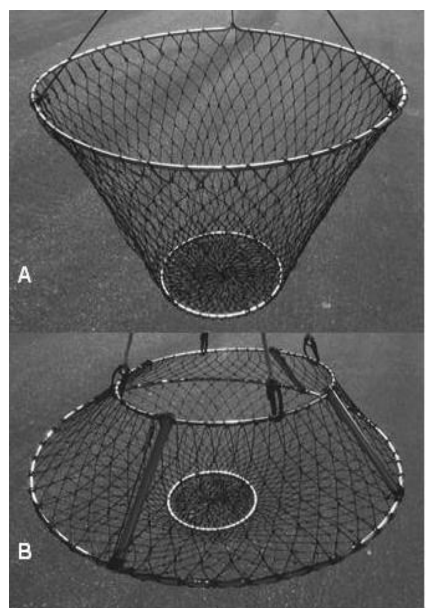

Figure 2-8: Traditional hoop net (A) and rigid conical hoop net (B).

CDFW was not able to quantify recreational catch until recent years through the recreational lobster **report card** (Section 5.1.1; Table 2-1). Low report card return rates cause uncertainty in recreational catch estimates, because returned cards may not reflect unreturned cards, and sample size is reduced for stratification. However, return rates have been improving and a non-reporting fee of $20 was implemented to cover costs of CA lobster management in 2014. An anticipated effect of that fee is an improvement in return rates. Estimates for recreational catch range from 292,442 pounds in 2013 to 527,357 pounds in 2009 representing 27 to 43% of the total recreational and commercial catch. While the estimated 95% confidence intervals for recreational catch are narrow, they do not incorporate uncertainty due to poaching or the potential that catch on returned report cards is not representative of catch on un-returned report cards.

CDFW allows two types of hoop nets: traditional hoop nets and rigid **conical hoop nets** (14 CCR § 29.80). The traditional hoop nets lie flat on the seafloor and only take their three-dimensional shape when pulled to the surface. A slow or jerky pull can allow lobster to escape out the top or sides. Conical hoop nets, introduced in 2006, have rigid sides and do not lie flat on the seafloor. The lobster must climb up and into the net to reach the bait. When disturbed, lobsters fleeing sideways are blocked by the net regardless of how the hoop net is pulled. A 2009 CDFW study found that conical nets catch about 57% more lobster than traditional style nets over time (Neilson et al., 2009). Additionally, Miller (2014a) found that the size of lobsters entrapped within a power plant cooling system significantly decreased following the introduction of conical hoop nets and the increased use of hoop nets in the recreational fishery. The power plant is located within Santa Monica Bay where only recreational fishing is allowed. This suggests the recreational fishery may be having an impact on the local population and continued monitoring is warranted.

Statistical comparison between hoop net fishermen and divers has been particularly problematic. For example, in 2009, only 50.9% of all report cards returned were from hoop net fishermen, even though both the creel survey and the recreational industry representatives indicated that a large majority of the recreational fishermen at that point were hoop net fishermen. The most recent set of report card returns (2014-15 fishing season) was composed of 60% hoop net fishermen. However, this result may still be underrepresenting the overall fraction of hoop net fishermen. When the report card requirement was first implemented, report cards tracked the calendar years. Starting in 2013, CDFW adjusted report cards to track individual lobster fishing seasons which cross consecutive calendar years, following input from various constituent representatives. Data from the 2014-15 fishing season lobster report cards estimated the recreational catch to be 199.2 mt (439,151 pounds), or about 31% of the total (i.e., recreational plus commercial) catch. The report cards also indicate that most CA lobsters captured by the recreational fishery are caught in areas where the commercial fishery is prohibited (Figure 2-9; FGC § 8258). It is unclear whether this pattern is caused by ease of access from ports or better fishing conditions. Communication with hoop net retailer representatives suggests that public interest in hoop nets may have plateaued (J. Salazar, pers. comm.), but future recreational effort increases may be inevitable due to human population growth in California. CDFW will continue to improve its data collection on the recreational sector and remain adaptive towards any change.

Economic overfishing - Fishing levels that exceed maximum economic yield.
Hoop net - A round net used to catch lobster by the recreational lobster fishing sector in California; it traditionally lies flat on the seafloor and assumes a basket shape upon retrieval to the surface.
SCUBA - "Self-Contained Underwater Breathing Apparatus" utilized to catch lobster by hand by the recreational lobster fishing sector in California; proposed here as a way for commercial fishermen to retrieve lost traps or cut out of entanglement.
Creel survey - Catch information gathered from recreational fishermen.
Conical hoop net - A modified style of hoop net used to catch lobster by the recreational lobster fishing sector in California; it is basket shaped, does not collapse, and does not lie flat on the seafloor.
Report card - A means of collecting fishery-dependent data on the recreational lobster fishery in California. Lobster report cards collect information on the number of people recreationally fishing for lobster each year, the gear they use, and their harvest and success rates. Required since 2008 to be filled out by all persons fishing recreationally for lobster in California.

Table 2-1: Estimate of Total Recreational CA Lobster (*P. interruptus*) Fishing Effort and Catch from 2008 to 2015 based on recreational report card data.

Estimates of Total Recreational Lobster Fishing Effort and Catch								
Calendar Year	**Number of Cards Sold**	**Return Rate**	**Estimated Number of Active Lobster Cards (Cards that recorded at least one trip)**	**Estimated Number of Fishing Trips**	**Average CPUE (# of Lobsters Kept Per Trip)**	**Estimated Weight of Landings in Metric Tons (mt) (pounds (lb))**	**Percent of Total (Recreational + Commercial) Landings**	**± 95% Confidence Intervals**
2008*	27,472	22%	24,038	104,085	2.1	160.93 mt (354,792 lb)	32%	6.73 mt (14,837 lb)
2009	32,343	14%	27,847	147,868	2.2	239.21 mt (527,357 lb)	43%	13.02 mt (28,715 lb)
2010	29,108	12%	25,033	127,168	2.1	197.24 mt (434,848 lb)	38%	12.96 mt (28,570 lb)
2011	33,376	16%	28,870	154,743	2.0	195.02 mt (429,953 lb)	36%	9.85 mt (21,722 lb)
2012	37,193	33%	28,527	127,801	2.0	185.97 mt (409,984 lb)	32%	6.14 mt (13,532 lb)
2013	14,514**	49%	11,437	71,024	2.1	163.26 mt** (359,928 lb)	32%***	*****
2013-14	33,668	48%	26,295	88,351	1.6	174.53 mt*** (384,781 lb)	32%****	*****
2014-15	36,414	54%	28,530	111,552	1.9	155.39 mt (342,583 lb)	26%	3.24 mt (7,136 lb)

***Lobster report card was implemented in the fall of 2008; CDFW only has estimates for the latter half of calendar year 2008**
****Season-length report card was implemented for the 2013-14 fishing season. While some recreational fishermen still purchased 2013 calendar year lobster report cards along with 2013-14 season-length report cards, other fishermen only purchased 2013-14 season-length report cards.**
***** 2013 "Estimated Weight of Landings in Tons" and "Percent of Total Landings" includes landings from 2013 calendar year cards, PLUS landings from September, October, November, and December on 2013-2014 full season cards.**
****** 2013-2014 "Estimated Weight of Landings in Tons" and "Percent of Total Landings" includes landings from 2013-2014 full season cards, PLUS landings from September, October, November, and December on 2013 calendar year cards.**
*******Unable to calculate due to calendar to seasonal switch.**

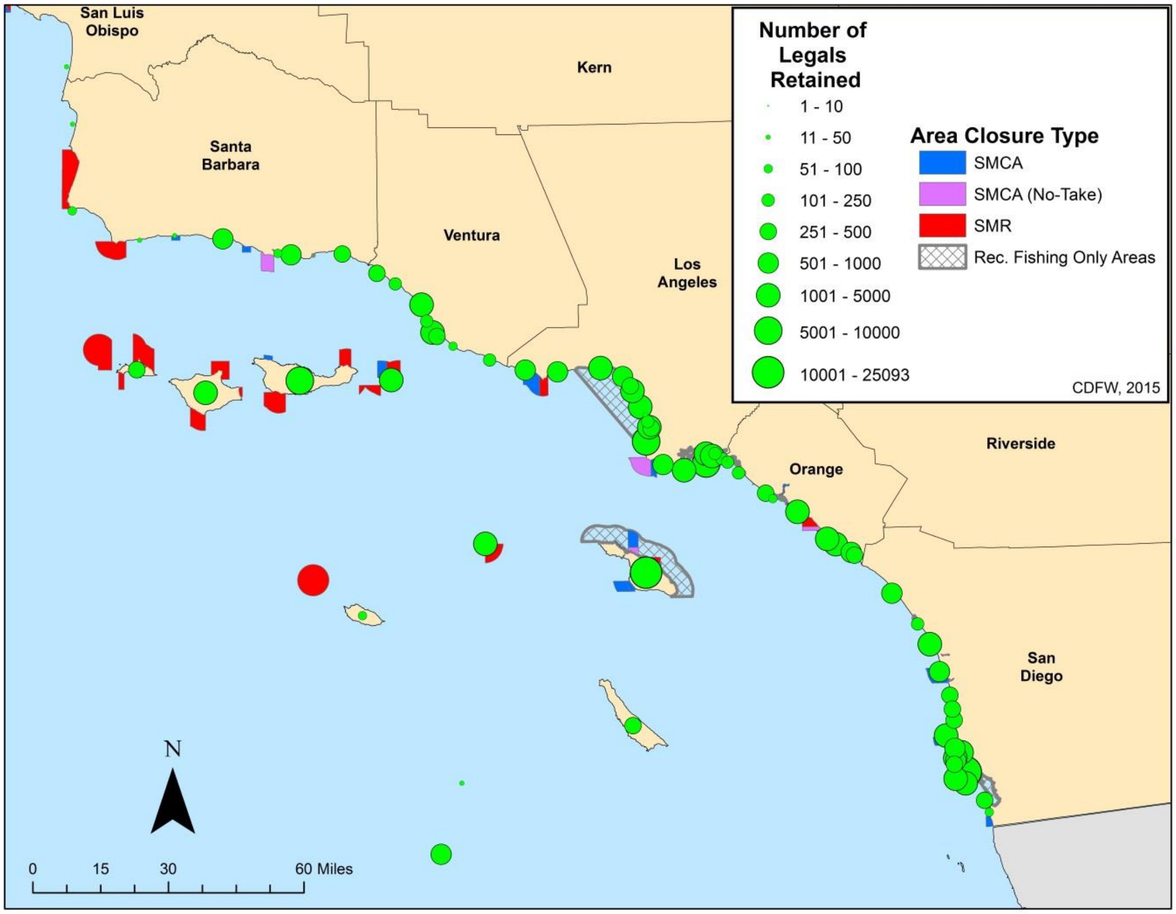

Figure 2-9: Number of legal CA lobsters (*P. interruptus*) reported retained from recreational lobster report cards in 2013 overlayed with area closures (MPAs and recreational-only fishing areas).
***SMCA = State Marine Conservation Area (may allow some commercial and/or recreational take)**
****SMR = State Marine Reserve (no take areas)**
*****Northern-most dot denotes total catch between San Luis Obispo up to CA-OR border**

2.3 Bycatch within the Fishery

Bycatch occurs in both the recreational and commercial CA lobster fisheries. There are generally two types of bycatch (FGC § 90.5) in the fisheries: 1) sublegal-size lobster; and 2) other non-targeted marine life. The MLMA calls for the minimization of bycatch when the amount or type is "unacceptable" (FGC § 7085(c)). Based on available data, CDFW concludes that there is no indication of unacceptable bycatch levels in either the commercial or recreational fisheries.

2.3.1 Commercial Fishing Bycatch

Trap fisheries generally have minimal bycatch of species other than invertebrates (Morgan and Chuenpagdee, 2003; Matthews et al., 2005). These traps are required to have both destruct devices (destruct clips/rings) to avoid ghost fishing as well as escape ports to minimize the catch of sublegal-size lobster. Traps are set on the bottom in rocky areas between approximately 3.05 to 91 m (10 to 300 ft) and are baited with whole or cut fish (CDFG, 2001). However, unattended traps can impact the marine ecosystem (e.g., increased chance of gear loss), and fishermen are required to raise and service them at intervals not exceeding 96 hours, weather permitting (FGC § 9004).

A Collaborative At-Sea Sampling Program made possible by Collaborative Fisheries Research West, California Sea Grant, and California Ocean Protection Council was initiated during the 2012-13 CA lobster fishing season. This program did not specifically focus on bycatch, however bycatch information was collected. Sampling was performed by fishermen throughout the **Southern California Bight** (SCB) with a total of 2,520 traps sampled. These data are reported in Table 2-2.

Table 2-2: Bycatch found in 2,520 commercial CA lobster (*P. interruptus*) fishing traps (Source: CASP unpublished data, Culver, 2013).

Common species name	Scientific name	% of total animals caught (5,284)
sublegal-sized CA Lobster	*Panulirus interruptus*	83.29%
Kellet's Whelk*	*Kelletia kelletii*	5.98%
Rock Crab*	*Cancer* spp.	4.20%
Wavy Top Snail	*Megastraea undosa*	0.47%
Sheep Crab*	*Loxorhynchus grandis*	1.29%
Cabezon	*Scorpaenichthys marmoratus*	0.45%
Lingcod	*Ophiodon elongates*	0.28%
CA. Scorpionfish (Sculpin)	*Scorpaena guttata*	0.04%
Swell Shark	*Cephaloscyllium ventriosum*	0.11%
Rockfish (Unidentified)	*Sebastes* spp.	0.02%
Goby (Unidentified)	Gobiidae spp.	0.02%
CA Sheephead	*Semicossyphus pulcher*	0.02%
Ocean Whitefish	*Caulolatilus princeps*	0.02%
Horn Shark	*Heterodontus francisci*	0.04%
Perch (Unidentified)	Embiotocidae spp.	0.04%
Skate (Unidentified)	Rajidae spp.	0.04%
Crab (Unidentified)	Decapoda spp.	0.02%
Sea Hare (Unidentified)	*Aplysia* spp.	0.09%
Sea Star (Unidentified)	Asteroidea spp.	2.44%
Kelp Crab (Unidentified)*	*Taliepus nuttallii / Pugettia producta*	0.09%
Octopus (Unidentified)*	Octopodidae spp.	0.23%
Urchin (Unidentified)	Echinoidea spp.	0.74%
Barred Sand Bass	*Paralabrax nebulifer*	0.02%
Snail (Unidentified)	Gastropoda spp.	0.06%

***Species that are legal to sell**

Available information shows that a majority of CA lobster commercial fishing bycatch consists of invertebrates, with sublegal-size lobsters making up a great majority of the total bycatch. The other most common bycatch in the CA lobster commercial fishery are Kellet's whelk, rock crabs, starfish, sheep crabs, urchins, and wavy top snails (Culver unpublished data, 2013). Data from CDFW commercial fishing logs suggest that the amount of sublegal-size lobster bycatch has increased in recent years.

Fishermen may unintentionally damage (break legs or antennae) sublegal-size lobsters when removing them from traps. One Australian study found that spiny

Southern California Bight (SCB) – The coastal and its immediate offshore areas between Point Conception to the north and the U.S. – Mexico border to the south. The curvature of the coastline and the relatively shallow depth of the area lead to oceanographic and biological characteristics that are clearly distinguishable from the central California coast.
Fecundity - The reproductive capacity of an individual female animal during a reproductive event or breeding season, generally expressed as the number of eggs or larvae per unit weight or per individual.

lobsters with broken appendages become less fecund due to extra energy being exerted for healing and repairing the broken appendages (Melville-Smith and de Lestang, 2007). Any similar impact on the **fecundity** of CA lobster and the survival rates of returned sublegal lobsters is currently unknown.

Commercial CA lobster fishermen can legally retain certain crabs, Kellet's whelks, and octopi (FGC § 8250.5). These bycatch are reported and included in the calculation of the total annual landings of each species. Since most bycatch that are not legally retained by fishermen can be returned to the ocean alive with proper handling, the ecosystem impact through bycatch for this fishery is limited (Miller, 1996; Hovel and Neilson, 2011;). Data from Mexico reflect similar patterns in bycatch. While a 2004 study suggests that bycatch is practically non-existent in the Mexican lobster fishery (SCS, 2004), a more recent study found the weight of the bycatch in that fishery to be 15% of the total catch (Shester and Micheli, 2011). Most of the Mexican bycatch, excluding sublegal lobster, consists of crabs and other invertebrate species. Recent studies also observed sea bird (cormorant) bycatch in Mexico and Florida (Matthews et al., 2005; Shester and Micheli, 2011). However, there has not been any cormorant mortality attributed to lobster traps in California, which are all outfitted with escape ports.

2.3.2 Recreational Fishing Bycatch

Recreational fishing for CA lobster primarily occurs from Point Conception, CA to the U.S. – Mexico border, including **offshore** islands and reefs. Lobsters are caught by hand during dive trips, and divers are required to release sublegal-size individuals immediately after measuring. Certain other invertebrates may also be retained by divers targeting lobster. Hoop netters are primarily boat-based. They generally set the baited nets on the bottom in shallow waters < 30.5 m (100 ft), and raise them after a soak time of < 2 hours. Available information shows that most of the hoop net bycatch is invertebrates such as sublegal-size lobsters, rock crabs of the *Cancer* genus, and sheep crabs. Some **finfishes** are also caught, with round stingrays being the most common (Neilson et al., 2009). Live finfishes and invertebrates can usually be released from hoop nets safely (Hovel and Neilson, 2011). Survival is high when animals are quickly returned to the water (Miller, 1996).

Offshore - All oceanic waters outside state waters or deeper than 100 fathoms.
Finfish - Any species of bony fish or cartilaginous fish (sharks, skates and rays). Finfish do not include amphibians, invertebrates, plants or algae
Total allowable catch (TAC) - A specified numerical catch objective for each fishing season; the attainment (or expected attainment) of which may cause closure of the fishery.

Data on hoop net bycatch is limited, and no data on diving bycatch exists. An unknown number of crabs are retained by hoop netters every year. Available data come from a CDFW hoop net study at Zuniga Jetty near San Diego Bay, CDFW video observations of hoop netting at Indian Rock at Catalina Island, and recreational gear data from the California Lost Fishing Gear Recovery Project. CDFW also relies on information provided by its enforcement officers as well as anecdotal information provided through online fishing reports posted on recreational fishing websites.

2.3.3 Legality of Bycatch and Seabird and Marine Mammal Gear Interactions

Commercial and recreational fishermen are not allowed to retain sublegal-size lobsters under current California law (FGC § 8252; 14 CCR § 29.90). However, fishermen may retain legal-size crabs and octopi provided that they have the valid permits (14 CCR § 125; 14 CCR § 29.85; FGC § 8250). Commercial fishermen may also retain Kellet's whelk until the whelk's annual **total allowable catch** (TAC) is reached (14 CCR § 127; FGC § 8250).

Seabird and otter bycatch is not common within the CA lobster fisheries. Research conducted on sea otter entrapment and mortality in fish and shellfish traps suggests that the CA lobster fishery is not expected to contribute to otter mortality if the current geographic extent of the fishery and the current otter range both remain unchanged (USGS, 2014). Of the 15 reported instances of trap-related sea otter mortalities during 1974-2007, 14 occurred in either Pacific cod or crab traps (Hatfield et al., 2011). One incidence of a sea otter mortality associated with lobster traps was recorded in 1987 (Carretta et al., 2014). The majority of California's southern sea otter mortalities on record were the result of shark attacks, boat strikes, mating trauma, diseases, parasites, infections, and biotoxins (CDFW-MWVCRC, 2013).

Marine mammal mortality as a result of entanglement in lobster fishing gear is rare in the CA lobster fishery. Lobster traps are generally deployed in less than 100 ft of water, a depth range where large marine mammals such as whales are not generally found. However, the number of reported whale entanglement on the west coast of the United States has been increasing in recent years (National Marine Fisheries Service stranding database) and reached a peak of approximately 35 in 2014 with a total of 231 for the period between 2000 and 2015 (Lawson, 2015). The majority of confirmed entanglements are attributed to categories for trap or pot fisheries and unknown gear with relatively few attributed to nets (Lawson, 2015). Among those with a confirmed gear type from a trap fishery, the large majority are due to the Dungeness crab fishery and relatively few to the lobster, rock crab and spot prawn fisheries (Lawson, 2015). However, it should be recognized that some portion of entanglements due to an unknown gear type may be attributable to the lobster fishery. Since the year 2000, there have been four reported incidences of gray whales, two humpback whales, and one unidentified whale entangled in lobster gear (Carretta et al., 2014; Carretta et al., 2015; National Marine Fisheries Service stranding database) and 1 incidence of bottlenose dolphin entanglement in 2008 (Carretta et al., 2014). Mortality due to entanglement was confirmed for the unidentified whale, and one humpback whale and one gray whale were reported as seriously injured.

The National Marine Fisheries Service classifies fisheries based on their level of interaction with marine mammals and guides when incidental take permits under MMPA are required. Under MMPA, a fishery would require an incidental take permit if it is classified as "Category I" or "Category II" (50 CFR § 229.2). The CA lobster fishery was classified as "Category III" in 2014 (79 FR 77934). Such fisheries "have a remote likelihood of, or no known incidental mortality and serious injury of marine mammals" (50 CFR § 229.2). The fishery should continue to remain in Category III as long as its annual take of any marine mammals continues to remain less than 1% of a given stock's potential biological removal level or, in combination with other mortality sources, is responsible for less than 10% of the stock's potential biological removal level (50 CFR § 229.2).

2.4 History of Conservation and Management Measures Affecting the Fishery

California has regulated the CA lobster fishery for over a hundred years. Current management measures include commercial fishing permits, recreational harvest report cards, gear restrictions, **size limits**, time and area closures, and a recreational possession limit. The Commission has complete management authority over the recreational fishery (14 CCR § 29.90) and significant management authority over the commercial CA lobster fishery (Table 2-3) (14 CCR § 121-122; FGC §§ 8254, 8259).

California law controls the commercial fishery's overall **fishery effort** with a **limited entry program** (FGC § 8259; 14 CCR § 122). Since 2005, fishermen with transferable permits are allowed to sell their permits under strict conditions.

> **Size limit -** The minimum size a fish or other organism must be for it to be possessed.
> **Fishing Effort -** A measure of some expenditure in pursuing a fishing activity. The measure in lobster fishing effort is usually in terms of number trap pulls (in commercial fishery), number of fishing trips, or time spent fishing.
> **Limited entry program -** Regulatory program that restricts the total number of permitted fishing licenses or vessels.

Individuals wishing to enter the fishery have to purchase a permit from an existing permittee. The number of permittees actively fishing has been stable since 2008. During the 2013-14 fishing season, 141 transferable permits and 51 non-transferable permits were renewed; 157 of those permits were actually fished.

On the recreational side, all fishermen are required to purchase a CA lobster report card regardless of their age, and all fishermen 16 years or older must purchase a sport fishing license unless they are fishing during free fishing days or on public fishing piers. All recreational fishermen are restricted by a daily bag and possession limit of 7 lobsters and a 3.25 inch (82.6 mm) minimum carapace size. Hoop nets are restricted to 5 hoop nets per person (2 if fishing from a public pier) and 10 hoop nets per vessel. Fishermen are also required to pull and inspect the contents of their hoop nets every 2 hours.

In 1998, the MLMA was passed and required the state to manage all fisheries sustainably, in part through the use of FMPs. In 1999, the Marine Life Protection Act (MLPA) was passed in California, which led to the establishment of a statewide network of **marine protected areas** (MPAs) (Section 4.7).

2.5 Economic and Social Factors of the CA Lobster Fisheries

The economic status of the CA lobster fishery was evaluated by an independent panel of experts in April 2013. The report (Appendix VI) analyzes the expenditures of the commercial fishery and recreational

Table 2-3: Regulatory history of the CA lobster (*P. interruptus*) fishery.

Year	Regulatory Change Affecting the Commercial CA Lobster Fishery	Type of Change
1894	1 pound minimum size in Los Angeles, San Diego, and Ventura Counties	Size limit
1901	Berried Females Protected (repealed)	Management
1901	First minimum length implemented (9½“ total length)	Size limit
1913	First slot limit introduced (9” – 13½“)	Size limit
1917	Slot limit modified (10½” – 16“)	Size limit
1955	3.25 inch carapace length minimum size implemented	Size limit
1957	2x4 inch wire mesh required or 2 inch high openings along two sides of traps to allow escape of undersized lobsters	Gear restriction
1961	Implementation of the modern day open season: The first Wednesday in October through the first Wednesday after March 15	Season
1961	Fish and Game Commission given authority to manage the fishery	Management
1961	Lobster permits required. New permits issued by lottery with a capacity goal of 225 fishermen	Management/ Permitting
1973	Logbooks required by law to record essential fishery information. Also, permit applications require estimate of number of traps to be fished	Reporting
1976	Escape ports are required for commercial traps	Gear restriction
1986	Fish and Game Commission given authority to limit the number of permits	Management/ Permitting
1992	The recreational season opener is moved to the Saturday preceding the first Wednesday in October to provide the sport fishery with four days of fishing prior to the commercial opener	Season
1994	Fish and Game Commission places a moratorium on new permits for 2 years in preparation for a switch to a limited entry permit fishery	Management/ Permitting
1996	Limited entry permit program begins	Management/ Permitting
2003	Lobster permit lottery repealed	Management/ Permitting
2011	CDFW initiates a spiny lobster Fishery Management Plan as mandated by the 1998 Marine Life Management Act	Management
2012	A network of new marine protected areas go into effect in Southern California as mandated by the 1999 Marine Life Protection Act	Fishing area restriction

fishery, as well as the economic significance of the commercial fishery based on the 2009-10 to the 2011-12 fishing seasons. The report provides a statewide perspective on the economic significance of the fishery and establishes a foundation for future economic analysis.

Ten commercial lobster fishermen were surveyed with questions relating to the cost of participating in the fishery based on methodologies established in a 2009 study (Hackett et al., 2009). The commercial lobster fishery's total 2011 operational cost was estimated at approximately $10.5 million. Of this, over half (> $6 million) comes from a combination of bait (~$1.6 million), fuel (~$1.3 million), crew wages (~$1.8 million), and federal taxes (~$1.1 million) (see Appendix VI).

The economic impacts (**total economic value added, total economic output)** of the commercial fishery were calculated based on factors such as expenditures (e.g., trap costs, fuel cost) and revenue (e.g., fishing income, export and domestic sales). The gross ex-vessel value of the fishery from the 2011-12 season was $12.9 million, and the statewide total economic output was over $22 million, contributing a total of 323 full-time equivalent jobs. The total economic value added to the economy during this same period was just under $12 million, with $695,893 contributing towards employee compensation (wages and salaries plus benefits for deckhands, crew members). Licensed CA lobster fishermen took in an estimated income of $3.8 million (see Appendix VI, Table 3).

The amount of economic impact the commercial fishery has on coastal communities differs across the southern California region, but the amount of added value is on a similar order of magnitude for each region. The fishery adds roughly $2.1 million dollars of net economic output to the economy of Santa Barbara County, $1.4 million to Ventura County, $2 million to Los Angeles County, $1.6 million to Orange County, and $3.5 million to San Diego County (see Appendix VI, Table 4).

Total economic value added – Total economic output less the goods and services used up to create that output; for lobster fishery, it means the net value of the lobsters after costs like trap purchases are accounted for. Also known as Net Economic Output.
Total economic output – The total amount of economic output that does not take into account the amount of intermediate goods consumed during the harvest/production process; for lobsters, this means the amount of money sales generate before costs such as trap cost are considered. Also known as Gross Economic Output.

The 2013 Economic Report represents the most recent attempt at quantifying the economic impact of the commercial lobster fishery. However, several areas of the report could be improved and revised. The total net income for the fishery was only estimated to be $11,188,354 which is unexpectedly low given 151 active permit holders in 2011. Communication with active commercial lobster fishermen suggests that the cost of commercial lobster fishing may have been overestimated in the report, which likely led to the low estimate for net income. Estimating the true cost of the commercial fishery is complicated by fluctuations in fuel price and competition dynamic within the fishery over time. In addition, the ex-vessel price of CA lobsters has continued to increase significantly since the report was produced, which likely has changed the magnitude of the total economic impact from the commercial fishery.

State-wide expenditures on recreational lobster fishing were calculated based on a telephone survey conducted by CDFW in 2012. The survey targeted a random sample from all individuals who returned a calendar year 2011 lobster report card. The survey found that Californians spent between $33 - $40 million dollars on recreational lobster fishing in 2011 (see Appendix VI). Of this, roughly $7 million is attributed to residents who live in zip codes that border the coastline, $20 million is attributed to other residents living in zip codes that are at least partially within 50 miles of the coastline, while roughly $10 million is attributed to residents living further inland. The largest sources of expenditures were non-coastal residents who live within 50 miles of the coast who fished CA lobster along the coast, and those who live more than 50 miles from the coast who dove for CA lobster offshore.

3. Natural History and Population Dynamics of the California Spiny Lobster

The California spiny lobster (*Panulirus interruptus*) is one of approximately 55 spiny lobster species found in tropical and temperate oceans worldwide, most of which are fished commercially and/or recreationally (Phillips and Kittaka, 2000; Booth, 2011). Spiny lobsters are named after the forward-pointing spiny projections that cover their bodies. The species lack the pincers found on clawed lobsters.

The body of *P. interruptus* has two readily identifiable parts: (1) a fused head and thorax (cephalothorax) enclosed in a carapace, and (2) the abdomen, or tail (Figure 3-1). The carapace protects most major organs and serves as the attachment point for the legs. In sexually mature males, the gonad pores (sperm ducts) are found at the base of the fifth pair of the legs. Females have enlarged swimmerettes, or pleopods, along each side of the tail and a small claw on the fifth legs.

Figure 3-1: External anatomy of CA lobster (*P. interruptus*). CL = carapace length.

3.1 Critical Habitat and Known Threats to the Habitat

> **Life history -** The history of changes an organism passes through in its development from egg, spore, or other primary stage until its natural death.

One of the primary objectives of the MLMA is to ensure that "the health of marine fishery habitat is maintained" (7056(b)). In order to accomplish this, an understanding of the spatial extent of habitats that support CA lobster throughout their **life history** is needed. The CA lobster is endemic to the North American west coast from Monterey, California southward to at least as far as Magdalena Bay, Baja California (Schmitt, 1921; Wilson, 1948). A small isolated population may have persisted in the northwestern corner of the Gulf of California (Kerstitch, 1989). Johnson and Snook (1927) reported its occurrence as far south as Manzanillo, Mexico. The core range, however, lies between Point Conception, CA and Magdalena Bay (Figure 1-1). The physical center of the range is within Mexico. Population density and fishery **productivity** within Mexico's border is the highest near Cedros Island and Vizcaino Peninsula in Baja California (Vega, 2003a).

> **Productivity -** Describes the birth, growth, and death rates of a stock. A highly productive stock is characterized by high birth, growth and mortality rates, and as a consequence has a high turnover. Such stocks can usually sustain higher exploitation rates and, if depleted, could recover more rapidly than comparatively less productive stocks.
> **Settlement -** In marine ecology, it means the process by which organisms change from an open ocean life history phase to assume a new mode of life as a member of a sea-floor community. In lobster, it is the stage at which juveniles move into the adult habitat where they become resident.
> **Substrate -** The surface or medium on or in which an organism lives (i.e., mud, sand, rocks)

Sub-adult and adult CA lobsters are commonly found on the seafloor at depths ranging from **intertidal** to 64 m (210 ft) (Allen, 1916; Lindberg, 1955; Mitchell et al., 1969; Robles et al., 1987;), while the **planktonic** larvae have been found offshore as far as 530 km (329 mi.) and at depths to 137 m (449 ft) (Johnson, 1960a; CDFG, 2001). Rocky structures/reefs are important **habitat** for CA lobster, and high quality rocky habitat is often characterized by the presence of brown algae such as giant kelp (*Macrocystis pyrifera*), feather boa kelp (*Egregia menzesii*), and stalked kelp (*Pterygophora californica*), as well as surfgrass (*Phyllospadix* spp.) (Lindberg, 1955; Engle, 1979). CA lobster habitats are generally described in relation to their juvenile (approx. < 3 years old) and adult (approx. > 3 years old) life stages.

Juveniles range from individuals that have recently settled from the planktonic stage (carapace length (CL) 7-8 mm) to individuals in the range of 44-56 mm CL (Mitchell et al., 1969; Parker, 1972; Serfling, 1972; Engle, 1979). CA lobster larvae prefer to settle on common surfgrass and red algae that are abundant in rubble habitats (Parker 1972, Engle 1979, Castañeda-Fernández de Lara et al., 2005). These shallow rubble habitats are crucial for the CA lobster (Winget, 1968; Blecha, 1972; Parker, 1972; Serfling, 1972; Engle, 1979; Castañeda-Fernández de Lara et al., 2005). These structurally complex habitats also protect and conceal juveniles from predators (Parker, 1972; Engle, 1979). CA lobsters typically remain in these habitats for 2-3 years post-**settlement** until they become sub-adults (Parker, 1972; Engle, 1979; Castañeda-Fernández de Lara et al., 2005).

Adult and sub-adult CA lobster commonly occupy natural hollow spaces within rocky **substrate**. They may also occupy hollowed-out holdfasts of giant kelp created by sea urchin grazing (Mai and Hovel,2007) or burrows excavated (either by CA lobsters or sand scouring processes) near the base of colonies of the sandcastle tube worm (*Phragmatopoma californica*) (Zimmer-Faust and Spanier, 1987). Human structures such as pier pilings (Stull 1991), industrial debris (Lindberg, 1955), harbor jetties (Neilson et al., 2009), and artificial reefs (Barilotti et al., 2005; Reed et al., 2006) can also serve as habitats.

CDFW, working with outside researchers, has compiled all readily available data detailing the spatial coverage of surfgrass[1], eelgrass (*Zostera spp.*)[2], giant kelp[3], hard rocky reef (natural)[4], and artificial reefs[1]. For areas where the bottom substrate habitats have not been previously mapped, aerial multispectral survey data were used to estimate the locations of hard substrate based on the presence of giant kelp coverage recorded in 1989, 1999, 2002-2006, and 2008-2009. Since kelp requires hard rocky substrate to settle and establish, the presence of kelp was determined to serve as an appropriate proxy to estimate reef areas that may act as lobster habitat. Figure 3-2 provides a snap-shot of known area that each of these habitats occupies within the historical range of the CA lobster fishery. For a detailed, known account of these habitats at a regional level, see Appendix III. It is important to note that any artificial or natural hard substrate associated with the sea floor can serve as CA lobster habitat, not all of which are depicted on the map.

Activities such as beach nourishment and urban runoff can adversely affect these habitats (Peterson and Bishop, 2005). Coastal development can also pose a threat to estuarine habitats (Kennish, 2002). Lastly, global climate change will lead to sea level rise and may intensify the impact of El Niño and its associated storm events (Shaughnessy et al., 2012; Section 3.11). Rising sea level coupled with more intense storms can further erode and destroy existing seagrass beds and kelp beds.

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[1] Collected by Minerals Management Service and compiled by Tenera Environmental
[2] ERMA. 2015. Web Application: Southwest Environmental Response Management Application, National Oceanic and Atmospheric Administration. http://erma.noaa.gov/southwest
[3] Aerial surveys conducted by CDFW
[4] Collected by Seafloor Mapping Lab at California State University Monterey Bay, United States Geological Survey, Ocean Imaging, and the San Diego Association of Governments

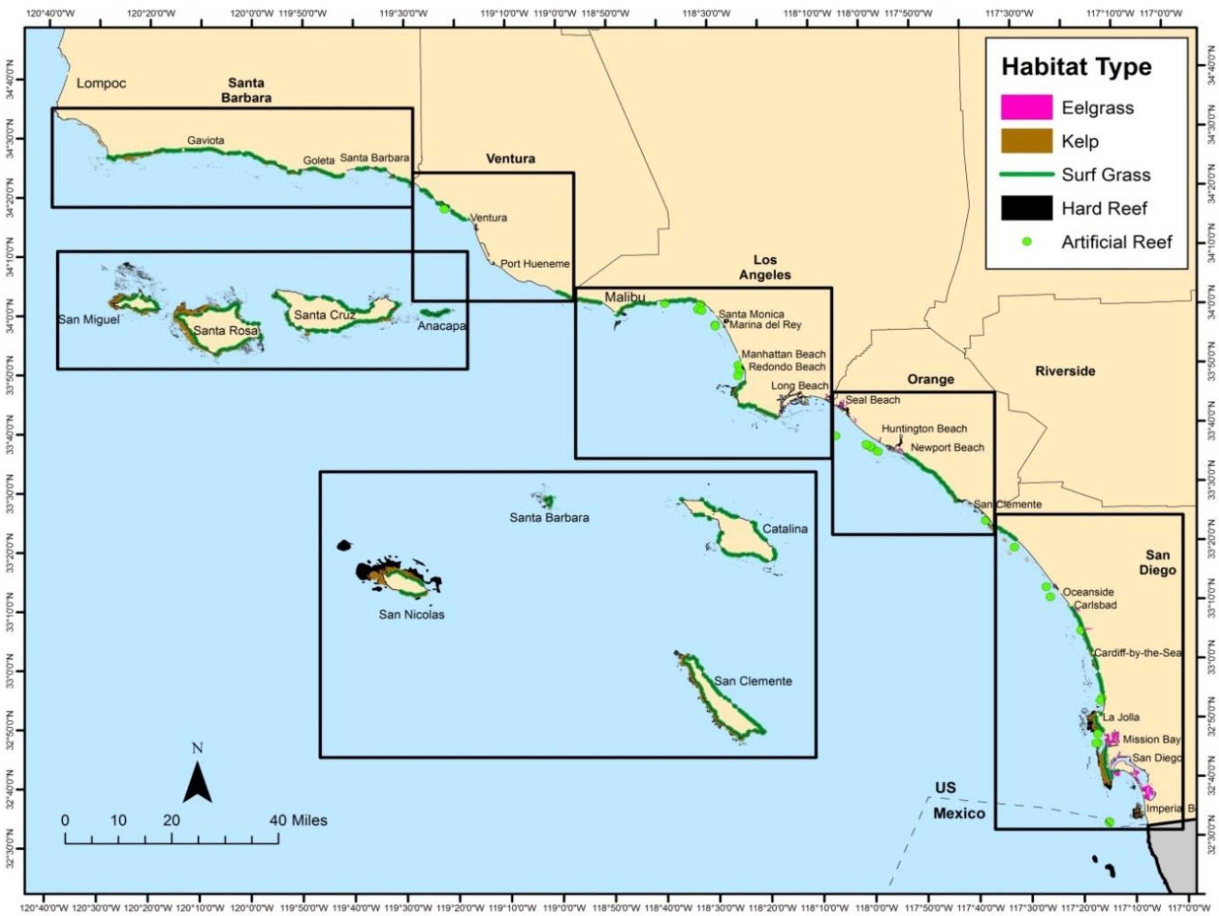

Figure 3-2: Locations of critical CA lobster (*P. interruptus*) habitat in the southern California Bight. Black boxes indicate insets provided in Appendix III: Habitat Maps by Area.

3.2 Growth

Like all crustaceans, CA lobsters have a rigid exoskeleton that covers the outer surface of their bodies. Once formed, this exoskeleton does not shrink or expand. In order to increase its body size, a CA lobster must shed its exoskeleton and replace it with a larger one (Mykles, 1980). The molt frequency and molt increment (size increase during each molt) of a CA lobster determines its growth rate. Rapidly growing young lobsters molt many times per year, but molt frequency decreases with age (Engle, 1979). Existing studies suggest that *P. interruptus* can usually reach a sexually mature size before reaching the minimum legal size of 82.5 mm CL (Table 3-1). However, how quickly or at what age individual CA lobsters can reach the **size at maturity** (SAM) is a complex scientific question. While a variety of modeling approaches allow estimation of growth rates and thus age at a given size, the von Bertalanffy growth equation may be most common (Chang et al., 2012). Currently CDFW uses the von Bertalanffy growth equation, which written as:

> **Size at maturity (SAM)** - The size at which 50% of animals in a population have reached sexual maturity and are capable of reproduction.

$$l_t = L\infty\left(1 - e^{-K(t-t_0)}\right). \qquad \textit{(Equation 3.1)}$$

Where l_t is the size at time t, $L\infty$ equals the average maximum achievable size, K is a growth constant that represents a rate, t is the time step, and t_0 is the size at age zero. Observations of maximum and minimum sizes of individuals can be used to estimate $L\infty$ and t_0 and then K can be calculated. The K

parameter may also be borrowed from comparable species. Parameters can also be derived by fitting the equation to annual growth increment data acquired from tag and recapture studies. Estimates for a CA lobster's lifespan, which is crucial for the calculation of the growth constant K (Chavez and Gorosteita, 2010), range from 30-50 years (Neilson, 2011). A species' asymptotic (maximum) size, $L\infty$, can also vary based on the methodology adopted (Mathews and Samuel, 1990). Choosing the appropriate parameters is important for the management of the fisheries, since the resulting growth curve will directly inform CDFW of the ability of the stock to replenish itself (Section 4.3). CDFW currently uses parameters derived by Vega (2003a) but is continuing to explore other methods for estimation of von Bertalanffy parameters as well as other types of growth models (see Appendix X).

Table 3-1: Size at which 50% of female of CA lobsters (*P. interruptus*) in various population samples were sexually mature (size at maturity: SAM).

♀ SAM (mm CL)	Location	Source	Method*
72.5	Baja (Sebastian Vizcaino bay	Ayala 1983	Ovary
72.6	Baja (Vizcaino Peninsula)	Vega 2003a	Sperm/Egg
70.0	California (Palos Verdes)	Lindberg 1955 (in Engle 1979. Converted using CL=0.31*TL)	Ovary
66.6 (215 mm TL)**	California (Palos Verdes)	Lindberg 1955 (215 mm TL converted to CL using: CL=0.31*TL)	Ovary
78.2 (215 mm TL)**	California (Palos Verdes)	Lindberg 1955 (215 mm TL converted to CL using: CL=0.3798*TL-0.342)	Ovary
63.5 (205 mm TL)**	California (La Jolla)	Fry 1928 (in Wilson 1948) (205 mm TL converted to CL using: CL=0.31*TL)	Not specified
74.4 (205 mm TL)**	California (La Jolla)	Fry 1928 (in Wilson 1948) (205 mm TL converted to CL using: CL=0.3798*TL-0.342)	Not specified
77.2	California (Palos Verdes, La Jolla)	Kay 2011 (Kay converted TL data of Fry 1928 and Lindberg 1955 using: CL=0.3798*TL-0.342)	Egg

Legal Size in California: 82.5 mm CL
***Methods used to measure SAM include analysis of dissected ovaries ("Ovary"), or the proportion of females with a spermatophore and/or eggs ("Sperm/Egg" or "Egg").**
**** SAM reported as total length (TL) by original researchers; TL's were converted to CL in preparation of this document or in other reports, as indicated in the "Source" column. Estimates 3a vs 3b and 4a vs 4b are from same data and differ only in the conversion factor from TL to CL. Although the large range of values for California (63.6-78.3 mm CL) may reflect some degree of natural variation, it may also be caused by differences in how total lengths (TL) were measured in early studies (i.e, Wilson 1948, Lindberg 1955, Backus 1960) and different methods used to convert these total lengths to carapace length (CL) by Engle (1979) and Kay (2011). Due to these inconsistencies, and the time elapsed since initial SAM observations, renewed estimates of SAM in California may be prudent. (Note: 3 ¼ inch legal size = 82.5 mm).**

3.3 Reproduction

Mating in *P. interruptus* occurs when a male places a putty-like spermatophore on the sternum of a female (Figure 3-1). These females are termed "plastered." The spermatophore is durable and can remain in place for months, which allows females to store sperm until eggs in their gonads are fully developed and ready to be fertilized (Ayala, 1983). Plastered females are common from January-May, but are most abundant from February-April (Figure 3-3; Mitchell et al., 1969; Bodkin and Browne, 1992). Females use their hind walking legs to scratch open the spermatophore, which fertilizes eggs as they are extruded. These females then attach the eggs under the pleopods.

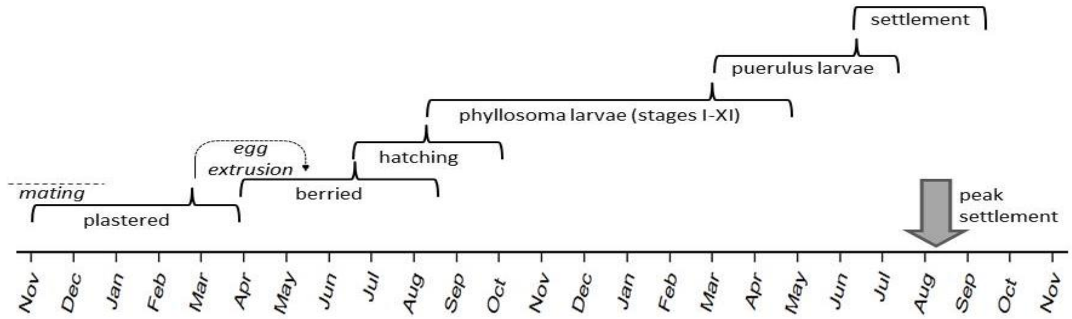

Figure 3-3: Timing of reproduction, larval development, and settlement for CA lobster (*P. interruptus*).

Females with eggs on their tails are referred to as "berried", and are commonly found in California from late April-August and are most abundant June-July (Figure 3-3, Mitchell et al., 1969; Bodkin and Browne, 1992). The time of year at which CA lobster can be found berried depends on factors such as latitude (Pineda-Barrera et al., 1981) and temperature (Vega, 2003b). Females produce one brood of eggs per year (Mitchell et al., 1969; Ayala, 1983; George, 2005).

Pelagic - Of or relating to aquatic organisms that live in the ocean without direct dependence on the shore or bottom.
Plankton - Very small organisms that passively drift with tide and current.
Nearshore - All oceanic state waters within 0-3 miles from shore or less than 100 fathoms deep, whichever is greater.

The total number of eggs carried by individual females (fecundity) increases with female carapace length (Figure 3-4). Lobsters in California carry fewer eggs than individuals in Baja, and this north-south increase in the number of eggs carried was also observed within Baja (Pineda-Barrera et al., 1981). The size at which 50% of female *P. interruptus* in a population are capable of reproduction has been estimated at a number of sites throughout Baja and California. In California, SAM estimates range from 63.5 – 78.2 mm CL, and Baja range from 72.5 mm - 72.6 mm (Figure 3-4; Table 3-1; Table 3-2). Egg- bearing females in the 55 – 60 mm CL size range have been encountered (although not common) during the current CDFW MPA Baseline study in southern California, with the smallest observed size being 53mm CL (Hovel et al., 2015).

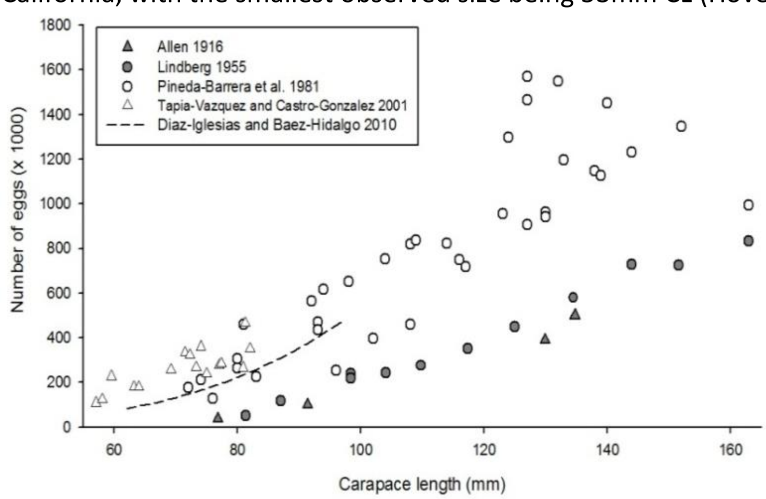

Figure 3-4: Fecundity of CA lobster (*P. interruptus*) from a number of studies throughout its range. Taken from Kay, 2011. *Observations of Lindberg (1955) and Allen (1916) are from California. Pineda-Barrera et al. (1981) and Tapia-Vazquez and Castro-Gonzalez (2001) sampled in Baja. Diaz-Iglesias and Baez-Hidalgo (2010) report an equation (but no raw data) of the relative fecundity, which is the number of eggs that produce healthy swimming larvae, for ovigerous females collected from multiple sites in Baja. (note: legal size = 82.5 mm CL)

3.4 Larval Biology and Dispersal

After an incubation period of approximately 8-9 weeks, developing embryos hatch from the eggs on the female's tail and enter the water column as free swimming (**pelagic**) larvae called phyllosoma (Johnson, 1956). Phyllosoma are flattened, transparent, and 1-2 mm long (4-5 mm including appendages) when they hatch. They then pass through 11 different stages of development and attain a body length of 26-32 mm (Johnson, 1956; Mitchell, 1971). Phyllosoma spend 7-8 months drifting with ocean currents and feeding on **plankton** (Mitchell, 1971; Dexter, 1972) then transform into a puerulus stage that closely resembles adults (Johnson, 1960a). The pueruli settle on **nearshore** reefs then molt into juvenile lobsters (Parker, 1972). The duration of the puerulus stage is estimated at 2-3 months, and settlement in California occurs from June-October with a strong peak in August (Figure 3-3; Parker, 1972; Serfling, 1972; Serfling and Ford, 1975a). The same general timing has been observed in Baja (Guzman del Proo et al., 1996). The arrival and "landing" of pueruli upon a potential habitat surface is referred to as settlement. Because peak hatching and settlement in California both occur in August, newly settled lobsters are assumed to be 1 year old upon settlement (Parker, 1972; Engle, 1979).

Table 3-2: Age at sexual maturity and legal size for CA lobster (*P. interruptus*).

Age at maturity*		Age at legal size		Source	Region	Method
M	F	M	F			
4-5	5-6	7-8		Lindberg 1955	California	lab, LF, molt
5	7	11	10	Mitchell et al. 1969	California	LF
3-4	5-6			Serfling 1972	California	lab, LF
5-6	8-9	11	13	Odemar et al. 1975	California	Tag
		8		Ford and Ferris 1977	California	lab, tag
		8-10		Bodkin and Browne 1992	California	Molt
3	5	4	7	Ayala 1976	Baja	unknown
4.5	6	6.5	8.5	Guzman del Proo and Pineda 1992	Baja	unknown

As reported from previous studies and adapted from Engle (1979). Methods used to determine ages include: laboratory study of captive individuals (lab), analysis of length-frequency data (LF), tag-recapture studies (tag), and molting frequency x molt increment (molt).
***sexual maturity for CA studies = 58 mm CL (M), and 70 mm CL (F); (Lindberg 1955, in Engel 1979); sexual maturity for Ayala (1976) = 65 mm CL**

While the center of the geographic distribution of the CA lobster is located around central Baja California, the SCB population is currently managed as an independent stock. The strong southward California Current usually prevents a large number of larvae from being transported north of Point Conception (Pringle, 1986). Other features within the SCB such as the Southern California Eddy and the deep Davidson current can help retain the larvae within the U.S. border (Johnson, 1960a; Mitarai et al., 2009; Figure 3-5). Features such as the Ensenada Front and the Baja California upwelling maximum tend to block the northward transport of larvae from the geographic center of CA lobster's distribution (Parrish et al., 1981; Selkoe et al., 2007).

Studies of CA lobster genetic population structure generally find high gene flow suggesting well mixed larvae. Iacchei et al. (2009) sampled the mitochondrial DNA of CA lobsters in California and Baja Mexico and found high gene flow and some significant structure but with little relationship to spatial pattern. Their results suggest a well-mixed population with the potential for some areas to self-recruit and they propose that the California lobster population is less reliant on larvae from Mexico than previously thought. Later Iacchei et al. (2013) used microsatellite markers and again found high gene flow and significant population structure but no correlation with distance among sample locations. However, higher kinship rates within sample sites than among sample sites suggested that larvae are not always mixed and may either self-recruit or remain in cohesive groups during the pelagic phase, particularly where currents are driven by high upwelling intensity. While this study provides evidence of some potential for self-recruitment, the frequency with which cohorts of larvae remain in cohesive groups until settlement and whether source and sink sites are consistent through time is unclear. Sites with the highest levels of kinship were within Baja.

Another study examined recruitment dynamics and genetics of two fish species (kelp bass (*Paralabrax clathratus*) and California sheephead (*Semicossyphus pulcher*)) that also have core ranges located within Baja California. Recruitment did not improve significantly in the SCB even when northward current flowing from Baja was particularly strong (Selkoe et al., 2007). The same study concluded that the genetic makeups of the SCB subpopulations of the two species suggest that they are not a sink population of the core Baja population (Selkoe et al., 2007). This information, coupled with records of phyllasoma being found hundreds of kilometers offshore (Koslow et al., 2012), suggest that recruits are kept within the SCB and are well-mixed between different parts of the SCB. While mixing across the US-Mexico border certainly occurs, it likely does not dominate CA population dynamics.

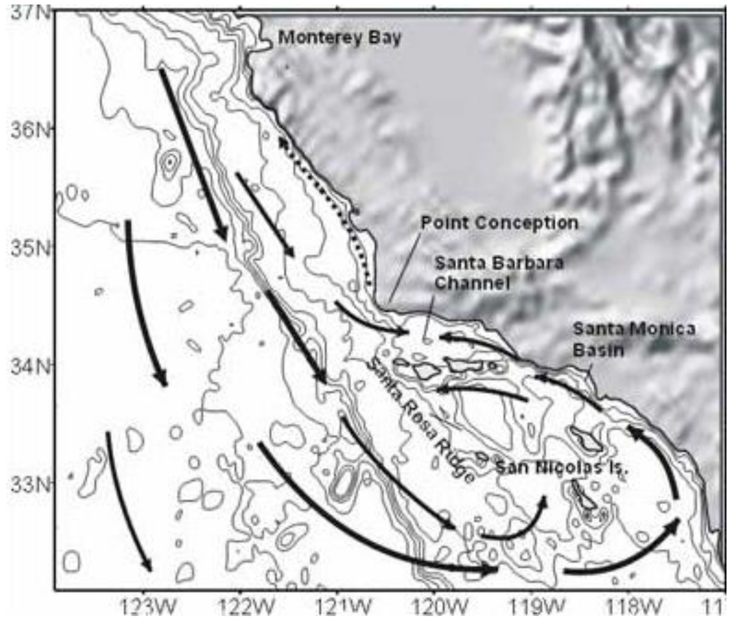

Figure 3-5: A simplified diagram of the North-South California Current, the South-North Seasonal Counter Current, and the resulting Southern California Eddy that help retain planktonic larvae of various marine species within the SCB. Credit: UCLA Nazlin lab.

3.5 Pathology

Spiny lobsters in the family Palinuridae do not harbor many naturally occurring diseases (Shields, 2011). However, a large diversity of disease-causing agents have been isolated from tissues of spiny lobsters held at artificially high densities (e.g., market pens) or from individuals subject to excessive handling or poor environmental conditions (Evans, 2000). Causative agents of these diseases include bacteria, viruses, fungi, and protozoans (Evans, 2000; Shields, 2011). The *Panulirus argus* virus 1 (PaV1) is one notable disease that is lethal to juvenile *P. argus* throughout the Caribbean (Behringer et al., 2010). Presently no disease epidemic, such as the withering foot syndrome found in abalones, is known to affect wild CA lobster.

Lobsters are known to accumulate the toxin domoic acid, which is produced by the diatom *Pseudo-nitzschia*. This microscopic alga is common and seasonally abundant in coastal waters. Domoic acid accumulates in the bodies of animals that filter diatoms and other food particles from seawater (e.g., mussels, scallops, etc.); these animals are preyed upon by CA lobster. Domoic acid can be concentrated in lobster and crab organs, but is typically less concentrated in the muscle tissue (e.g., meat of the tail, legs, and antennae). For this reason, it may at times be safe to eat lobster tails and not viscera when Pseudo-nitzschia blooms are present but consumers should check with authorities (https://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Shellfish.aspx).

3.6 Movement

Nocturnal - Relating to, or occurring at night.
Physiological - Of or relating to the normal functioning of an organism.

CA lobsters exhibit two general types of movement: **nocturnal** foraging and seasonal inshore-offshore movements. Foraging involves nightly movements across spatial scales that range from 1-1,000 m (3.3 – 3,281 ft), with the average distances being closer to 10-250 m (33-820 ft) (Stull, 1991;

Hovel and Lowe, 2007; Withy-Allen and Hovel, 2013). One study recorded an average nightly forage distance (±1 SE) of 143 ± 10 m (469 ± 32 ft) for an individual, with a maximum distance of 475 m (1,558 ft) and a minimum distance of 48 m (157 ft) per night (Withy-Allen andHovel, 2013). Many recreational divers, hoop netters, and commercial fishermen target CA lobster during these nightly forays because they are often easier to find and capture.

The cumulative distances moved by CA lobsters making relatively short distance foraging movements could result in longer displacements across MPA boundaries with important implications for MPA effectiveness for CA lobster conservation. Measurement of CA lobster home ranges helps to indicate whether nightly movements are additive, resulting in long distance dispersal, or if lobsters move in a more circular pattern returning to a place of origin on subsequent nights. In the La Jolla Ecological Reserve, individuals were found to maintain small home ranges of between 651 m^2 (0.16 ac) and 5,912 m^2 (1.46 ac) per week, based on the area in which an individual had 50% and 95% chance of being found, respectively (Hovel and Lowe, 2007). Furthermore, individuals tend to retain site-fidelity after each forage trip, often returning to the same general geographic feature (i.e., a particular rock formation or kelp bed) as opposed to the same exact shelter (Hovel and Lowe, 2007). These results indicate that MPAs may result in increased survival rates for CA lobsters within their boundaries.

Seasonal inshore-offshore movement is characterized by occupancy of shallow reefs in summer and fall months, when surface waters are relatively warm and storm activity is low, followed by movement into deeper water with the arrival of winter swells, storms, or colder surface waters (Mitchell et al., 1969). The **physiological** advantages of moving into warm shallow water include faster growth (Engle, 1979) and accelerated egg development (Mitchell, 1971). The timing and intensity of cues that initiate movement out of shallow water have not been rigorously studied. Studies suggest that female CA lobsters tend to exhibit more seasonal movements, potentially due to the need to seek optimal spawning locations (Kelly,2001; Withy-Allen and Hovel, 2013).

3.7 Predation and Defense

Many predators prey on juvenile CA lobster (Table 3-3), the most common of which are California sheephead, cabezon (*Scorpaenichthys marmoratus*), rockfishes (*Sebastes* spp.), kelp bass, giant sea bass (*Stereolepis gigas*), and octopus (especially the two-spot octopus, *Octopus bimaculata*). Fish predators of adult lobsters tend to be the larger individuals such as male California sheephead and giant sea bass. Southern sea otter (*Enhydra lutris nereis*) may also become an important predator in the future, and continued range expansion of sea otters could have serious effects on the CA lobster fisheries (Odemar et al., 1975; USFW, 2005). As of 2014, the southern limit of the otter range has not expanded, and the most recent survey suggests that the southern boundary of the species' range may have retracted slightly (USGS, 2014).

Lobsters encountered in open areas (e.g., while feeding at night) often attempt to flee by repeatedly flapping their tails, which propels them backward and away from perceived threats (Nauen and Shadwick, 1999; Nauen and Shadwick, 2001). Spiny lobsters encountered in their shelters often withdraw to the interior of the shelter, or flee through exit holes at the rear of shelters. If escape is not possible, spiny lobsters may attempt to defend themselves by orienting their bodies and antennae directly towards the predator (Herrnkind et al., 1975; Zimmer-Faust and Spanier, 1987; Spanier and Zimmer-Faust, 1988, Loflen and Hovel, 2010; Figure 3-6). This is especially common at the entrance of shelters, where many individuals can block the entrance by forming a phalanx with this posture. Right after a molting event, a lobster's antennae and exoskeleton remain soft for about one week. During this time lobsters are especially susceptible to predation and tend to limit movements that increase the risk of being eaten (Mitchell et al., 1969).

Figure 3-6: CA lobsters (*P. interruptus*) inhabiting dens in the natural environment, displaying typical posture with antennae directed outwards and in gregarious groupings (left panel).

3.8 Prey

CA lobsters typically forage at night, when they exit the relative safety of their shelters and actively search for food (Allen, 1916; Lindberg, 1955; Roth, 1972; Engle, 1979; Zimmer-Faust et al., 1985; Stull, 1991). CA lobsters are often described as **scavengers**, but they also function as predators and grazers (Table 3-4). CA lobsters routinely attack live prey such as mussels (Robles 1987, 1997), snails (Engle, 1979; Schmitt, 1982; Schmitt, 1987), and sea urchins (Tegner and Dayton, 1981; Tegner and Levin, 1983; Eurich et al., 2014). Common food items routinely observed during field observations and laboratory experiments in gut and fecal contents include bivalves, echinoderms, small crustaceans, gastropods, and corraline algae (Table3-4).

Scavengers – Animals that feed on dead or decaying organisms.

Table 3-3: Predators of CA lobster (*P. interruptus*).

Predator	Predation event observed/studied	CA lobster in gut contents of predator	Anecdotal
CA Sheephead	1[T], 4	1, 4,6*	3, 4, 5, 6
Moray eel	1[T]	4*	1, 4, 3, 6
Giant (black) sea bass		1*	3, 4
Octopus	2, 6, 7[T]		1, 3, 4, 6
CA lobster			3
Southern sea otter			8, 9
Horned shark			5
Leopard shark		4*	4
Cabezon	6[j], 7*	4, 7*	4, 6
Rock fish (Sebastes)		4, 6[j,]*	4
CA scorpion fish (sculpin)	6[j]	4	4
Kelp bass		4, 6*	6
Black surfperch		6[p]	
Spotted kelpfish	6[j]		
Smoothhound shark	7*		

Studies are divided into three categories: those in which predation was observed or studied in the field ("Predation event observed/studied"), those in which stomach contents of predators were examined ("*P. interruptus* in gut contents of predator"), and studies in which predation was mentioned from second-hand or anecdotal accounts ("Anecdotal").
X*= observations reported but were not first-hand
X[T] = lobsters in traps mutilated when these predators co-occur in trap
6[j] = very small juvenile lobsters preyed upon
6[P] = newly settled pueruli preyed upon
([1]Allen 1916; [2]Maddox 1933; [3]Wilson 1948; [4]Lindberg 1955; [5]Mitchell et al. 1969; [6]Engle 1979; [7]Winget 1968; [8]Odemar 1975; [9]USFW 2005)

CA lobster diets vary with age and size. Juveniles spend their early years in surfgrass while adults frequent habitats associated with hard-bottom. Habitats and food types can vary by locations, even for sites that are close to each other (Winget, 1968). Foraging distance increases as an individual grows (Tegner and Levin, 1983; Ling and Johnson, 2009) and therefore can also affect what prey items are available to a given lobster. A CA lobster's size is itself a limitation of what it can eat. For example, Eurich et al. (2014) found that smaller individuals had difficulty breaking through the test (external shell) of large urchins, whereas larger CA lobsters are more capable of consuming these prey. The interaction further depends on the population density (CA lobster and urchin) and the prey quality, as CA lobsters prefer healthy urchins from kelp-beds over urchins with limited gonad tissue found in urchin barrens (Tegner and Levin, 1983; Ling and Johnson, 2009; Eurich et al., 2014).

Table 3-4: Prey items of CA lobster (*P. interruptus*), categorized by three study types.

Prey Item	Gut/Fecal			Field			Lab		
Mollusca	C[4,5]								
Bivalves	C[7,8]								
mussels (*Mytilus)*	C[3,9]			C[2,9-12,14]		E[13]			E[20]
Gastropods	C[3,7,8,9]			C[6,14]		E[13]			E[17,18]
Echinoderms	C[4]	R[5,7]							
Sea urchins	C[3]			C[15]		E[13]	C[16]		E[21]
Sea cucumber									E[19]
Crustaceans	C[4,5,7,8,9]								
P. interruptus	C[3]		E[1]						
Crabs	C[3,9]								
Bryozoans		R[3,4,5,7,8]							
Polychaetes	C[3]	R[5,7,8]				E[13]			
Hydroids		R[3]							
Sponges		R[3,4,5,7]	E[1]						
Eggs	C[4,5]								
Fish	C[4,8]	R[3,4]	E[1]						
Squid									E[20]
Foraminiferans		R[5,8]							
Coralline algae	C[3,4,5,7]	R[8]							
Surf grass	C[4,7,8]	R[4,5]							
Other algae	C[4,9]	R[3,4,7,8]	E[1]						

("Gut/Fecal" = gut and/or fecal content analysis; "Field" = field observations; "Lab" = lab observations). For Gut/Fecal studies, prey are reported as common (C) or rare (R) in samples. For field observations, prey were indicated as commonly attacked (C) or rarely attacked (R). For lab experiments, prey that were preferred in choice experiments are noted as commonly (C) preferred or rarely eaten (R). Also reported are prey that were observed to be eaten (E) in situations for which there was no measure of preference or frequency.

([1]Allen 1916; [3]Lindberg 1955; [4]Winget 1968; [5]Engle 1979; [7]Castaneda-Fernandez de Lara et al. 2005; [8]Diaz-Arredondo and Guzman del Proo 1995; [2]Fry 1928 (in Wilson 1948); [6]MacGinite and MacGinite 1949; [9]Robles 1987, 1997; [10]Robles and Robb 1993; [11]Robles et al. 1990;[12]Robles et al. 2001; [13]Zimmer-Faust and Case 1982; [14]Schmitt 1982, 1987; [15]Tegner and Dayton 1981; [16]Tegner and Levin 1983; [17]Shabani et al. 2007; [18]Kicklighter et al. 2005; [19]Eckert 2007; [20]Diaz-Iglesias et al. 2011; [21]Eurich et al. 2014)

3.9 Ecosystem Role of CA Lobster

The interactions between CA lobsters and their prey are considered direct effects because the action of one species (i.e., predator) directly affects another species (i.e., prey). Through direct predation, CA lobsters have been found to limit the **abundance** of the top snails (*Tegula aureotincta* and *T. eisinia*) in cobble and rocky reef habitats (Schmitt, 1982; Schmitt, 1987). CA lobsters have also been found to limit the density and size of mussels (*Mytilus californianus*, *M. galloprovincialis, Septifer bifurcatus*) and gastropods (snails) in rocky intertidal habitats at Catalina Island (Robles, 1987; Robles et al., 1990; Robles, 1997; Robles et al., 2001). In addition, CA lobsters are thought to limit the local abundance of red and purple sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) on reefs in southern California (Tegner and Levin, 1983; Lafferty, 2004).

CA lobster predation can also trigger indirect effects in marine ecosystems. The most clearly demonstrated indirect effect of lobster predation in marine ecosystems involved predation upon intertidal mussels. Robles and Robb (1993) observed that as CA lobsters preyed upon intertidal mussels, red algae were able to colonize and grow in the empty spaces previously occupied by the mussels. In this case, CA lobster predation upon mussels indirectly influenced the abundance of algae.

Abundance - The total number of animals in a population. This is rarely known, but usually estimated from relative abundance although other methods may be used.
Biomass (B) - The total weight of organisms at a given point in time in a defined stock, area, population, or catch.

As previously stated, CA lobsters are thought to limit the local abundance of red and purple sea urchins on reefs in southern California. Urchins are herbivores that consume algae and kelp. In southern California, the **biomass** of giant kelp (*M. pyrifera*) can be inversely related to urchin abundance (Ebeling et al., 1985; Arkema et al., 2009) or the intensity of urchin grazing (Harrold and Reed, 1985). Therefore, CA lobster can impact giant kelp indirectly by releasing it from urchin grazing and thus enhancing the persistence and extent of kelp forests (Dayton and Tegner, 1998; Jackson et al., 2001; Dayton, 2003; Graham, 2004; Lafferty, 2004; Halpern et al., 2006; Eurich et al., 2014).

3.10 Regional Differences in Lobster Biology and Ecology

Both commercial log data and the collaborative at-sea sampling program (CASP) (Yaeger et al., 2015) demonstrate that the average size of CA lobsters increases along a south to north gradient within the SCB. There are likely multiple reasons for this relating to both fishery dynamics and biology. As noted in Section 2.1, fishing effort is not equally distributed. The particularly high fishing effort and catch off Point Loma in San Diego likely contributes to reduced average lobster size. Mean CPUE for legal-sized CA lobster across whole fishing seasons has generally not been significantly different among regions of the SCB during the last three fishing seasons (Yaeger et al., 2015). This suggests that fishing effort may be well matched to abundance. However, CPUE for legal-size lobsters declines more sharply across the season in the southern region of the SCB. Additionally, the northern Channel Islands are relatively difficult to access and local MPAs had been in place for almost 10 years at the time of CASP sampling, possibly contributing to lower fishing pressure and greater average size in the region.

Biological explanations for differences in average size include temperature, habitat quality, and recruitment patterns. Higher temperatures are known to increase lobster growth rates elsewhere (Pecl et al., 2009). This does not explain larger lobster sizes in the northern region of the SCB where temperatures are typically colder. However higher temperatures are known to increase lobster activity and catchability (Ziegler et al., 2003, 2004). Therefore larger sizes in the north may relate to decreased vulnerability to harvest, giving lobsters more time to grow before eventually being captured. Hovel et al. (2011) also observed generally increasing CA lobster sizes at southern sites within the SCB and measured a significantly higher growth rate at Laguna, CA where average size was highest. These findings suggest complex interactions between fishing effort and several environmental factors influencing growth and vulnerability. Abundance of sub-legal CA lobsters is greater in the southern regions (Yeager et al., 2015) indicating higher recruitment, as might be expected due to proximity to the center of the species geographic range.

There are potentially regional differences in reproductive dynamics across the SCB although differences are not well understood. Several aspects of CA lobster reproductive biology were found to correlate with environmental factors in Baja California, Mexico (Vega 2003b). Rates of spermatophore deposition on females were found to be correlated with low SST and strong upwelling while egg laying and hatching were accelerated in response to increasing summer temperatures. Variation in these environmental characteristics is likely to similarly influence reproduction in the SCB. SAM may also vary with latitudinal temperature gradients. Differences in sex ratio and/or trap vulnerability among regions may also affect regional reproductive output. CASP data did not find consistent differences among regions in the sex ratio of legal-size individuals in traps. However, significantly more female sub-legal CA lobsters were captured in all regions and all sampling years (Yaeger et al., 2015). This greater vulnerability of females to traps has important implications for the effects of fishing on reproduction. Areas with high fishing effort and thus repeated capture and release of sub-legal females will induce relatively more stress on those females. Melville-Smith and de Lestang (2007) demonstrated a reduction in Australian western rock lobster fecundity due to handling stress.

3.11 Climate Change Impacts on CA Lobsters

Climate Change (CC) is a shift in global climate pattern characterized by increasing global air and ocean temperatures in most regions, widespread melting of snow and ice, and rising global average sea level (IPCC, 2013). These widespread environmental changes have been attributed to the emission of greenhouse gases (GHG), such as carbon dioxide (CO_2), methane, and nitrous oxide brought on by industrialization. While atmospheric methane and nitrous oxide are significant contributors to climate change, CO_2 is currently considered to be the primary contributor. A more detailed discussion on CC background mechanisms are presented in Appendix V.

Various CC effects will likely impact the CA lobster fishery. Sea surface temperature (SST) in the SCB is predicted to rise (NOAA, 2012). Warmer atmospheric temperature may also change the **upwelling** and circulation pattern of the region (Bakun, 1990; Pisias et al., 2001; Snyder et al., 2003; Bakun et al., 2010; Rykaczewski and Dunne, 2010). CC can also lead to more intense storms and increased runoff along the southern California coast (IPCC, 2013). Lastly, it is widely believed that increasing atmospheric CO_2 concentration will continue to acidify the ocean (Caldeira and Wickett, 2003; Royal Society, 2005; Pecl et al., 2009). Figure 3-7 illustrates the various factors (A-F) and pathways that CC can impact the CA lobster fishery. It is important to note that CC is an incredibly complex phenomenon. While scientists can make reasonably accurate predictions on big picture changes, predicting on a smaller geographic scale (e.g., SCB) is still challenging (IPCC, 2013) (See also Appendix V).

Warmer SST in the pelagic environment may lead to better survivorship, and growth in the SCB. As for fishery effects of CC, warmer coastal environments may make adult CA lobsters more active and easier to capture (Pringle, 1986; Koslow et al., 2012). Furthermore, since California is at the northern edge of the lobster's current domain range, higher SST could extend the population northward. Conditions such as **El Niño** (see Appendix V), which leads to warmer water along the California coast, could provide episodic transport of larvae north from Mexico which could also increase harvest (Pringle, 1986).

Upwelling - On the California coast, upwelling is the upward movement of deep waters into the nearshore ecosystem due to springtime winds moving the topmost layers of water away from land.
El Niño - A periodic warming of the ocean surface waters in the eastern Pacific Ocean. It is characterized by a lack of upwelling of cold, nutrient-rich waters nearshore.

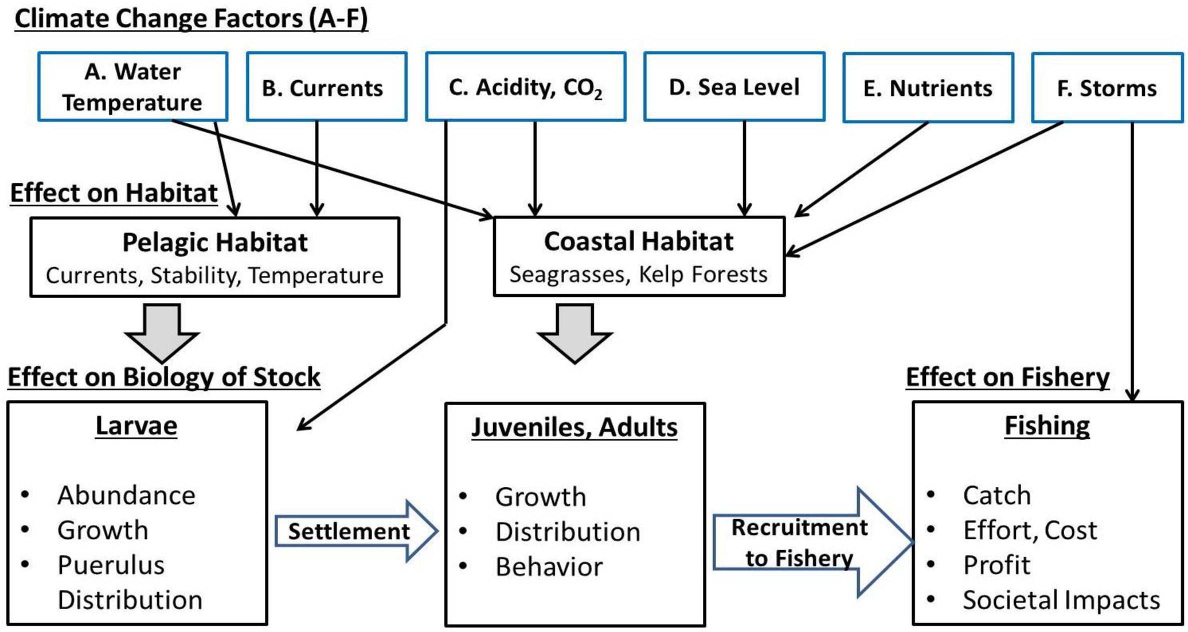

Figure 3-7: Schematic showing relationships between Climate Change variables (labeled A-F), habitat, lobster biology, and the fishery. Further topics listed within the individual boxes are specific variables that are expected to change under CC. Credit: Dr. K. Hovel, San Diego State University

As SST increases, species typically found off Baja California could begin to occur with greater frequency within the southern California kelp forests. Such changes have already been observed in some kelp forests (Field et al., 1999). Kelp itself may be impacted by increasing SST and reduced nutrients. It is unclear at this point exactly how kelp forests will respond to warming SST, but the effect is likely negative (Steneck et al., 2002). Likewise, CA lobster, being more subtropical, may or may not be directly (i.e., physiologically) affected by increasing SST. However, there may be an increased likelihood of disease with higher water temperatures. For example, the bacterial epizootic shell disease found in east coast lobster stocks has been linked to higher water temperature (Glenn and Pugh, 2006).

Whether CC would intensify upwelling in southern California or suppress it is still subject to ongoing scientific debate (B and E, Figure 3-7) (Bakun et al., 2010; Rykaczewski and Dunne, 2010). Weaker upwelling leads to declines in **zooplankton** abundance (Roemmich and McGowan, 1995) and a decrease in CA lobster larvae food sources. Stronger upwelling can increase the CA lobster larvae food sources, but it can also change the dispersal and recruitment pattern of the stock in the open ocean (Gaylord and Gaines, 2000; Connolly et al., 2001) (B, Figure 3-7). Harley et al. (2006) suggested that increased upwelling may decrease the populations of some **benthic** species such as lobsters by moving potential recruits offshore and away from suitable habitats. This is probably more applicable to regions north of Point Conception and would thus act to inhibit northward settlement of the lobster. Sea level rise will lead to coastal inundation and increased coastal erosion, especially during more intense storms and high tidal periods (D, Figure 3-7). Coastal erosion can lead to silting of coastal habitats, in particular seagrass beds used for settlement and adult foraging. Even in areas that will not experience intense silting, seagrass beds would still be sensitive to changing light wavelengths brought about by increased turbidity and changing water depth (Moore et al., 1997).

Zooplankton - Small animals passively carried along with water currents and other water movement.
Benthic - On or relating to the region at the bottom of a sea or ocean.

More intense storms combined with increased nutrient runoff (E and F, Figure 3-7) can also damage or completely destroy seagrass beds. This would reduce the amount of suitable habitat for lobster puerulus settlement, resulting in fewer successful recruits. Similarly, kelp beds could be damaged or destroyed at more frequent intervals, thereby disrupting adult lobster habitat and its immediate ecosystems (Pecl et al., 2009). In addition, more intense storms could also hinder fishing activities and damage deployed lobster traps.

Lastly, CC may also lead to a more acidic ocean (C, Figure 3-7). Water corrosive enough to dissolve seashells has been observed off California and is expected to become more frequent (Feely, 2008). The types of organisms potentially affected include snails and mussels, corals, and many phytoplankton species. It is unclear if there will be any direct adverse effects on lobster (Pecl et al., 2009). Many crustaceans, including the American Lobsters on the east coast, are able to resist acidifying ocean water (Ries et al., 2009). However, even if CA lobsters can maintain their protective shells in a more acidic environment, there would still be adverse impacts. Compensating for the corrosive effect of carbonates requires significant energy that would otherwise be used for reproduction and growth (Long, 2013). Additionally, calcified CA lobster prey such as urchins and bivalves could be impacted leading to cascading effects on CA lobster growth and survival.

4. Measures for Conservation and Management of the CA Lobster Fishery

The primary goal of fishery management under the MLMA is sustainability (FGC § 7050(b), § 7056). The MLMA and the Master Plan define sustainability as:

a) Continuous replacement of resources, taking into account fluctuations in abundance and environmental variability.

b) Securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining biological diversity, and, in the case of fishery management based on maximum sustainable yield, taking in a fishery that does not exceed optimum yield (FGC § 99.5).

CDFW aims to sustainably manage the CA lobster fishery through a **harvest control rule** (HCR) that consists of 3 reference points, an HCR matrix, and a toolbox of 8 regulatory options.

4.1 Overfishing, Sustainable Yield, and Overfished

The MLMA's mandates for sustainability are closely tied to the concept of **overfishing** as defined by the Fish and Game Code. Fish and Game Code section 98 defines overfishing as "a rate or level of taking that the best available scientific information, and other relevant information that the commission or department possess or receives, indicates is not *sustainable* or that jeopardize the capacity of a marine fishery to produce the maximum sustainable yield on a continuing basis [emphasis added]." Other types of overfishing refer to economic and ecosystem effects of harvest in addition to more specific effects on a stock. These include:

> **Harvest control rules (HCR)** -Harvest control rules are plans of action that prescribe adjustments in harvest regulations (e.g. fishing effort, total allowable catch, minimum legal size) and are activated ("triggered") when the calculated amount of a resource that can be taken (the defined upper limit, also known as "threshold reference point") is reached or surpassed.
> **Yield per recruit (YPR)** - A theoretical value that describes the yield to a fishery that is contributed by a given number of recruits (usually a single recruit).

Recruitment overfishing: Fishing that depletes the mature adult population (spawning stock) to a level at which reproduction is inadequate to replenish the population (Sissenwine et al., 1987).

Growth overfishing: Fishing in which **yield per recruit** is lower than theoretical maximum values due to the harvesting of small and rapidly growing fish (Diekert, 2012).

Economic overfishing: Level of fishing effort that exceeds **maximum economic yield (MEY)** (Flaaten, 2010).

Ecosystem overfishing: Level of fishing that creates significant adverse impact to the species diversity, trophic composition, and productivity of an ecosystem (Murawski, 2000).

These different types of overfishing each present their own threats to sustainability. **Recruitment overfishing** is a threat to the biological sustainability of a fishery; this type of fishing activity is most commonly linked to collapse of fish stocks. In contrast, economic and **growth overfishing** can be biologically sustainable, but reduce the economic and social sustainability of a fishery. Finally, ecosystem overfishing threatens the integrity of the larger ecosystem, which is ultimately essential for the conservation of the stock as well.

Maximum economic yield (MEY) - The maximum possible revenue after accounting for the costs of fishing that may be achieved in a fishery. MEY typically is reached at smaller catches than MSY.
Instantaneous Fishing mortality (F) - The rate at which organisms are harvested or killed due to fishing; F is an instantaneous rate that reflects the rate at which a proportion of a population is being lost, whereas the harvest rate (*u*) is an annual rate that reflects the rate at which a number of fish from a population is being lost.
Maximum sustainable yield (MSY) - In a marine fishery, means the largest catch that can be taken from a stock continuously over time that does not result in a continuing reduction in stock abundance, assuming constant environmental conditions. MSY is generally presented as a maximum annual catch that can be maintained indefinitely; however, MSY can change with fluctuations in abundance and environmental variability (e.g. shifts in ocean regimes), requiring adjustments in allowable harvest.

Each type of overfishing is associated with a particular harvest rate. Fishery scientists usually describe the rates at which fish are removed from a stock with two types of measurements. The first and more intuitive measurement is the *harvest rate* (*u*), which is the proportion of all legally harvestable fish that are taken in a fishing season. Values for harvest rates can range from 0-1. For example, harvest rates of 0, 0.5, and 1 indicate that none, half, and all of the harvestable fish are taken every season, respectively. The second measurement is the **instantaneous fishing mortality rate** (*F*), which can be calculated directly from the harvest rates (and vice-versa). Unlike *u*, *F* is described in the less intuitive log space and comports better with complex scientific calculations used in fisheries models.

The total harvest from each season is considered the fishery yield, and together with harvest rates and sustainability objectives form interrelated metrics for evaluating the fishery (Figure 4-1). An extremely low harvest rate will result in a low

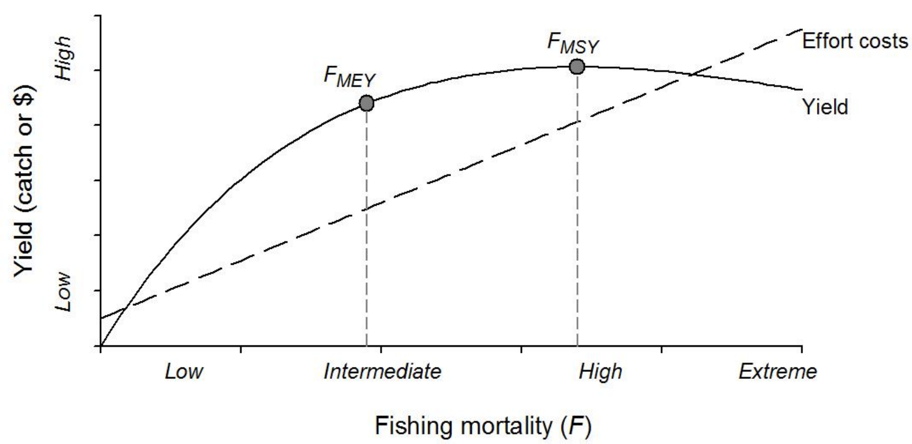

Figure 4-1: The general relationship between fishing mortality (or harvest rate) and fishery yield (solid curved line). Also shown is hypothetical effort cost (diagonal dashed line). The fishing mortality that produces maximum economic yield (F_{MEY}) can be visualized as the fishing mortality at which the distance between the yield curve and the effort cost line is greatest.

fishery yield which may not satisfy the economic and social sustainability objectives of the fishery. As harvest rates increase, fishery yield also increases. But once the harvest rates increase beyond a stock's ability to regenerate itself, growth and recruitment overfishing may occur which would drive down the yield of the fishery. For a fishery under equilibrium conditions, the total harvest that equals the stock's ability to regenerate is called the **maximum sustainable yield** (MSY), and the fishing mortality rate associated with this yield is referred to as F_{MSY}.

Any fishery would also have an MEY. Any amount of fishing effort (e.g., # of traps fished, days at sea) has costs associated with a number of factors (e.g., additional fishing gear, bait, fuel, crew days). Consequently, the cost of fishing increases as effort and harvest rate increase (diagonal dashed line in Figure 4-1). Due to this increase and the dome-shaped relationship between harvest rate and fishery yield, there is usually a mortality rate (F) at which a fishery achieves MEY, or F_{MEY}. A fishing mortality rate that exceeds F_{MEY} represents economic overfishing. F_{MEY} is almost always lower than F_{MSY} (Flaaten, 2010). Thus, a harvest rate that is biologically sustainable may still lead to economic overfishing and undermine the economic objectives of a fishery.

A high harvest rate can also undermine the environmental objectives set forth by MLMA if fishing leads to habitat damage, unacceptable bycatch levels, and/or trophic disturbance. For example, if CA lobsters are fished to an extent that they are no longer able to control the urchin population, overgrazing of kelp forests by the urchins may occur. The loss of kelp may then negatively impact the resilience of the CA lobster stock (Section 3.9). Academic researchers have begun to tackle the task of quantifying ecosystem overfishing over the past several years (Murawski, 2000; Methot et al., 2013).

In addition to overfishing, the MLMA also requires CDFW to define the criteria for when a fishery is considered "**overfished**" (FGC § 7086). Under the MLMA, "[if] a fish population is depressed, and the principle means for rebuilding the population is reduction of take, then the fishery is to be classified as overfished" (FGC §97.5). A fishery is "**depressed**" when "a declining population trend has occurred over a period of time appropriate to that fishery" (FGC § 90.7).

It is important to note that the term overfished refers to the status of a fish stock, while overfishing refers to the activity of fishing and describes fishing practices in which too many fish are removed. When only a relatively small proportion of an available stock is being harvested (low harvest rates), overfishing is unlikely and **stock size** typically remains high (not overfished). When a relatively high proportion of an available stock is being harvested (high harvest rates), the risk of overfishing increases, and the stock is more likely to drop below a level that would classify it as being overfished.

Overfished - A stock that is at unacceptably low levels because it has experienced overfishing and has not been rebuilt.
Depressed fisheries - The condition of a fishery for which the best available scientific information and other relevant information that the Commission or Department possesses or receives, indicates that a declining population trend has occurred over a period of time appropriate to that fishery. With regard to fisheries for which management is based on maximum sustainable yield, or in which a natural mortality rate is available, "depressed" means the condition of a fishery that exhibits declining fish population abundance levels below those consistent with maximum sustainable yield.
Stock Size – Total estimated number or biomass of fish within a stock.

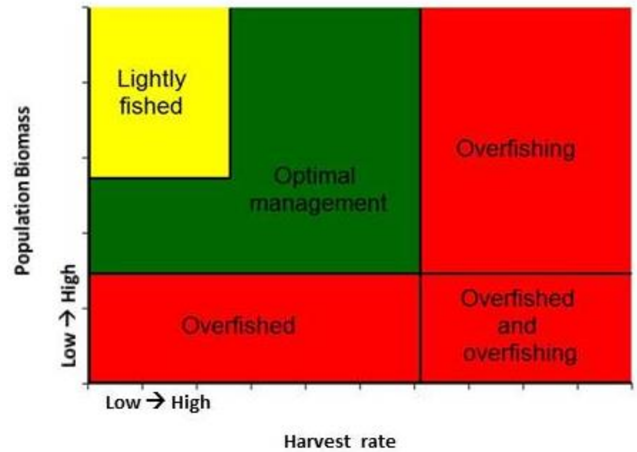

Figure 4-2: The general relationship between harvest rate and stock size.

Furthermore, an overfished stock is not always being subjected to overfishing, and vice-versa. Consider, for example, a **depleted** stock that is closed to fishing. After fishing stops, the harvest rate falls to zero, but until stock biomass rebuilds, the stock remains overfished. This condition would be represented by the lower left-hand region of Figure 4-2 (low harvest rate and low biomass). Paradoxically, during the period when a newly emerging fishery is fished down to levels associated with the MSY the fishing rate appears to be unsustainable, because there is no surplus production in an unfished stock. However, surplus production increases as biomass approaches MSY, and sustainability is achieved if the harvest rate matches surplus production, despite that same harvest rate being responsible for fishing the stock down from unfished biomass. A stock would not be considered "overfished" until the stock size suffers a dramatic decline (upper right-hand portion of Figure 4-2), to levels significantly below the biomass associated with MSY. The designations of overfishing and overfished ultimately depend on the sustainability objectives of the society.

4.2 Introduction to Harvest Control Rules

Many fishery managers around the world are moving towards adopting dynamic HCRs as their means of achieving MEY and MSY as well as avoiding overfishing and facing overfished stocks. HCRs are a type of management framework that "formulate[s] a procedure for making harvest policy decision[s]." It does so by "identify[ing] a pre-agreed course of management action as a function of identified stock status and other economic environmental conditions" (WCPFC, 2012). The HCR framework here is comprised of five fundamental components (Figure 4-3):

1) Harvest regulations
2) Data collection
3) Data Analysis
4) Reference point(s)
5) HCR matrix

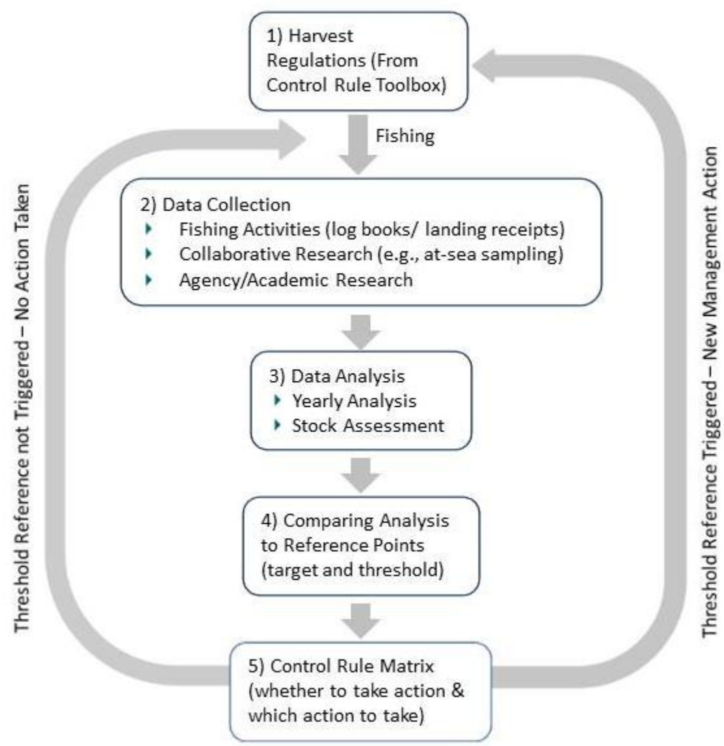

Figure 4-3: The relationship among the five elements of a general fishery management framework.

4.2.1 Harvest Regulations

Harvest regulations are the rules that define how fishermen are allowed to harvest fish. These regulations typically take one of three specific approaches for ensuring sustainability: (I) managed escapement (used exclusively in salmon fisheries); (II) use of a dynamic time scenario (e.g., common when a stock is tied to extremely variable environmental conditions or when high bycatch is a problem), and; (III) manage for a sustainable harvest rate (Figure 4-4, modified from NRC 1998). The goals of these approaches are the same: to ensure fishery sustainability by avoiding overfishing and to achieve recovery when a stock is overfished.

For most fisheries, management with escapement goals or a dynamic time scenario is inappropriate or logistically impossible (NRC, 1998). The more practical alternative is to manage for a harvest rate that maintains relatively high fishery yield without causing overfishing. Broadly speaking, there are three types of harvest regulations: biological regulations, effort-based harvest regulations, and catch-based harvest regulations (items IIIa-c in Figure 4-4).

Harvest regulations - The rules that define how fishermen are allowed to harvest fish. Harvest regulations are diverse and include restrictions on size of animals harvested, effort, total catch, gear types, season, or location where fishing is permitted.

4.2.1.1 Biological Harvest Regulations

Biological harvest regulations directly protect some portion of a stock and buffer it against recruitment overfishing and growth overfishing. Common biological regulations include legal size limits (minimum and maximum), sex-based regulations, seasonal closures, and spatial restrictions (e.g., MPAs) (Figure 4-4, item IIIa).

Minimum legal size (Min LS) protects rapidly growing young fish, some of which may be reproductive. A Min LS can prevent recruitment overfishing only if it is larger than the size at which fish first start reproducing. A Min LS can prevent growth overfishing only if it protects rapidly growing young animals.

Maximum legal size (Max LS) is intended to protect large animals that have high fecundity and buffers against recruitment overfishing. Max LS may also have ecological and/or market benefits. A management framework that employs both a Min LS and Max LS is often referred to as having a "slot" or "over/under" size limit.

Sex-based regulations are designed to safeguard the reproductive output of females with the assumption that remaining males present in a fished population can successfully fertilize all the available eggs. Fishermen may only be allowed to harvest male animals (male only fishery) larger than the size at sexual maturity, as is the case for the US west coast Dungeness crab fishery.

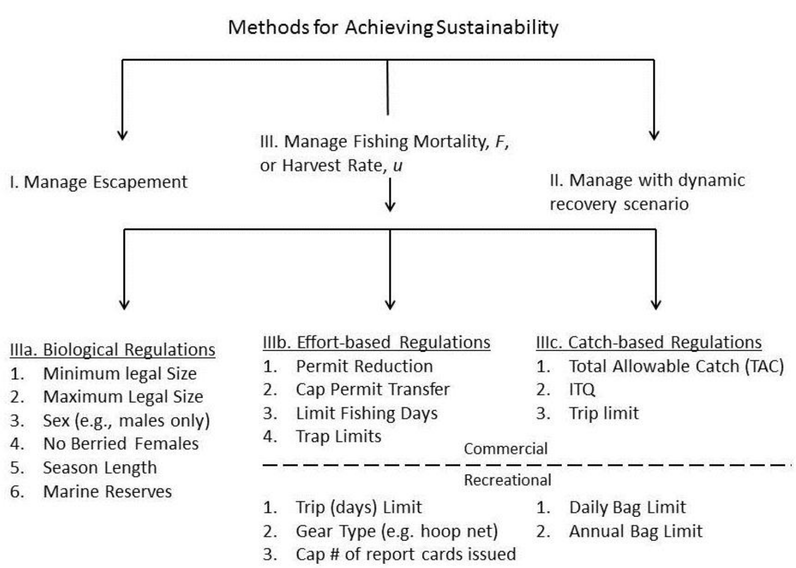

Figure 4-4: Methods for achieving fishery sustainability, including the three types of harvest regulations for harvest rates.

Alternatively, a fishery can prohibit the landing of berried females (females that are carrying eggs), as in the Atlantic USA/Canada fishery for American lobster *Homarus americanus*. These two examples serve to mitigate the impact of fishing on the **spawning potential** of the stock.

Area closures prohibit all or some fishing activities in prescribed areas. Heavily fished lobster populations around the world tend to show rapid increases in biomass, average size of individuals, and abundance inside closed areas (Diaz et al., 2011; Moland et al., 2013).

Spawning Potential – The reproductive output (# of eggs) that may be produced during the lifetime of an average female.

Seasonal closures act as biological regulations when they protect animals during the reproductive phase of their life cycle – such as the closure of the CA lobster fishery during summer in California. Seasonal closures also reduce total annual effort (see *Effort-based regulations*).

4.2.1.2 Effort-Based Harvest Regulations

Whereas biological regulations serve to lessen the impact of fishing on the population dynamics of a stock, effort-based regulations protect the portion of the stock that is vulnerable to harvest (legally harvestable). This can help prevent recruitment overfishing and growth overfishing, but can also prevent economic overfishing when increases in effort (and harvest rate) begin to provide diminishing return in terms of yield (i.e., the flattened part of a yield curve, Figure 4-1).

Limited Entry programs limit the total number of participants in a fishery.

Capping permit transfers (e.g., an annual limit) can limit the activation of latent **capacity** in a fishery, thereby avoiding abrupt increases in effort.

Seasonal closure does not have to correspond to a targeted species' life cycle; instead, it can serve to only control fishing effort by defining a maximum number of days per year that an individual can fish.

Gear limits define a maximum amount of gear (i.e., traps or hoop nets) a fisherman can use.

Gear type regulations generally restrict the use of gears that destroy habitat or catch portions of the stock protected with biological harvest regulations. They may also protect immature individuals (i.e., escape ports) or reduce bycatch mortality (i.e., excluder devices in trawls, or barbless hooks for salmon). These regulations can also control the harvest rate by prohibiting new gear types that increase harvest efficiency. However, it is important to note that gear type restriction can impose economic inefficiency on fishermen.

4.2.1.3 Catch-Based Regulations

As with effort-based regulations, catch-based harvest regulations serve to protect the portion of the stock that is vulnerable to harvest (legally harvestable).

Daily **bag limit** is a daily limit on the number or weight of fish that a recreational fisherman may legally retain.

Annual bag limit is an annual limit on the number or weight of fish that a recreational fisherman may legally retain.

Total allowable catch (TAC) is the total catch that can be taken during each fishing season. A TAC works by protecting a fraction of the stock

Capacity - The potential ability of a vessel or a fleet of vessels to capture organisms. This ability is based on the number of fishing vessels in the fleet, the size and technical efficiency of each vessel, time spent fishing, and management regulations.
Bag limits - The total amount of fish or other species that may be captured per person per day by law.
Individual transferable quota (ITQ) - A program which limits the catch allowed per license or individual as well as the number of individuals who participate.

that is large enough to ensure sustainable reproduction, which stabilizes catches and associated economic output of the fishery from year to year. In TAC fisheries, catch is often monitored during the season, and managers usually close the fishery once the TAC is reached, although in-season catch projections may allow the use of less disruptive regulatory measures if taken before reaching the TAC. In some fisheries, the TAC for an upcoming season is adjusted in response to recent trends in some reference indicator such as catch per unit effort (CPUE) or recruitment. Adjustment can also occur in response to going over or under the TAC in the previous season. Federal fishery management plans are required to establish a mechanism for specifying an annual catch limit, which is a form of a TAC (16 USC § 1853(a)(15)). Federal managers are required to take actions whenever an annual catch limit is exceeded (50 CFR §§ 600.310(f)(2)(iv), (g)(3)).

One limitation of TAC is that it does not prevent the “race to fish”, a dynamic in which fishermen competitively attempt to catch fish before other fishermen catch them. In fact, a TAC can accelerate the race to fish because it shrinks the portion of fish available for harvest. In response, fishermen often invest in tools that provide a competitive advantage such as faster boats, more traps, and better technology – an effect known as “capital stuffing” (Copes, 1986).

Individual transferrable quota (ITQ) is a dedicated portion of a TAC. In TAC fisheries, the race to fish and capital stuffing can be addressed with a quota system like ITQ (Costello et al., 2008). Quotas grant fishermen exclusive access to some fraction of a TAC. A quota system can also lead to additional economic benefits by allowing fishermen to focus fishing during periods of peak market price or spread fishing activities out over a longer period of time to avoid market gluts. The key incentive with quota management is that fishermen can wait to harvest their “share” of the catch. Individual transferable quotas (ITQs) are a common form of quota that may be transferred among fishermen. Transferable quota systems are designed to balance fleet dynamics by allowing for more flexible fishing operations. ITQs require focused monitoring and enforcement, which can add to management costs.

4.2.2 Data Collection

Data collection gathers information that directly informs the stock assessments and management decisions (Figure 4-3). The MLMA stipulates that FMPs employ the best available scientific information (FGC § 7050(b)(5)). This is referred to as **essential fishery information** (EFI), which includes information about species life history, habitat requirements, status and trend of the population, fishing effort, catch level, fishery’s effect on the fish population, and “any other information related to the biology of a fish species […] in the fishery that is necessary to permit fisheries to be managed [sustainably]” (FGC § 93; Section 5.2, 5.3).

EFI is gathered by CDFW from a number of fishery-dependent (e.g., commercial logbooks and recreational report cards) and fishery-independent sources (e.g., research programs conducted by agency staff, academic staff, or NGOs). Information from logbooks, landing receipts, and report cards are confidential (FGC §§ 1050.6, 8022(a)). CDFW is increasingly interested in developing collaborative programs bringing fishermen together with scientists associated with academic institutions or NGOs to increase the quality and quantity of data collected (NRC, 2004; Section 5.3).

Essential fishery information (EFI) - With regard to a marine fishery, means information about fish life history and habitat requirements; the status and trends of fish populations, fishing effort, and catch levels; fishery effects on fish age structure and on other marine living resources and users; and any other information related to the biology of a fish species or fishery that is necessary to inform management.

Thresholds (reference point thresholds) – For the purpose of this FMP, the levels of stock size or reproductive potential, or fishing mortality rates that are not sustainable.

4.2.3 Data Analysis

Raw data have limited management value until they are analyzed, which may be a formal stock assessment or a less formal analysis. A stock assessment integrates a diverse range of EFI to evaluate the status of a fish stock, including past and current stock levels, and includes information to help guide future harvest rate. A stock assessment can provide a clear picture of the present condition of a stock (i.e., is it *overfished*?) and the impacts of current harvest practices (i.e., is *overfishing* occurring?). CDFW will determine how often, or when, to perform stock assessments for the CA lobster based on availability of new data or updates, and response time of the stock to changes in the environment or the fishery.

4.2.4 Fishery Management Reference Points

Analyzed data must be placed into the context of policy/value judgment. For example, a drop in catch level should trigger management actions only if a relevant statutory/regulatory mandate or a manager deems it important. This is where a **threshold reference point** comes in. Threshold reference points signal when a stock would require management attention. Many HCRs used for other fisheries use a single reference point (e.g. biomass) but distinguish three levels or threshold types termed target, trigger and limit reference points. These divide the range in stock status into healthy, overfishing, and overfished zones. This "precautionary approach" was outlined by the United Nations Fish Stock Agreement of 1999 and was adopted by the Canadian government (DFO, 2006) among others.

Frequently reference points are based on the concept of MSY. They are specified relative to the fishing mortality level that produces MSY (F_{MSY}) or the stock biomass level at MSY (B_{MSY}). MSY may be calculated using dynamic models with detailed stock-recruitment information when it is known. Examples include the non-parametric production model developed by Sissenwine and Shepherd (1987) and dynamic pool models used by Shepherd (1982) and Mace (1994). Many fisheries do not have the data resources required for these models and therefore MSY proxies are used. For example, the Canadian precautionary approach suggests that B_{MSY} may be replaced with the average biomass (or index of biomass such as catch or CPUE) over a productive period. This may be considered a B_{MSY} proxy or simply an alternative fishery indicator as suggested by Sainsbury (2008).

Alternatively, "empirical reference points" are not model based and are based on directly observable properties of a stock (Sainsbury, 2008). Unconventional empirical reference points that need not be based on MSY include a desirable recruitment level (Shepherd et al. 2001), particular size or weight distributions (Punt et al., 2001), or presence/absence within portions of the stock's range (Hobday et al., 2004). While these measures do not require a model for their derivation, it may be advisable to use complex modeling for identification of appropriate targets and limits (Sainsbury et al., 2000). This will be an ideal use for the CA lobster Management Strategy Evaluation (MSE) model once fully developed (see Section 4.6).

Whenever a stock reaches a reference point threshold, resource managers must investigate the cause and potentially provide a response. A number of specific reference points are used in spiny lobster fisheries around the world and are described below: i) stock size; ii) total catch each season; iii) CPUE; iv) harvest rate (fishing mortality); v) YPR/SPR; and vi) recruitment indices.

i) Stock size

Estimates of stock size measure how a stock has been impacted through fishing and whether or not the stock is overfished or is at risk of becoming overfished. A common metric for stock size is B/B_0, which is the current biomass (B) divided by the virgin stock biomass (B_0). Other measures of stock size may refer to the number of fish present, the total spawning biomass, or the biomass that is available to the fishery.

ii) Catch (total catch per season)

Since stock assessments are costly to conduct, catch trend over time can instead serve as a tentative proxy for relative stock size. A significant change in catch can always be susceptible to multiple interpretations. However, the fact that a significant change in catch appears is itself a clear indicator that, at a minimum, an impact at a biological, ecological, or anthropogenic level is occurring.

Using total catch as a proxy for stock size can be misleading when factors other than stock size influence the number of fish captured. For example, changes in water temperature in southern California may influence the activity level of lobsters on the seafloor, and in turn alter their catchability (the probability that an individual will be captured in fishing gear). Such behavioral changes are not necessarily accompanied by changes in stock size, but they may influence total catch and therefore the perception of stock size. Regulatory changes that alter the access or efficiency of fishermen (and therefore catch rates) can similarly impact total catch.

iii) Catch per unit effort (CPUE)

CPUE is used by fishery managers in two important ways. First, it serves as a proxy for the relative abundance of fish in an area. This proxy assumes that there is a relationship, though not necessarily a linear one, between the condition of a stock and the rate at which they are captured under any given unit of effort (e.g., time spent fishing, amount of gear deployed). As with total catch, long-term trends in CPUE can provide insight into changes in the stock, which will influence management decisions.

In addition, CPUE is also very useful for tracking the optimal effort level and detecting economic overfishing. An example of this is found in management zone “CRA8” of the New Zealand fishery for *J. edwarsii* (Bentley et al., 2005). The lobster stock in this zone was classified as overfished, and a CPUE-based rebuilding plan was proposed. The objectives of this CPUE-based plan were (among others) the restoration of spawning biomass as well as the maintenance of high catch rates that ensure economic viability (Bentley et al., 2005).

CPUE data are relatively inexpensive and easy to collect, but they can be influenced by factors other than fish abundance (e.g., new regulations, environmental variability, catchability, and selectivity). CPUE-based reference points can also be misleading when advances in technology (e.g., gear construction, vessel electronics) make the fishermen more efficient and the gain in efficiency is not reflected by adjusting the reported unit of effort (e.g., trap pulls, number of traps fished). In such a scenario, fishermen may be perceived to have maintained the same level of effort while in reality their effective effort may have increased substantially. This phenomenon is known as **effort creep**, and is thought to have been an important contributor to the catch/stock declines in fisheries for *Panulirus cygnus* in Western Australia and *J. edwarsii* in South Australia (Bentley et al. 2005; Section 4.4).

Effort Creep - A phenomenon where technology advancements in a fishery are able to mask the declining efficiency of a fishery caused by stock declines

iv) Harvest rate/ fishing mortality

Estimates of current harvest rates (or, fishing mortality) provide information that helps managers maintain fishery yield while avoiding recruitment overfishing and economic overfishing (Figure 4-1).

v) Yield per recruit (YPR)

The yield that a fishery can achieve (i.e., pounds of fish caught; monetary value of fish sold) changes as a function of the harvest rate, and is often expressed in terms of YPR. YPR is the theoretical yield that is produced from a single recruit (or some fixed number of recruits) that is subjected to different harvest rates.

vi) Spawning potential ratio (SPR)

In addition to yield, harvest rate also affects the ability of a stock to replace itself. Because fishing tends to reduce the number and the size of individuals, it has the potential to negatively impact the reproductive output of a population, or spawning potential. The SPR is usually a ratio of the number of eggs produced by a fished population divided by the number of eggs produced by an unfished population. SPR values range from 1-0. For example, SPR values of 1, 0.5, and 0 correspond to harvest rates at which a population can produce all, half, or none of the eggs produced when the stock is unfished, respectively (Figure 4-5). At low harvest rates, SPR values are high because many large animals remain in the population (Figure 4-5). At higher harvest rates, SPR declines and may ultimately reach zero if no size limit is in place to protect at least some portion of the breeding stock. It is important to note that SPR assumes that an unfished population would produce a relatively constant amount of eggs or maintain a relatively constant spawning stock biomass (Rochet, 2000).

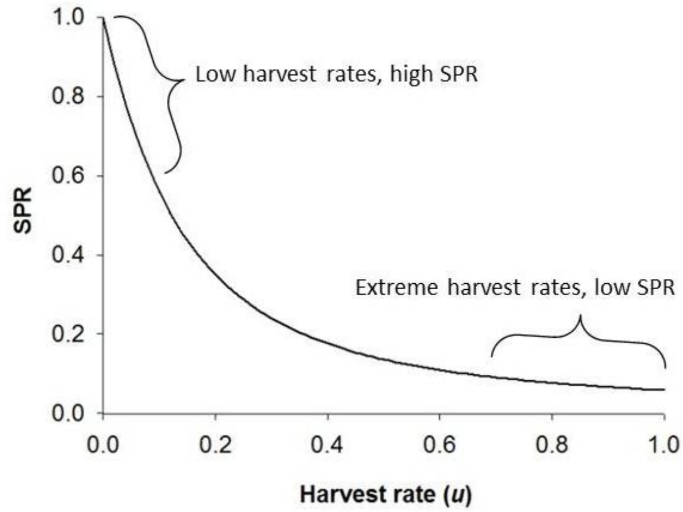

Figure 4-5: The general relationship between fishing mortality (or, harvest rate) and spawning potential ratio (SPR).

Depending on the amount of scientific information available to resource managers, various methods can be used to calculate a stock's current spawning potential, the unfished spawning potential, and an SPR level that is sustainable (Table 4-1). A model is required for calculation of spawning potential, but complexity can range from the simplest methods that scale up from an average weight (as the Cable-CDFW model does), to more complex models utilizing size frequency data, stochasticity and stock-recruitment data. Methods for calculating the egg production or yield of an unfished population in particular vary greatly. For example, the SPR of a hypothetically unfished stock for the Cuban spiny lobster fishery was calculated based on egg production of a theoretical unfished population with the assumption that growth rate and fecundity would be the same whether the individual is in a fished or unfished population (Puga et al., 2005). On the other hand, the SPR of a theoretical unfished Western Australia lobster stock was calculated based on spawning stock biomass with density dependent variables (Hall and Chubb, 2001). Others have empirically measured the egg production of current unfished stocks existing within marine reserves. Although the methods for calculating SPR can vary among different fisheries, the underlying purpose is generally the same: to gauge a fished stock's ability to replenish itself.

vii) Abundance of larvae or recruits

When measured over many years, trends in the abundance of larvae (or very young recruits) returning to a fishing ground can provide indirect evidence of a stock's relative spawning biomass. The abundance of larvae/recruits often varies year-to-year due to environmental conditions, and therefore may not be related to fishing mortality. However, long term trends (e.g., increasing, decreasing, or stable abundance) can inform managers about the reproductive potential of a stock. In some cases, levels of recruitment can be used to forecast future catches (Phillips, 1986) or estimate spawning stock biomass (Lasker, 1985).

Table 4-1: Spawning potential ratio (SPR) used around the world.

Species	Location	$SPR_{THRESHOLD}$	Source	Rationale / Derivation
Panulirus argus	Cuba	0.143	Puga et al. 2005	Replacement line analysis
	USA: Atlantic and Gulf of Mexico	0.20	FMP	Theoretical (Goodyear 1993); empirical (Mace and Sissenwine 1993)
	USA: Atlantic and Gulf of Mexico	0.05	Addison 1997	Not specified; proposed for use in conjunction with recruitment (to the fishery) observations
	USA: Florida	0.05	Bohnsack et al. 1990	Historical levels associated with catch: proposed in FMP
	USA: Caribbean	0.20	Bohnsack et al. 1990	Theoretical (Goodyear 1993)
	USA: Caribbean	0.20	FMP	Not specified, "committee recommendation"
Panulirus cygnus	Western Australia	0.20	Hall and Chubb 2001	Historical performance of fishery
Jasus edwardsii	Victoria, Australia	0.20	FMP	Not specified
	New Zealand	0.20	NRLMG Report 2010	Not specified
Homarus americanus	USA – NE Atlantic	0.10	Addison 1997 Rosenberg et al. 1994	Historical performance of fishery

4.2.5 Harvest Control Rule Matrix

An HCR prescribes management actions (e.g., continue monitoring or implement regulatory changes to the fishery) when a certain reference point is triggered. Responses are required when reference points thresholds are reached or surpassed (Section 4.3). An HCR can consist of a simple relationship between one reference point threshold and one response (e.g., fishery closes when catch drops below a certain level). The precautionary approach prescribes three types of response to three different threshold levels of a reference point. Drastic measures would be taken when the reference point drops below the limit level, more measured responses would be implemented when below the upper stock reference point, and management might be reduced when above the target level. A single regulatory response option might be used such as changes to a TAC. Another HCR approach uses multiple reference points (e.g., Catch, CPUE, SPR, YPR, Fishing Mortality). One form of this approach, termed "traffic light", monitors multiple reference points and the number above or below thresholds leads to different levels of management response (Caddy 2002). The benefits of approaches using multiple reference points and/or a blend of model-based and empirical reference points have been noted by several researchers (Halliday, 2001; Hilborn, 2002; Caddy, 2004; Fogarty, 2004,). Additionally, multiple harvest regulatory options (e.g., Seasonal Closure, Size Limit, Gear Restriction, TAC) can provide the necessary management flexibility to address specific fishery issues. In these types of HCRs, the relationship between triggers and responses (i.e., Harvest Regulations) is complex and interconnected.

A clearly detailed decision matrix is a formal mechanism that guides the appropriate management responses based on the triggering of different reference points. This mechanism provides managers with a pre-determined and transparent decision-making process that preserves scientific and policy decision-making prerogatives.

4.3 HCR for the CA Lobster Fishery

An HCR was developed by CDFW with substantial input from the LAC and independent scientific experts. The associated reference points were also peer reviewed by an external committee of scientific experts (Appendix VII). The CA lobster HCR applies adaptive management by gauging the status of the fishery with specific reference points and tailoring responses when management actions are needed to ensure sustainability and prevent overfishing. It also fulfills the MLMA mandate that requires "each fishery management plan or plan amendment prepared by CDFW shall specify criteria for identifying when the fishery is overfished" (e.g. FGC § 7086(a)).

The HCR is composed of three components. Three specific reference points serve as the metrics to assess the state of the fishery and the CA lobster stock. A Control Rule Matrix details how the reference points will work together to identify an emerging issue within the fishery and its underlying causes. Lastly, a tool box of eight regulatory options gives CDFW and the Commission flexibility to address emerging and ongoing issues. The HCR is not guaranteed to capture every possible issue the fishery will face, and like any other management tool, resource managers will need to exercise independent judgment when using the HCR. In the future, CDFW will explore ways to improve the HCR, such as modifying reference points, or methods for their calculation, to more accurately reflect the status of the fishery and meet the MLMA management objectives. Future improvements may or may not (depending on the type of change) be subject to an amendment process (Section 6.2.2).

Landing receipt - A document provided by the Department to commercial fish markets for recording landing information. Information required includes date, port of landing, species or market category of fish, pounds landed, and price paid.

4.3.1 Reference Points for CA Lobster Fishery

The three reference points chosen for the CA lobster HCR are based upon:

1) Catch (the total catch in a single season)
2) CPUE (the number of legal lobsters caught per trap pull)
3) SPR (# eggs produced by current fished population / # eggs produced by unfished population)

These make use of both model-based and empirical data streams. Total catch ($CATCH_{CURRENT}$) and CPUE ($CPUE_{CURRENT}$) can be calculated directly from landing receipts and commercial logbooks without any change to current CDFW data collection. SPR can be calculated by inputting data from landing receipts and logbooks through computer models such as the Cable-CDFW Model. A single limit threshold separates desirable and undesirable states for each reference point. Designation of the threshold levels for each of the reference points uses an empirical (not model-based) approach by referencing a stable and productive period for the stock. Different combinations of position relative to these reference points can develop a nuanced picture of stock status. For example, decline in catch alone can be caused by decline in stock size, but can also be caused by unrelated factors (e.g., policy change, lower catchability of animals). However, an increase in catch accompanied by a decrease in CPUE may suggest that economic overfishing is occurring. This multiple reference point approach is similar in function to the traffic light fisheries management approach and can result in multiple divisions of stock state (overfished, overfishing, healthy) akin to the precautionary approach. Moreover, the varied information content of the three reference points allows for more tailored management responses than could be justified by a single reference point with multiple levels.

4.3.1.1 Catch-Based Reference Point

The catch-based reference point for a particular season is calculated as follows:

$$CATCH_{CURRENT} = \frac{average\ catch\ for\ 3\ most\ recent\ seasons}{average\ catch\ for\ 10\ most\ recent\ seasons} \qquad (Equation\ 4.1)$$

The catch-based threshold reference point is any value for $CATCH_{CURRENT}$ that is equal to or less than **0.9:** $\boldsymbol{CATCH_{THRESHOLD} = CATCH_{CURRENT} \leq 0.9}$**, (*Equation 4.2)***

It is important to note that this reference point is primarily designed to detect trend. Catch can fluctuate drastically from year to year due to socioeconomic, environmental, and biological factors. These annual fluctuations often do not reflect problems that warrant management responses (Figure 4-6). Averaging the catch from the three most recent seasons for the reference point numerator serves to smooth those fluctuations. The 10-year running average in the denominator of the reference point was chosen because long-term environmental changes might alter our expectations for sustainable catch levels (upwards or downwards). Commercial landings of CA lobster appear to be influenced by warm and cold water regimes driven by the Pacific Decadal Oscillation (PDO) (Neilson, 2011). Fisheries-independent data on lobster abundance based on entrainment in power plant systems does not show a correlation between young of the year or slightly sub-legal lobsters and environmental indices including the PDO (Miller, 2014a). However, increases in abundance and decreases in average size at some power plants after the 1989 regime shift do indicate the potential for recruitment success to be driven by changes in environmental factors at longer time scales (Miller, 2014a). Moreover, the abundance of phylosomal larvae in oceanographic samples from the SCB is significantly correlated with El Nino events, mean sea-surface temperature, and the PDO (Koslow et al., 2012).

In addition to detecting noteworthy trends, initiation of the moving average in the present implicitly values the healthy stock status within the last 10 years. A $CATCH_{CURRENT}$ value of 1.0 would indicate that

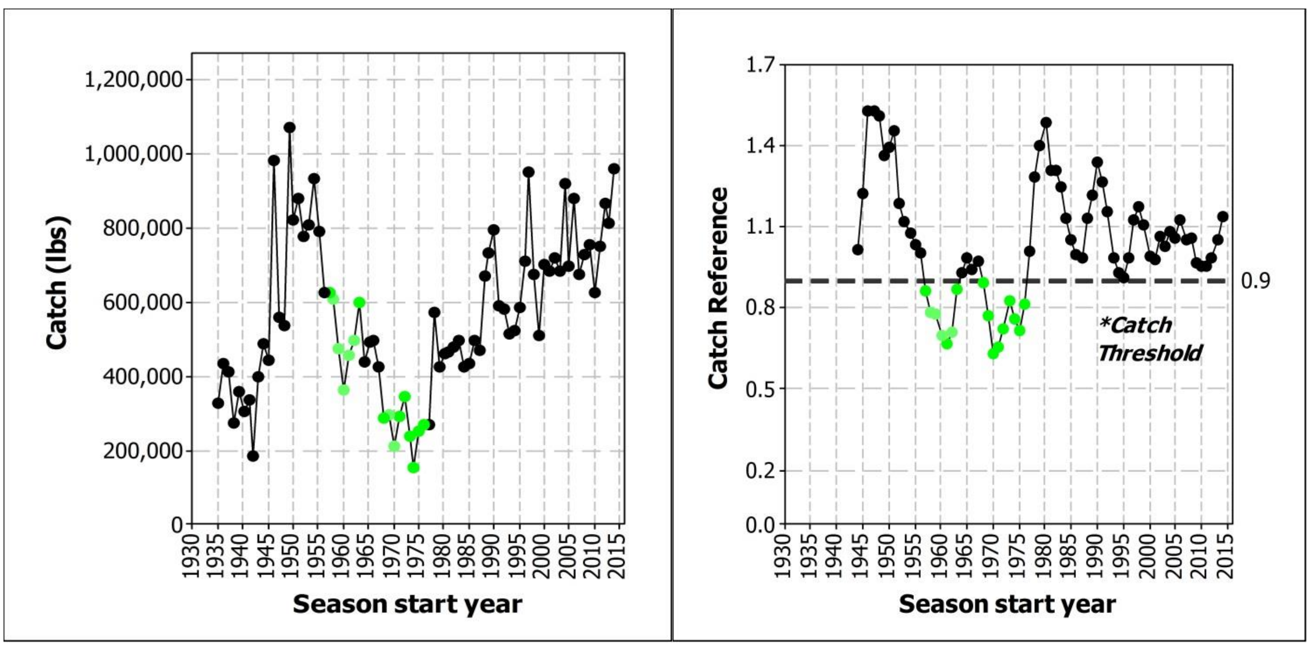

Figure 4-6: Annual catch (left panel) and catch reference values based upon Equation 4.1. With a threshold reference point (CATCHTHRESHOLD) of CATCHCURRENT = 0.9, CATCHTHRESHOLD is exceeded (i.e., catch is conisdered to be low and triggers management consideration) in years where values the right-hand panel fall below the 0.9 value line (represented by green dots). Values at or near 1.0 in the right-hand panel indicate stable catches. Individual years listed (x-axis) are the year in which an individual lobster season began (e.g., 1935 = 1935-36 season).

catches are stable, i.e. catches over the last three years are similar to the last 10 years. Setting the reference point threshold at 1.0 would indicate that the fishery does not want to tolerate any reduction in catch from the current state. However, ideal catch rates will fluctuate from year to year with recruitment variation and catches within 80% of an apparently high stable point (i.e., MSY) are a reasonable expectation for sound management (Hilborn, 2010). Based on the independent science review committee recommendations to make the catch threshold more sensitive and responsive and CDFW analyses, the $CATCH_{CURRENT}$ value was modified from 0.8 to 0.9 resulting in a more sensitive threshold. Reaching this threshold would indicate that catches for the three most recent seasons are less than 90% of the average catch from the 10 most recent seasons, suggesting both a declining trend that warrants consideration and a separation from the high, stable catches of the last 10 years. However, because a reference point based on a moving average may not detect small gradual changes, CDFW will initiate further analysis whenever $CATCH_{CURRENT}$ drops for 6 seasons in a row. $CATCH_{CURRENT}$ declined for 10 seasons in a row during the steep decline of the 1950s and 60s. While the $CATCH_{THRESHOLD}$ of 0.9 would have already been triggered after 6 seasons of that period, future stock dynamics may show slower declines that warrant management action but would not otherwise be detected.
CDFW developed the moving average approach through consultation with several lobster fishery experts during the LAC process (Dr. Ray Hilborn, Dr. Matthew Kay, Dr. Hunter Lenihan, Dr. Richard Parrish, and Dr. Jeremy Prince). An examination of California's catch history also indicates that a $CATCH_{THRESHOLD}$ of 0.9 would have provided warning of major declines in catch performance in the modern era of this fishery and appropriately, would not trigger management during rebuilding phases or catch levels likely reduced by environmental regime (Figure 4-6). The most recent $CATCH_{CURRENT}$ value for the 2014/15 season is above the 0.9 threshold.

4.3.1.2 CPUE-Based Reference Point

The CPUE-based reference point for any season ($CPUE_{CURRENT}$) is calculated in the same manner as $CATCH_{CURRENT}$:

$$CPUE_{CURRENT} = \frac{average\ CPUE\ for\ 3\ most\ recent\ seasons}{average\ CPUE\ for\ 10\ most\ recent\ seasons} = 0.9 \qquad (\textit{Equation 4.3})$$

The CPUE-based threshold reference point is any value for $CPUE_{CURRENT}$ that is equal to or less than 0.9:

$$CPUE_{THRESHOLD} = CPUE_{CURRENT} \leq 0.9 \qquad (\textit{Equation 4.4})$$

The rationale for using the value of 0.9 (originally proposed at 0.8) is based on recommendations from the independent science review committee to make the CPUE threshold more sensitive. Using a moving average is based on input from experts and stakeholders through the collaborative LAC process, which determined that a moving average of CPUE would signal important adverse change (e.g., economic overfishing) within the fishery that may warrant management consideration. CPUE data has only been available since 1973 (Figure 4-7), but retrospective analysis of $CPUE_{CURRENT}$ (Figure 4-7) since that time indicates that this threshold is able to detect important changes in the fishery. $CPUE_{THRESHOLD}$ would have been crossed seven times; three sequential seasons in the mid-1990s and the last four fishing seasons on record. Both catch and the number of trap pulls dipped sharply in 1991 and remained depressed for a series of years leading to the $CPUE_{THRESHOLD}$ being crossed. Alternatively, low CPUE and $CPUE_{CURRENT}$ values since 2010 have been the result of a sharp increase in the number of trap pulls while catch has maintained consistently high levels. Effort increase in the 2010/11 season was likely driven by an increase in the price/pound for CA lobster and both have remained high. These instances below $CPUE_{THRESHOLD}$ point to verifiable changes in the dynamics of this fishery relating to fisherman behavior and economics. Different years are below the $CPUE_{THRESHOLD}$ than those that are below the

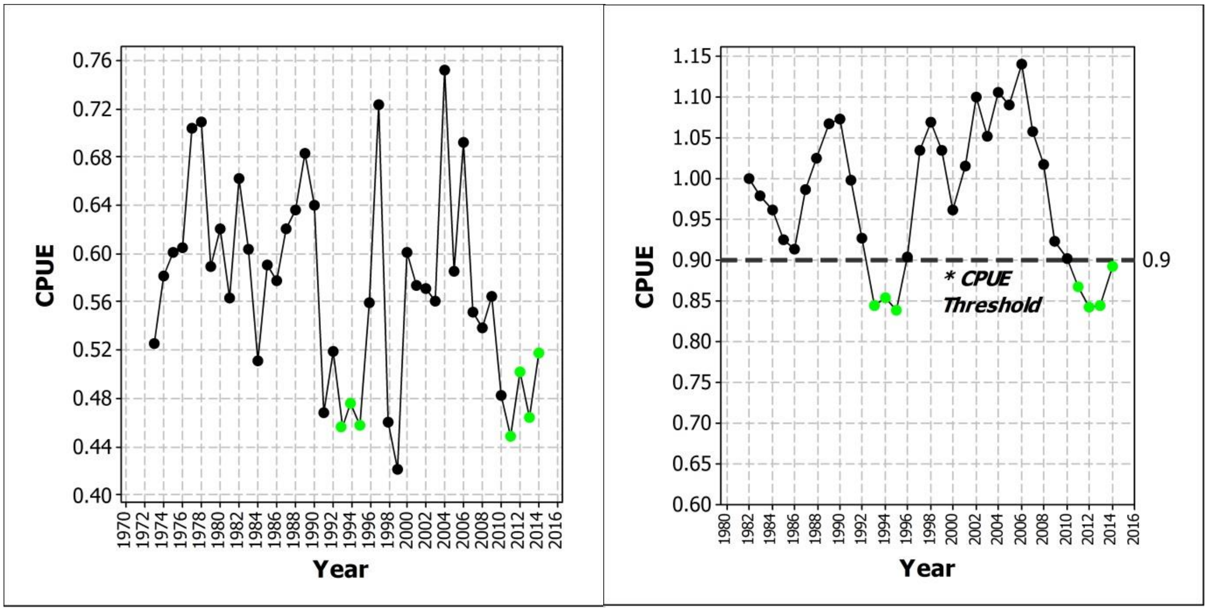

Figure 4-7: Annual CPUE (left panel) and CPUE reference values based upon Equation 4.3. With a threshold reference point (CPUETHRESHOLD) of CPUECURRENT = 0.9, CPUETHRESHOLD is exceeded (i.e., catch is considered to be low and triggers management consideration) in years where values the right-hand panel fall below the 0.9 value line. Values at or near 1.0 in the right-hand panel indicate stable catches. Individual years listed (x-axis) are the year in which an individual season began (e.g., 1970 = 1970-71 season).

$CATCH_{THRESHOLD}$, suggesting that these two reference points are complementary and not redundant. As is the case with the catch reference point, CDFW will initiate an investigation if the $CPUE_{CURRENT}$ drops for 6 years in a row even if the $CPUE_{THRESHOLD}$ is not crossed.

4.3.1.3 SPR Reference Point

The SPR reference point has the most biological information content of the three reference points and thus is the best indicator of the potential for recruitment overfishing. SPR can be calculated in several ways. The method currently employed by CDFW utilizes data from commercial logbooks and commercial landing receipts to calculate the average weight of lobsters caught in a given year. CDFW then relates average weight to a corresponding fishing mortality (*F*) which allows estimation of SPR. This calculation is currently accomplished using the Cable-CDFW Model (Appendix X). SPR is a model **output** based on 46 user-specified inputs, each responsible for the calculation of various biological, economical, and operational characteristics of the fishery. The age-length relationship, for example, incorporates three inputs: $L\infty$, K, and t_0 (the maximum length a CA lobster can biologically attain, the growth rate, and a number that adjusts the initial size of a lobster for the calculation, respectively; Section 3.2). Average weight can be used to estimate the reproductive potential of a stock because it 1) expresses the age of lobsters when removed from the population and thus their number of reproductive seasons before death, and 2) the female size at reproduction dictates fecundity. Methods for calculating the spawning potential of an unfished stock (the denominator of the SPR ratio) vary, as described in Section 4.2.4. The Cable-CDFW uses a theoretical unfished stock without density dependence.

The threshold for the SPR reference point is any current value of SPR that is less than the average SPR calculated for the fishing seasons from 2000/01 to 2007/08. These years were deemed stable and productive by the 2011 CDFW stock assessment and are considered here as "reference" years for calculation of the threshold.

$SPR_{THRESHOLD} = SPR_{CURRENT} < SPR_{REFERENCE}$, (*Equation 4.5)*

A distinction should be made between the calculation of $SPR_{CURRENT}$ and $SPR_{THRESHOLD}$ values in this and other management contexts. Several types of models that allow calculation of $SPR_{CURRENT}$, like the Cable-CDFW model, do not require stock-recruitment data or model-based estimates of MSY. However, analysis of sustainable SPR levels and thus appropriate placement of an $SPR_{THRESHOLD}$ does require stock-recruitment relationship information. In the absence of this data, frequently fisheries managers set $SPR_{THRESHOLD}$ levels by looking to comparable taxa (Mace and Sissenwine, 1993). For example, SPR thresholds used for many other lobster fisheries are based on the calculated value of 0.20 (i.e., 20% of unfished spawning biomass or egg production) commonly used for finfish fisheries (Table 4-1; CFMC, 1990; Mace and Sissenwine, 1993; SAFMC, 1998; DiNardo, 1999;). Crustaceans such as lobster are thought to be able to persist at lower levels than many finfish and the calculations of $SPR_{THRESHOLD}$ for some lobster fisheries with the necessary stock-recruitment data are lower than for most finfish. For example, the $SPR_{THRESHOLD}$ values have been estimated to be 10% for the American lobster fishery off the northeast coast of the United States (Zhang et al., 2012), 14% for Caribbean spiny lobster in Cuba (Puga et al., 2005), and 2.5% for a Newfoundland stock of American lobster (Ennis and Fogarty, 1997).

The approach taken by this FMP is that the $SPR_{THRESHOLD}$ should not be based on calculations for other species or value judgements of other jurisdictions. In the absence of stock-recruitment information and associated production modeling, the reference years for the CA lobster fishery serve to set a threshold that is conservative, empirically based, and specific to a period when the stock and fishery were stable and productive (Neilson, 2011). While the $SPR_{CURRENT}$ and $SPR_{REFERENCE}$ values are model-based, the Cable-CDFW model is a non-dynamic equilibrium model, meaning it does not incorporate environmental variability or a stock-recruitment relationship. It assumes constant recruitment under any exploitation scenario and therefore that any level of exploitation is sustainable and will not lead to recruitment overfishing. Steneck and Wahle (2013) describe why equilibrium modeling was inappropriate for the American lobster fishery and may be inappropriate for other lobster fisheries as well. This draw-back is related to the fact that while the Cable-CDFW model does estimate F, it cannot incorporate stock-recruitment replacement information to estimate F_{MSY}. Therefore the $SPR_{THRESHOLD}$ in this FMP is $SPR_{REFERENCE}$ rather than SPR_{MSY}.

Other methods for calculation of F (and thus SPR) exist and some are capable of incorporating environmental stochasticity and/or variable recruitment including catch curve analysis (Sparre and Venema, 1998; Groeneveld, 2000; Kay and Wilson, 2012), Leslie-Delury depletion models (Leslie and Davis, 1939; Delury, 1947; Restrepo, 2001; Gonzalez-Yanez, 2006) and length-based mortality estimators (Beverton and Holt, 1956; Ault et al., 2005). Those that incorporate the distribution of individual lobster sizes, rather than an overall average size, add additional value and ability to distinguish processes effecting lobster life stages differentially (Muller, 1997; Puga, 2013). However annual length frequency data are not available for CA lobster. It should be noted that current genetic evidence (reviewed in Section 3.3) suggests that CA lobster are well mixed during the larval phase. This suggests that stock-recruitment relationships at sub-regions of the SCB are likely to be weak due to mixing among regions. If mixing between the California and Baja Mexico stocks also weakens the California stock-recruitment relationship, the SPR reference point described here will only serve to describe the effect of fishing on the adult stock and not its potential replenishment. Because of these larval dynamics and their consequences, the Cable-CDFW model equilibrium assumption of constant recruitment may be more reasonable for this stock than for many other invertebrate fisheries.

SPR is also the component in the HCR where the effects of MPAs are factored into the management of CA lobster fisheries. Through the Cable-CDFW Model, CDFW accounts for MPA effects on SPR through six different inputs. These are: 1) the total fraction of the species' habitat covered by the MPA, 2) migration rate into the MPAs, 3) migration rate out of the MPAs, 4) a reduced fishing mortality rate experienced by individuals that cross the MPA boundaries, 5) average length of MPAs, and 6) average distance between MPAs. The model treats all MPAs as if they have reached full maturity and therefore increased survival within simulated MPAs has allowed for the number and size of lobsters inside to reach equilibrium. Only areas that prohibit both recreational and commercial take are considered MPAs. Although recreational-only areas do protect lobster from commerical traps, they receive disproportionately higher fishing effort from the recreational sector (Figure 2-9). Lobster report card data indicates that the majority of recreational fishing effort for lobster is taking place in recreational only areas.

CDFW currently estimates the percentage of lobster habitat protected by MPAs to be 14.6% based on mapped areas and proxies for hard bottom habitats and MPA area. Other habitats used by CA lobster were not included because 1) hard bottom is the CA lobster primary habitat, and 2) other habitat types were not mapped with equal reliability across the SCB. For example, surfgrass habitat mapping only delineates linear segments of coastline with and without surfgrass. The width in the offshore direction is unknown and will vary according to shoreline slope and patterns of water turbidity. Even the relatively well mapped hard bottom habitat is not equally available in all regions of the SCB, so proxy information must be used. Kelp canopy was used as an indication of hard bottom in unmapped areas. However, coverage of the canopy can be different from the extent of the reefs on which kelps are attached. Furthermore, the lack of kelp canopy in an area does not necessarily indicate the absence of reefs. Table 4-2 provides the habitat area known to be hard or soft substrate, the proportion of rocky habitat estimated using kelp as a proxy, and the area that is unknown. During the early 2000s there were only a small number of no-take MPAs (e.g., northern Channel Islands, La Jolla) and using the best available information, CDFW estimates approximately 4.5% of CA lobster habitat at that time was closed to both commercial and recreational fishing. CDFW will continue to incorporate better habitat information as they become available.

Table 4-2: Percentage of bottom area by region from shore to 300 m depth covered by hard, soft, or unknown habitat types and their data sources. North and south mainland regions are delineated by Dana Point.

Region	Substrate	Source	Percent Area
Mainland North	Hard	Coarse	0.2
	Hard	High Resolution	1.3
	Hard	Kelp	1.5
	Soft	Coarse	2.7
	Soft	High Resolution	54.2
	Unknown	N/A	40.2
Mainland South	Hard	High Resolution	9.0
	Hard	Kelp	0.2
	Soft	High Resolution	60.1
	Unknown	N/A	30.7
Northern Channel Islands	Hard	High Resolution	3.9
	Hard	Kelp	3.6
	Soft	High Resolution	43.9
	Unknown	N/A	48.9
Southern Channel Islands	Hard	Coarse	12.7
	Hard	High Resolution	2.6
	Hard	Kelp	4.5
	Soft	Coarse	25.1
	Soft	High Resolution	22.0
	Unknown	N/A	33.0

Because $SPR_{THRESHOLD}$ is calculated as the average of the reference years, annual SPR values fluctuated above and below that average during those years and to the present. The highest SPR value was associated with the highest average weight observed during the 2001-02 season. Average weight was at a minimum during the 2005-06 season but has since been rising and reached a value higher than 2001-02 during the most recent 2014-15 season. SPR has been rising, in part because of rising average weight, but also because of model simulated MPA benefits applied to the 2012-13 season and those that follow. Under current conditions with 14.6% MPA coverage the model provides an SPR enhancement of four to five percentage points over the SPR calculation at the same average weight with 4.5% MPA coverage (Figure 4-8). This improvement reflects the importance of the MPAs to the reproductive potential of the species as well as the insurance they provide against recruitment overfishing. The metric used to measure a stock's reproductive potential should reflect the effects of a management tool designed in part to protect that very stock's reproductive potential. However, it is unlikely that the MPAs, implemented in 2012 as a result of the south coast MLPA process, have actually achieved equilibrium and their full potential. Given that the average weight during the 2014-15 fishing season was above the average of the reference years, $SPR_{CURRENT}$ for 2014-15 was also above $SPR_{THRESHOLD}$ with or without the model benefit from MPAs. CDFW will monitor average weight and SPR closely until further research illustrates substantial benefit of MPAs to CA lobster and that the model-simulated enhancement to reproductive potential is warranted.

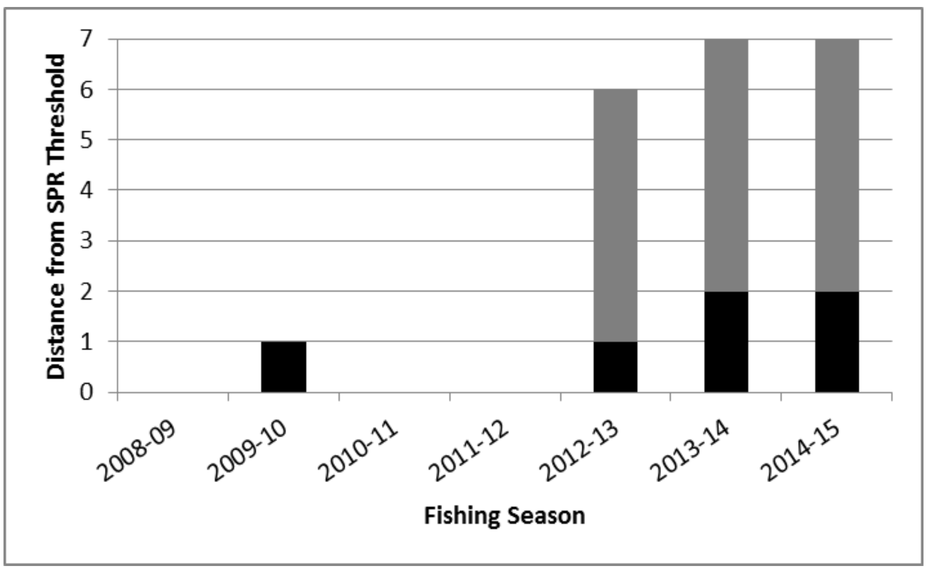

Figure 4-8: Percentage points above SPR threshold with 4.5% (black) and 14.6% (gray) CA lobster habitat within MPAs. Seasons with no bars are equal to SPR threshold.

A current limitation of the Cable-CDFW model is its decreasing sensitivity in estimation of F and SPR as average weight decreases (see Appendix X). Figure 4-9 illustrates an aspect of this issue with the flattening of the curves with increasing F. As average weight declines and F increases, SPR changes little and cannot extend to zero. With MPAs in place, SPR asymptotes at a higher level. The current average weight corresponds to an F estimate where the SPR curve bends and accuracy of SPR estimation is good. The average weight where model accuracy declines depends on input parameters, particularly growth. Collection of age and growth information is a high priority and CDFW will seek to augment and validate existing information and improve the growth parameters and/or update the equations describing growth within the Cable-CDFW model. These refinements will not require amendments to the FMP as they represent improvements in accuracy and not a shift in the Cable-CDFW Model approach (see Section 6.2.2). Additionally, model refinements apply to calculation of both $SPR_{CURRENT}$ and $SPR_{THRESHOLD}$ and therefore represent concurrent improvements to both estimates (see Appendix X).

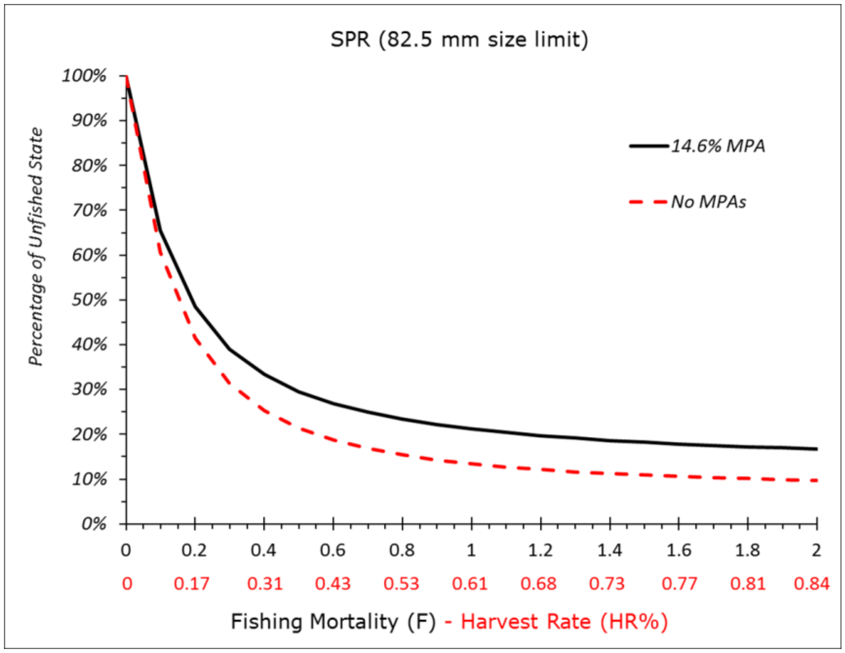

Figure 4-9: Relationship between spawning potential ratio (SPR) and fishing mortality (F) CDFW-Cable Model outputs under conditions with no MPA coverage and 14.6% MPA coverage.

Available CDFW data from logs and landing receipts show that individuals in the northern Channel Islands are notably larger than the minimum legal size, while lobsters in the south are generally caught very close to the legal size. Given equal fecundity and growth and recruitment rates the Cable-CDFW model indicates higher F in the south and lower SPR because southern CA lobsters would participate in fewer spawning seasons before capture. However higher abundance of small CA lobsters in the south may be due in part to higher recruitment and not only a product of higher F. Additionally, CA lobsters in the south may be sexually mature at a younger age and smaller size. Larger numbers of sub-legal CA lobster reproducing at a smaller size may increase SPR in the south and these dynamics would not be reflected in the Cable-CDFW model. Analysis of CAPS data indicates higher reproductive capacity in the south despite smaller average size due to the far greater abundance of sub-legal individuals (Yaeger et al., in prep.). This highlights that the Cable-CDFW model should not be used to compare regionally specific model outputs based on regionally specific average weight without also incorporating regionally specific growth, recruitment rates and reproductive characteristics. Considering that model parameters cannot currently be estimated at local scales and information on population mixing due to the species' protracted larval phase, treating the entire CA lobster stock within the U.S. border with one SPR value is appropriate. Information related to regional differences in the species' biological parameters and in fishery dynamics will need to be improved to better assess the adequacy of using a single SCB-wide SPR value (Section 5.2).

4.3.2 Implementation: HCR Matrix

The three reference points selected to monitor and manage the CA lobster fishery (Catch, CPUE, and SPR) are incorporated into an HCR Matrix. This matrix provides a "dashboard" approach to assist managers in interpreting the status of Catch, CPUE, and SPR reference points in relation to their respective thresholds (Table 4-3). Based on these interpretations, the matrix would prescribe particular courses of action to address the current condition of the fishery. Depending on the respective trend and status of each measurement (i.e., have any of the threshold reference points been exceeded?), the matrix identifies various management strategies ranging from easing harvest regulations, to no regulatory action, to further restricting the fishery.

The HCR is discretionary and not every triggering event will necessarily lead to an immediate regulatory response. Additional evaluation is needed before taking action to determine if external factors (i.e. new regulations, market dynamics, or environmental changes) have caused or contributed to the reference point(s) being exceeded. This process will include consultations with the fishing communities and other

Table 4-3: Harvest Control Rule (HCR) Matrix. Interpretation of different scenarios in which threshold reference points are exceeded, and recommended management responses. Symbols for each reference point are: ↑("safe", does not exceed threshold), and ↓ (exceeds threshold). Note that once *CATCH*$_{THRESHOLD}$ or *CPUE*$_{THRESHOLD}$ are exceeded, monitoring CPUE and Catch trends provides valuable information that managers can use to "fine tune" the fishery or to detect overfishing early (i.e., before the stock becomes overfished).					
Scenario	**Reference Point**			**Interpretation/possible causes**	**Suggested management response sequence**
	CATCH	*CPUE*	*SPR*		
1	↑	↑	↑	○ Stock productivity and fishery performance stable and/or increasing	a) Monitor reference point trends b) Make no change (if reference points are stable or just above thresholds) c) Ease effort regulations (if reference point trends are increasing)
2	↓	↑	↑	○ Fishery under-harvested (i.e., fishing effort and harvest rates are low, could be caused by drop in price or other economic factors)	a) Monitor reference point trends b) Make no change (if CPUE/SPR trends stable/just above threshold) c) Ease effort regulations (if explanations for decreasing catch are not biological and CPUE/SPR trends increasing)
3	↑	↓	↑	○ Catchability down ○ Potential economic overfishing ○ Potential early warning of recruitment overfishing	a) Monitor reference point trends b) No change (if SPR trends are stable/above threshold) c) Effort reduction (if SPR trends declining) d) No change, or ease catch restriction (if catchability is proven to be lower than usual and is causing CPUE decline)
4	↓	↓	↑	○ Catchability down ○ Potential economic overfishing ○ Potential early warning of recruitment overfishing (fewer recruits surviving to adulthood)	a) Monitor reference point trends b) Investigate underlying causes c) Confirm SPR trends and model inputs d) If action is needed, implement one or more of the eight regulatory options in the control rule toolbox as appropriate e) Effort reduction (if SPR trends declining)

Table 4-3 Continued: Harvest Control Rule (HCR) Matrix.

Scenario	Reference Point			Interpretation/possible causes	Suggested management response sequence
	CATCH	*CPUE*	*SPR*		
5	↑	↑	↓	○ Stock overfished ○ Recruitment largely provided from Mexican stock	a) Investigate underlying causes b) Confirm SPR trends and model inputs c) If action is needed, implement one or more of the eight regulatory options in the control rule toolbox as appropriate
6	↓	↑	↓	○ Stock overfished, and ○ Possible catchability increase (effort creep due to technology, etc.)	a) Investigate underlying causes b) Confirm/monitor CPUE (misreporting?) c) Confirm SPR trends and model inputs d) If action is needed, implement one or more of the eight regulatory options in the control rule toolbox as appropriate
7	↑	↓	↓	○ Stock overfished ○ Overfishing indicated	a) Investigate underlying causes b) Confirm SPR trends and model inputs c) If action is needed, implement one or more of the eight regulatory options in the control rule toolbox as appropriate
8	↓	↓	↓	○ Stock overfished ○ Overfishing indicated ○ Disease	a) Investigate underlying causes b) Confirm SPR trends and model inputs c) If action is needed, implement one or more of the eight regulatory options in the control rule toolbox as appropriate

stakeholders. For example, if the triggering of the catch-based reference point coincides with a new effort-based regulation, the first task would be to determine if the triggering event is caused by the new regulation. If it is determined that the triggering event is caused by the new regulation and not biological processes, no further management action may be necessary. In the event that management actions are warranted, the HCR calls for the implementation of one or more of the eight regulatory options provided in the control rule toolbox (Section 4.3.3).

4.3.3 Regulatory Options Linked to the Control Rule

This FMP prescribes a control rule toolbox of eight regulatory options (not in order of rank) that are available to decision makers (Table 4-4) when threshold reference points are triggered, and there is reason to either restrict or ease fishing opportunity. The specific actions in the toolbox are:

1) Change in commercial **trap limit**
2) Change in recreational bag limit
3) TAC
4) District Closures
5) Change in season length
6) Change minimum size limit
7) Impose a maximum size limit
8) Sex selective fishery (Male-only fishery or female-specific size restriction)

Trap limit – A type of regulatory measure that restricts the number of traps a fisherman may fish at any one time within a given season.
Allocation - In the LFMP allocation means a certain amount of lobster set aside for recreational, commercial, and ecosystem needs.

Each of the eight regulatory options in the control rule toolbox carries specific benefits and limitations (Table 4-4) that managers will need to carefully evaluate, including impacts to constituents, level of regulatory change, and duration of regulatory change (i.e., how long it will remain in place). CDFW will consult with the fishing communities and other stakeholders in order to better inform any management recommendation to the Commission on the proper regulatory response.

<u>1) Implementation and subsequent adjustments to commercial trap limit</u>

Relative to fisheries for finfish and other invertebrates, crustacean (crab and lobster) fisheries can sustain more intense harvest rates without rapidly collapsing (Zhang et al., 2012; Ennis and Fogarty, 1997). This resilience against fishing pressure often allows commercial lobster fisheries to remain at high effort levels that can be economically inefficient and unnecessary for maintaining high yield. Over time, such effort level can lead to economic overfishing, and if left unregulated, can lead to recruitment overfishing. Therefore, reducing effort when fishery performance (e.g., CPUE) or stock status (e.g., SPR) is in decline would likely address the root cause of such declines. As specified in Table 4-4, effort adjustment also allows for increases when reference indicators (e.g., Catch, CPUE, SPR) indicate that the fishery is underutilized. A trap limit would directly reduce the number of traps fishermen put in the water.

The CA lobster fishery is not currently regulated by a trap limit. However, recent rise in fishing effort has contributed to recent $CPUE_{CURRENT}$ values below the $CPUE_{THRESHOLD}$ (Section 4.3.1.2) and has led to possible economic inefficiency within the fishing sector (Sections 2.1). Furthermore, an excess of lost traps may create further environmental and social concerns. CDFW has worked closely with its constituents to resolve these issues, and as part of the implementing regulations for this FMP, the CDFW will propose a formal trap limit program that allows the Commission to adjust commercial sector fishing effort (Section 4.4.5). Once the limit is in place the Commission will be able to adjust it as needed based on the HCR.

2) Change in recreational bag limit

An adjustment to the recreational bag limit would serve to control effort in the recreational sector. Adjustment options may consist of daily, weekly, monthly, or annual limits. A bag limit would change the amount of lobsters a recreational fisherman can keep. The MLMA requires any type of **allocation** within an FMP to be equitably shared between the recreational and commercial sectors (FGC § 7072(c)). Any proposed change to the recreational bag limit is allocative by nature, and should be considered in conjunction with possible adjustments for the commercial sector.

3) TAC

A TAC or a TAC/ITQ management framework can prevent a stock from being overfished. However, management challenges in quota fisheries include, but are not limited to, allocation of catch among fishermen, consolidation of capacity when quota is transferable, accounting for natural fluctuations in stock size that may render the TAC too restrictive or aggressive from year to year (e.g., Johnston and Butterworth, 2005), access to the fishery if/when quota shares increase in price, and increased administrative and enforcement costs to regulatory agencies. Advocates of quota systems argue that the high cost of transferring quota shares should lead to increased stewardship among current fishermen because they have an incentive to protect their asset. This and other aspects of TAC/quota management are complex (e.g., Branch, 2009) and often contentious. While some studies emphasize the successes of TAC and quota approaches to management (Costello et al., 2008; Bonzon et al., 2010), others suggest that they should be considered cautiously on a per-case basis (del Valle and Astorkiza, 2007; Bromley, 2009; Ecotrust, 2009; Gardner et al., 2013).

If the SPR-based threshold reference point is exceeded, a TAC could be established for California. Approaches for determining a TAC for California include, but are not limited to: (a) accurately estimate the biomass of the stock, and then determine what fraction of the stock the fishery is allowed to harvest; (b) determine a conservative catch level (i.e., one that is historically low/modest) that is clearly sustainable and set that as the TAC, or; (c) identify a target CPUE and adjust the TAC through time until CPUE falls to within some range of the target value (e.g., New Zealand zone CRA8, see Bentley et al. 2005). Equitable distribution of the TAC between the commercial and recreational sectors will be necessary (FGC § 7072(c)). If a quota system is adopted, allocation between and within sectors (commercial and recreational) will need to be considered. Quota allocation is likely to be highly contentious.

4) District Closures

Some areas may be closed only to certain types of fishing, and areas closed to fishing tend to experience very low fishing mortality (although some fishing mortality can occur due to spillover and poaching). Population increase inside closed areas can increase the spawning output of the entire stock. However, closing areas off to fishing can also displace fishing effort to other areas, placing more pressure on the unprotected portion of the stock (Section 4.2.1.1). Furthermore, existing CDFW records show that most of the recreational take in the state occurs in locations where commercial fishing is prohibited (Santa Monica Bay, Long Beach Harbor, San Diego Bay, and the front side of Catalina; Figure 2-9).

A number of areas (Districts) are presently closed to commercial harvest. Prominent examples include the north side of Catalina Island, Santa Monica Bay, and harbor jetties. If the SPR-based reference point threshold is exceeded, these areas could be additionally closed to recreational harvest. Doing so would enhance the spawning output of populations in these areas. The FMP only accounts for the effect of areas closed to both commercial and recreational fishing on SPR using the Cable-CDFW Model (Section 4.3.1.3).

5) Change in season length

Seasonal closures reduce fishing mortality by reducing the number of days that fishing is allowed each year. Closed seasons can protect stocks during important life events, such as spawning. A longer closed season could also improve survival of individuals that would have succumbed to fishing, which in turn increases SPR. The current closed season in California protects reproduction, and any extension of current seasonal closures is unlikely to provide substantial protection for reproductive behaviors or activities. However, it is possible that climate change may lead to a shift in the timing of reproduction or a change in the length of the reproductive season. Such changes could prompt a change in season length. If the SPR-based threshold reference point is exceeded, fishing season length could be shortened, either by delaying the opening date or by closing the season early. That said, most catch occurs during the first part of each season, therefore reducing the duration of the season would have a disproportionately small effect on fishing mortality.

6) Change minimum legal size

Increasing the Min LS would ensure that animals will, on average, reproduce more times before they are caught. Furthermore, females will be slightly larger and produce more eggs. Increasing the Min LS is a simple, effective, and direct way to increase SPR. However, it will lead to extra cost for the fishermen as they make adjustments to their gears (e.g., enlarge escape ports). If the SPR-based threshold reference point is exceeded, the Min LS could be increased to a size that ensures a target SPR within a specified time frame. A reduction in Min LS would have the opposite effect, if future conditions suggest that SPR could be reduced.

7) Establish maximum legal size

If the SPR-based threshold reference point is exceeded, a Max LS could be implemented to protect larger spawning females. As the communities inside MPAs mature, they will likely comprise more of these adults with higher fecundity, and a Max LS would be expected to protect these important spawners as they move outside of the boundaries of the MPAs. Trophy animals would not be available to the recreational community.

8) Sex selective fishery

A sex selective restriction allowing the harvesting of male lobsters (and consequently not allowing the harvesting of female lobsters) could be implemented for the CA lobster fishery. If the SPR-based threshold reference point is exceeded, changing sex regulation for females could be an efficient mean to increase SPR. As stated in Table 4-4, there are advantages and disadvantages to this system that should be carefully considered. Prohibition on the take of berried females is another sex selective provision that could be considered.

Table 4-4: Control rule toolbox: The eight regulatory options available to decision makers if threshold reference points are triggered and their relative benefits vs. limitations

Regulatory options	Benefits	Challenges/Limitations
1) Change commercial trap limit	• Restores economic performance (CPUE) and stock status (SPR) • Directly addresses most common management problem in lobster fisheries (high harvest rates due to high effort) • Applicable when performance/stock increases (i.e., harvest rates can be scaled upwards in absence of crisis, or after recovery) • Accentuates the multiple benefits of trap limit for other MLMA objectives (i.e., Table 5.1)	• Mechanisms only applicable to commercial • Requires implementing a trap limit program • May disrupt established business/fishing practices
2) Change recreational bag limit	• Restores stock status (SPR) • Directly addresses most common management problem in lobster fisheries (high harvest rates due to high effort) • Applicable when performance/stock increases (i.e., harvest rates can be scaled upwards in absence of crisis, or after recovery)	• Mechanism only applicable to recreational
3) TAC	<u>Without individual quota system (e.g., ITQ)</u> • Can provide long term stability to catch and prevent overfishing • Adjustments and rebuilding measures are simple and efficient <u>With individual quota system (e.g., ITQ)</u> • Can provide long term stability to catch and prevent overfishing • Can ease "race to fish" • Can encourage fishing during high market value periods (unless cost of fishing is higher then), this is often later in the season for CA lobster – can have economic benefits • Can lead to effort reduction (but not guaranteed) • TAC/ITQ can be tuned to other fishery performance measures (e.g., CPUE); maximize efficiency	<u>Without individual quota system (e.g., ITQ)</u> • Encourages "derby" fishery, exacerbates high effort level, and compromise safety ("race to fish") • Allocation across sectors difficult (commercial vs. recreational) • Difficult to monitor recreational catch against a TAC (current system is not sufficient) • Recruitment/stock size variability problematic for setting optimal/appropriate TAC • Data-intensive; usually based upon stock assessment • Increased administrative and enforcement costs <u>With individual quota system (e.g., ITQ)</u> • Difficult to monitor recreational catch against a TAC (current system is not sufficient) • Allocation both across and within sectors difficult • Recruitment/stock size variability problematic for setting optimal/appropriate TAC/quota • Data-intensive; usually based upon stock assessment • Increased administrative and enforcement costs

Table 4-4 Continued: Control rule toolbox.

Regulatory options	**Benefits**	**Challenges/Limitations**
4) District closures (e.g., Santa Monica Bay, jetties, Catalina)	• Directly protects stock and increases SPR • Protected areas can be directly incorporated into stock assessment • Streamlining management by prohibiting all lobster fishing in certain CDFW fishing districts • Can directly target localized issues	• If implemented alone, does not reduce high effort in fished areas (potential root of problem), thus does not improve economic performance • Increased congestion in open areas • Likely to reduce yield, reduce public access • May disrupt established business/fishing practices
5) Change season length	• Ease and immediacy of implementation and enforcement (applies both sectors in same manner) • Can estimate benefits from historical catch records	• If implemented alone, does not reduce high effort (potential root of problem) unless large change is made, thus does not improve economic performance • The timing of catches made within season varies regionally (high early season in south, more prolonged in north), thus impact will bear regional disadvantages. Not likely to be uniformly effective throughout range of fishery • Shortens and temporally eliminates access to market
6) Change minimum size limit	• Ease and immediacy of implementation and enforcement (applies to both sectors in same manner) • Directly protects stock and increases SPR • Easily incorporated into stock assessment	• Disproportional economic impacts in southern portions of range where most animals in catch are close to legal size • High cost to commercial fishermen needing to adjust trap openings • If implemented alone, does not reduce high effort, thus does not improve economic performance • Initial season could have major catch reduction
7) Impose a Maximum Size Limit	• Ease and immediacy of implementation and enforcement (applies to both sectors in same manner) • Directly protects stock and increases SPR • Impact easily incorporated into stock assessment • Enhances other MLMA objectives: (1) Ecological benefits of large animals in food chain, (2) non consumptive users	• Benefits (increases in SPR) are minimal at high harvest rates because few animals survive to large size • If implemented alone, does not reduce high effort (potential root of problem), thus does not improve economic performance • May disproportionally impact recreational sector
8) Sex Selective Fishery (male only or female-specific size restriction or condition)	• Ease and immediacy of implementation and enforcement (applies to both sectors in same manner) • Directly protects stock and increases SPR; similar method works in *H. americanus* fishery (V-notch program) and crab fisheries (i.e., Dungeness) • Enhances other MLMA objectives: (1) Ecological benefits of large animals in food chain, (2) non consumptive users	• If implemented alone, does not reduce high effort (potential root of problem), thus does not improve economic performance • Reduced yield to fishery, likely large effect • Mating dynamics unknown, small males might not fertilize eggs of larger protected females due to (1) sperm limitation and (2) antagonistic interaction between large females and small males during mating

4.4 Management of Other Lobster Fisheries

Commercial lobster fisheries exist in many parts of the world. The lessons learned from these global lobster fisheries have played an important role in shaping this FMP. The following review of four select lobster fisheries from other parts of the world highlights the various tools used in lobster fishery management. A comprehensive list of fisheries is listed at the end of this section (Table 4-5).

4.4.1 Baja Mexico *Panulirus interruptus* Fishery

The Mexican lobster fishery operates through fishing cooperatives which are regional groups of fishermen with rights that were first allocated by the government in 1936 (SCS, 2011). Concessions granted to each cooperative define the allowable species, fishing zone boundaries, and effort levels for each cooperative. Adherence to these concessions and prevention of poaching is largely ensured by the cooperatives themselves. Lobster is harvested by 26 cooperatives from the border with the US to Margarita Island but only 10 of those cooperatives, located in the region from Punta Abreojos to Isla Cedros, catch approximately 80% of the catch. Nine of those cooperatives are jointly certified by the Marine Stewardship Council. Federal government control over stock assessment and management is held by the National Institute of Fisheries (Instituto Nacional de Pesca (INAPESCA)) and instituted through the Regional Center of Fisheries Research (CRIP) in La Paz and Ensenada. Co-management and collaboration (e.g. data collection) is required by law as a part of concessions and cooperatives are included in discussions of research results and management recommendations through workshops. Landings data on logs is collected by CRIP and compared to landings data recorded on receipts of sale submitted to the national aquaculture and fishing commission (CONAPESCA).

The fishery is managed using a combination of a minimum legal size (82.5 mm CL), a closed season, a prohibition on taking berried females, trap design requirements, and particular fishing areas and trap limits for each cooperative (SCS, 2011). Commercial landings in Mexico during 2000-10 were approximately 4 times those in CA. Very little lobster is taken recreationally. During the 2010-11 fishing season, approximately 1,250 fishermen operated 564 boats and 28,296 traps (Vega, pers. comm.). The stock has been assessed using a variety of models (Chavez and Gorostieta, 2010; SCS, 2011). INAPESCA used the results of a biomass dynamic model (Hilborn and Walters, 1992) applied by Vega et al. (2000) to set the biomass at maximum sustainable yield (BMSY) as a reference point. The stock is considered below optimum when B/BMSY is <1 and above optimum when the ratio is >1. Specific management responses to a ratio <1 are not prescribed. Investigations in 2014 found that B/BMSY is approximately 1.58 and therefore above optimum, but increased effort was not recommended due to a desire to avoid economic overfishing (SCS, 2014).

4.4.2 South Australia *Jasus edwarsii* Fishery

The South Australian lobster fishery has been regulated with limited entry, seasonal closure, minimum harvestable size, trap limit, trap design restrictions, and a prohibition against keeping berried females (SAFMR, 2006; SAFMR, 2007). A trap limitation was implemented in the 1980s when fishing capacity began to expand due to technological advances (Sloan and Crosthwaite, 2007). Each fishing license is restricted to fishing between 20-100 traps (SAFMR, 2006), but a fisherman or a holding company may own more than 1 fishing license (FAO, 2001). The recreational part of the fishery accounts for less than 5% of the fishery's annual harvest, and is further managed through daily limits and gear restrictions. In addition, recreational fishermen are required to clip the tails of each lobster they catch; the clipping helps identify recreationally caught lobsters and prevent them from entering the commercial markets.

In the early 2000s, landing and CPUE for the fishery dropped due to unfavorable environmental conditions (Linnane et al., 2013a). State managers then implemented a TAC of 625 mt (1.38 million pounds) for the fishery in 2003 and a system of limited permit entry in 2007 (Sloan and Crosthwaite, 2007; Linnane et al., 2013a). The stock has since improved but has not fully recovered (Linnane et al., 2013a). The improvement may have been due to a more stringent TAC of 470 mt (1 million pounds) that was implemented in 2008 (Linnane et al., 2013a; Linnane et al, 2013b). The lower TAC may have prevented growth overfishing, but it could take years before recruitment improves (McGarvey et al., 1999; Phillips and McWilliam, 2009).

The fishery currently uses a formal HCR based on CPUE, measured as the weight of legal-sized lobster per trap lift, and recruitment abundance, measured as the number of sublegal-sized lobster per trap lift (Sloan and Crosthwaite, 2007). When both CPUE and recruitment decrease below specific reference points, managers must either decrease the TAC by 10%, introduce spatial management measures, or both. When CPUE and recruitment increase beyond specific reference points, managers are required to increase the TAC by 10%.

4.4.3 Florida *Panulirus argus* Fishery

The Florida lobster fishery contains a large recreational component (Sharp et al., 2005). The recreational fishery was estimated to account for 24% of the total lobster landings in the state during the 2009-10 fishing season (SAFMC, 2012). The fishery is managed in part through seasonal closure, minimum size restriction, trap/bag limit, trap design restrictions, TAC, and prohibition against keeping berried females for both recreational and commercial fishermen (Florida Administrative Code (FAC) § 68B-24.001 *et seq.*).

The fishery first experienced decline in the early 1990s in part from overfishing (Milon, 1999; Matthews, 2004). The state then implemented a tag-based trap limitation during the 1993-94 season, which would decrease the number of traps within the state through attrition until a target goal of 400,000 traps is reached (FAC § 68B-24.009). Fishermen may transfer their trap limits to immediate family or other lobster permitted fishermen, but transfer outside family would incur a fee of $2 per transferred trap as well as a 10% reduction on the number of tags transferred (FAC § 68B-24.009; Florida Statutes Annotated (FSA) § 379.3671(2)(a)1.). The trap limitation and other conservation measures have likely improved both the health of the stock and the efficiency of the fishery (Milon et al., 1999).

4.4.4 Western Australia *Panulirus cygnus* Fishery

The Western Australia lobster fishery has maintained a high sustainable yield for decades. Management measures for the commercial fishery include management by zones, seasonal closure, minimum size, limited entry, trap limit, trap design restrictions, TAC, a maximum size for females, and prohibition on keeping berried females (GWADF, 2014). Recreational fishermen are allowed to use traps or to dive for lobsters, but they are subject to daily bag limit, and may take lobsters only during the day (GWADF, 2013). The recreational fishery is small, accounting for only 2.6% of the total fishery landing in the 2010/2011 season (GWADF, 2012).

Harvest from this fishery increased substantially in the 1980s and 1990s due to technological advances which resulted in depressed recruitment, but was relieved through the implementation of biological (e.g., maximum female size limit) and effort-based measures (e.g., trap limit) (Hall, 2001). Recruitment dropped again in the mid-2000s. This recent decline was most likely caused by unfavorable oceanographic conditions (Brown, 2009). In response to the drop in recruitment, the fishery managers decided to implement a fishery-wide TAC (GWADF, 2014). The managers are currently implementing an ITQ system to divide the TAC into transferable components (Fletcher and Santoro, 2012).

Table 4-5: Global Lobster Fishery Overview.

Lobster Species (Jurisdiction)	Biology-based Management Tools: Minimum Size	Maximum size	Taking of Berried Females Restricted	Taking of Molting Lobsters Restricted	MPAs and Other Area Closures	Seasonal /Temporary Closure	Minimum Trap Service Interval	Catch-based Tools: Bag/ Daily Limit	TAC	ITQ	Effort-based Management Tools: Limited Entry	TAE (Total Allowable Effort)	Trap Limit	Gear Design Restrictions	Gear Type Restrictions	Tail Clipping for Recreational Fishery	No Fishing at Night	Co-Management by Regions	Main Source of Reference
Panulirus interruptus (California)	C R				C R	C R	C	R			C			C	C R				
Panulirus interruptus (Baja California, Mexico)	C		C		C	C					C			C	C			C	SCS, 2004
Panulirus argus (Cuba)[1]									C	C[2]					C			C	Muñoz-Núñez, 2009
Panulirus argus (Florida)	C R		C R			C R		C R	C				C	C	C[3] R				FAC § 68B-24.001
Panulirus cygnus (Western Australia)	C R	C R	C R		R	C R		R	C	C			C R	C R		R	R	C	GWADF, 2012
Panulirus japonicus (Japan)													C[4]	C	C			C	Nonaka et al., 2000; Phillips et al., 2000
Palinurus elephas (Spain)	C		C			C							C	C	C				Quetglas et al., 2004; Goñi and Latrouite, 2005
Palinurus gilchristi (South Africa)			C						C			C[5]							Reg. in Terms of the Marine Living Resources Act, 1998 C. 44
Jasus edwarsii (New Zealand)	C R		C R	C R	R			R	C	C			R	R				C	NZMPI, 2009; NZMPI, 2014
Jasus edwarsii (South Australia)	C R		C R			C		R	C		C		C	C		R		C	SAFMR, 2006; SAFMR, 2007
Jasus lalandii (South Africa)	C R		C		C	C			C	C				C	C R		R		Reg. in Terms of the Marine Living Resources Act, 1998 C. 44
Homarus americanus (Maine, USA)	C R	C R	C[6] R[7]					R			C[8] R[9]		C	C				C	13-188 CMR §§ 25.01 *et seq.*; 12 MRS §§ 6446 *et seq.*

1 Recreational fishery introduced in 1996, but no creational sector exists (Regulaciones Pesqueras de Cuba 164/1996d; but see Phillips et al., 2000)
2 Total catch quota shared between 10 management regions
3 Fishermen may dive or trap for lobsters, but not both
4 Fishery uses nets instead of traps; number of nets limited per boat
5 Days at sea limited
6 A V-shaped notch is fixed on a female before release
7 A V-shaped notch is fixed on a female before release
8 Not all management areas are limited entry, but Maine residency always required for license
9 Maine residency always required for license
C = Commercial and R = Recreational

4.4.5 Maine *Homarus americanus* Fishery

In Maine, a combination of good management practice and favorable environmental conditions has resulted in historically high landings (Steneck, 2006). Both commercial and recreational fishermen are regulated with minimum and maximum size, trap limit, trap design restriction, and prohibition against taking of berried females (13-188 CMR §§ 25.01 *et seq.*). The commercial sector is further restricted with an area-based limited entry program (12 MRS §§ 6446-6447). Each management area may also further reduce the 800-per-fisherman trap limit required by the state through a voting process within the fishing community (12 MRS §§ 6446, 6447(5)(A); 13-188 CMR 25.10(2)). The stock is not considered to be overexploited, but concerns related to suboptimal economic performance, increases in territorial conflicts, trap entanglements (i.e. excess gear in the water), and harbor congestion have surfaced (Acheson and Acheson, 2010).

4.5 The LAC Process and the Resulting Regulatory Proposals

CDFW convened the LAC to facilitate communication and build consensus between various constituent groups and CDFW. The LAC is composed of representatives for the recreational fishermen, commercial fishermen, non-consumptive recreational users, conservation interests, and the various levels of government. The process included nine regular meetings between June 2012 and September 2013. The process also involved specific communications such as the 2013 Commercial Trap Survey, which allowed members of the commercial fishing community to provide input detailing the fishing practices and perspectives on the fishery.

During the LAC process, constituent representatives were able to reach consensus on a number of items pertaining to the CA lobster fisheries, such as recognizing the current distribution of catch between the commercial and recreational fisheries to be acceptable. The LAC also reached consensus on five objectives to guide future allocation considerations for the lobster fishery:

1. Identify current effort levels for each sector and establish controls to prevent unrestricted growth.
2. Identify the proportion of overall catch and/or effort from each sector, and if necessary, take corrective action to maintain those proportions if the percent of total catch and/or effort by sector deviates significantly from a pre-determined base period.
3. Recognize the current differences between sectors in traditional fishing grounds and time-of-day fished, and seek to maintain those differences.
4. If increases or decreases to the fishery are required due to application of the control rule, those changes should seek to maintain equitability and not give an advantage to either sector unless biological triggers require a change to allocation.
5. End illegal commercialization.

Most importantly, the LAC also formed consensus on several regulatory recommendations that would benefit the fisheries and/or the natural resources. These proposals were compiled into a finalized consensus recommendation on September 11, 2013. The LAC recommendations (described below) were submitted to the Commission for its consideration at the June 2015 Commission meeting along with Department recommendations.

<u>Commercial trap limit recommendation</u>

In 2013 CDFW mailed a focused commercial lobster trap survey to all lobster operator permit holders (141 transferable and 53 non-transferable permit holders). The survey asked specific questions regarding individual trap fishing effort and sought to assess the level of support for a commercial trap limit. A total of 111 permit holders responded; the majority of survey responses (62%) were submitted by fishermen who target lobster south of Santa Monica Bay (including Santa Barbara Island, Santa Catalina Island, San Clemente Island, and Cortez Bank). Over 76% of all respondents replied “yes” to the question “do you think there needs to be a trap limit?" Of the respondents who favored a trap limit, 48% wanted a trap limit of 300 traps or less, and 34% wanted a trap limit of 350-400 traps. Other notable responses include a 78% "no" for regional trap limits (northern vs. southern parts of the fishery), 52% responding "yes" to being able to stack two permits to increase their trap numbers under a trap limit, and 67% responded "no" to stacking more than two permits.

The result of this survey was presented to the LAC during the development of the LAC Commercial Trap Limit Proposal. Through consensus, the LAC recommended a trap limit of 300 attached to each fishing permit. The LAC formalized this proposal in part to cap and potentially reduce current effort level. However, the proposal also aims to eventually cap the long-term effort capacity of the commercial fishing fleet at 42,300 traps (141 permits x 300 traps each). Furthermore, each fisherman may stack a maximum of two permits. The proposed mechanism will give fishermen the flexibility to fish up to 600 traps each. Fishermen may receive more tags during a season to replace tags lost during rare and unforeseen catastrophes. The LAC also proposed a phase-in trap limit approach to allow each fisherman to purchase a one-year temporary permit for 300 more traps when for the first three years after the trap limit goes into effect. The phase-in permits were proposed to give fishermen time to adjust their fishing practices during the initial implementation of the trap limit.

The LAC process acknowledged that even with the ability to hold two permits, some existing fishermen, especially those fishing between 600-1,200 traps, may need to extensively modify their fishing practices. However, the interest of these fishermen must be balanced with: the risk of pollution due to lost gears if trap intensity continues to escalate; the externalized economic inefficiency impacting the rest of the commercial fleet; and the desire of other fishermen and other stakeholders wishing to see fewer traps in the water. The CDFW considers the LAC trap limit proposal as an appropriate balance and will recommend it as part of the implementing regulations for this FMP. CDFW also considers the trap limit as an important substantive regulatory proposal from the FMP/LAC process. Unlike the other regulatory proposals listed in this section, the commercial trap limit is an integral part of the HCR. It is a pro-active initiative aimed to improve the biological, social, and economic sustainability of the CA lobster fisheries.

<u>Permission to carry SCUBA gear on commercial vessels</u>
Existing regulations do not explicitly prohibit SCUBA equipment on commercial lobster vessels. However, regulations do prohibit commercial fishermen from using SCBUA equipment "to assist in the take of lobsters" (14 CCR 122(g)). SCUBA gear is an important tool for recovery of lost traps that otherwise might remain in the marine environment. It can also be used for disentanglement in instances when trap lines are caught on a vessel's propeller. This proposal will clarify that commercial fishermen may use SCUBA for the purpose of securing traps, retrieving lost gear, or to unfoul a line from a vessel; it will remain illegal to use it for the take of lobster.

<u>More than one permittee may operate from the same vessel</u>
Neither the FGC nor the CCR prohibits two or more holders of lobster operator permits from operating from the same vessel. However, how liabilities are shared between these fishermen in the event of a violation is unclear. As such, the LAC proposes joint liability for operator permit holders operating from the same vessel in the event of a violation.

<u>Extend the trap service interval</u>
Federal regulations require fixed gear (includes traps) in federal waters to be serviced at least every seven days (50 CFR § 660.230(b)(3)). The desire to conform to federal regulation and to provide lobster fishermen with more flexibility in servicing their gear led the LAC to propose a longer soak time for lobster traps, extending it from four to seven days. This extended service requirement would only apply to lobster traps.

Formalize the use of notes in the commercial fishery

Lobster fishermen are allowed to authorize another lobster operator permit holder to pull his or her trap by assigning that permit holder a note. This system was designed to allow one permit holder to pull the traps of another in the event of an emergency, such as sudden illness or vessel breakdown. The LAC proposes to formalize the note system with more CDFW oversight through the submission of a waiver for CDFW approval in order to minimize potential abuse.

Additional grace period for deploying and retrieving traps

The LAC also proposes to extend the grace period for trap deployment before the commercial season opens and the grace period for trap retrieval after the commercial season closes. Commercial fishermen are currently allowed to deploy traps in the water 6 days before the season opens. They are also given 6 days to remove their traps from the water after the season closes. However, all traps left in the water during the grace periods must be unbaited with doors wired open. Fishermen may not bait the traps until 24 hours prior to the season opening, and traps must still be emptied of baits and wired open when season closes.

The LAC considers the current grace period length to be too short. Commercial fishermen tend to over-stack their decks with traps and create hazardous conditions. To decrease the chance of accidents and navigational hazards, the LAC proposes to extend the grace period for deploying and retrieving traps to 9 days. Fishermen are still prohibited from baiting the traps until 24 hours before the season opens, and traps must still be emptied and wired open when the season closes.

Branding of commercial buoys

Existing regulation requires lobster fishermen to have their respective fishing license numbers on their buoys in contrasting colors (14 CCR § 122(k)). Feedback from commercial representatives suggests that numbers that are branded onto the buoys are just as legible as the ones that are painted. Furthermore, branding does not erode as quickly as paint, which translates to less effort on the part of the fishermen to maintain legibility. For these reasons, LAC is proposing to explicitly allow fishermen to paint their license numbers in contrasting colors or to brand the numbers in a clearly legible form.

Tail clipping/hole-punching of retained recreational lobster

Tail-clipping/hole-punching is practiced in other recreational lobster fisheries. For example, Australia requires marking retained recreationally-caught lobsters, where enforcement officers can use clipping or hole-punching to distinguish recreationally-caught lobsters from commercially-caught lobsters. The same can be accomplished in California. This tool is relatively simple to implement and enforce and can help prevent recreationally-caught lobsters from entering the black market.

Prohibition on mechanical hoop net pullers

A prohibition on mechanical hoop net pullers has been proposed to deter poachers from using the pullers to poach commercial traps. The LAC has also proposed to incorporate an exemption for fishermen with disabilities.

Changing the opening time for recreational season

The midnight opening time for the recreational season has led to confusion amongst the recreational fishing community. Concerns over safety were also discussed by the LAC, due to fatalities routinely occurring on opening nights. Furthermore, a midnight opening is more difficult for CDFW to enforce than a day time opening. Due to the safety and enforcement issues associated with a midnight opener, the LAC proposes to move the recreational season opener to an alternate time. However, the LAC has expressed concerns over potential economic impacts to the Commercial Passenger Fishing Vessels and dive charter boats if the opener is moved to after midnight compared to before midnight, as this could result in one less night of fishing.

Marking recreational hoop net floats
The LAC has also reached a consensus on supporting a rule requiring the marking of all hoop net floats with the operator's unique identifications (e.g., individual license numbers, GO ID numbers). This is intended to allow enforcement officers to better identify hoop net operators and lost gear.

Clarifying regulatory language on diving for lobsters
Current regulation prohibits the possession of "hooked devices" when diving for lobsters. This has led to different interpretations of the language as well as citation for spear fishermen who were in possession of spear guns while attempting to take lobsters by hand. The LAC proposes to clarify the language, remove the reference to "hooked device," and focus the regulatory language on how lobsters may only be taken by hand when diving. Merely carrying spearfishing gear while taking lobsters should be legal, while the use of such gear to aid in lobster fishing should remain illegal.

4.6 Management Strategy Evaluation Model (MSE)

An important step that CDFW is taking to further improve CA lobster fisheries management is the refinement of the **management strategy evaluation model** (MSE). MSE is a sophisticated model that integrates traditional fishery stock models with management measures to predict the effects of those measures. It is an individual-based simulation model. This means that each individual lobster is simulated as a unique agent and the fate of each lobster is dependent on its state-based probability of moving, reproducing, living, or dying in each time step. A lobster's state is described by features such as sex, reproductive stage, and size. The model incorporates the effects of both the recreational sector and the commercial sector and provides an estimate of future performance of the CA lobster stock under different sets of management activities.

Management strategy evaluation (MSE) – For the purposes of the spiny lobster FMP, the MSE is a computer model that simulates lobster population dynamics, designed by a team led by Dr. Yong Chen, University of Maine. The MSE was designed to allow CDFW to monitor and evaluate the effects of management measures and the lobster fisheries on the lobster population.

4.6.1 Capability of the MSE

The MSE includes: 1) an operating model for simulating the dynamics of the spiny lobster stock and fishery; 2) historical and simulated fishery-dependent, fishery-independent, and biological data; 3) a stock assessment model yielding estimates of the current stock biomass/abundance and fishing mortality; 4) a set of alternative management actions that are practical, enforceable, and can be simulated; 5) a set of performance measures for evaluating the performance of these management actions with respect to management objectives; and 6) a set of harvest control rules determining how the management regulations should be adjusted based on a set of defined biological reference points and stock assessment results. The model is very sophisticated, and it requires tremendous resources to run effectively. As in most fishery stock models, the MSE incorporates known characteristics of a fish population and its associated fisheries to simulate a virtual population. MSE can be used in that capacity to determine important population-level characteristics, such as abundance (i.e., perform a stock assessment). The MSE, for example uses total MPA coverage to calculate a probability of encounters between individual lobsters and lobster fishermen. The encounter rate is then used to determine the fishing mortality of the stock.

However, MSE's capability extends beyond the ability to conduct stock assessments. Once an MSE run produces a simulated CA lobster stock that is comparable in its key attributes to the actual stock, it could then apply different hypothetical HCRs to the virtual population and predict the performance of each HCR (e.g., comparing the 10-year yield of an HCR using a $CATCH_{THRESHOLD}$ of 0.9 with an HCR using a $CATCH_{THRESHOLD}$ of 0.8). The model would determine whether any threshold reference point has been reached during each virtual fishing season and apply changes to the stock's fishing mortality accordingly to simulate management actions. The model then records the status of the stock, such as total yield, over multiple fishing seasons. CDFW would then be able to assess the merit of different management options using these results. The MSE currently does not take changing environmental trends into its calculation, though CDFW scientists are attempting to incorporate such considerations into the MSE model.

4.6.2 Incorporating the MSE

The core components of the model were completed in the fall of 2013. However, the model is not yet ready for deployment. Current model outputs exhibit unresolved patterns in residuals and questionable population trends for MPAs, suggesting that it requires further development. While the current version of MSE is able to incorporate all the management measures within the control rule toolbox (Section 4.3.3), it cannot incorporate CPUE and SPR as reference points. As in the refinement of $CATCH_{THRESHOLD}$, MSE can potentially use and refine $SPR_{THRESHOLD}$, after the program code is modified to provide SPR estimates. In the meantime, CDFW will continue to improve these inputs with various monitoring efforts, including the effects of new management actions (e.g., at-sea sampling, lobster report cards, landing receipts; Section 5.1.1). If the MSE model is adapted to calculate SPR, CDFW would use the model as an alternate means of calculating $SPR_{THRESHOLD}$. Alternatively, if one of the reference points used by MSE is found to be a better indicator of the CA lobster stock's ability to replenish itself, the FMP will be amended appropriately to incorporate the new metric.

Eventually, the MSE has the potential to streamline future management actions for the CA lobster fisheries and reduce administrative uncertainties. More importantly, the model offers CDFW the potential to assimilate and analyze biological and regulatory information much more quickly, which would ultimately serve to enhance the fisheries. Once the model is fully developed, CDFW will make the appropriate recommendations to the Commission.

4.7 CA Lobster and Ecosystem Management

This FMP adopts an ecosystem approach to management. In this context, consideration for factors such as population structure, habitat, trophic interactions, cumulative impacts of the fisheries, and climate change is crucial (COS, 2012). The first part of this FMP is dedicated to the incorporation of information on both the environmental impact of the fisheries (Chapter 2) as well as the ecosystem role of the CA lobster (Sections 3.7, 3.8, 3.9) into the FMP, in addition to the information related to the CA lobster's own natural history (Chapter 3). Next, management measures were considered in the context of other existing state regulatory structure. One of the most notable existing measures is the system of interconnected MPAs that have been established in the SCB since 2012.

On January 1, 2012, the south coast regional network of 50 MPAs, covering 355 square miles or about 15% of state waters, went into effect (including 13 previously established MPAs in 2003 at the northern Channel Islands that were retained without change)(https://www.wildlife.ca.gov/Conservation/Marine/MPAs/Statistics). These MPAs were established to achieve a set of six ecosystem-based conservation goals, most of which are not strictly related to fisheries (FGC §§ 2851, 2853). However, properly managed MPAs have been shown to enhance fisheries under the right circumstances by protecting critical habitats (Grafton et al., 2006). The MPAs, especially the state marine reserves, make it unlawful to "injure, damage, take, or possess any living, geological, or cultural resource" unless the activities are part of a permitted research, restoration, or monitoring process (PRC § 36710(a)). Protection of critical habitat can, for the case of CA lobster, translate to increased spawning potential (Kay, 2011).

It is currently estimated that 14.6% of all known SCB CA lobster habitats are protected by MPAs (Section 4.3.1.3) assuming that CA lobster fisheries occur out to 100 m (~300 ft) depth). Refinement of the data, such as analyzing the difference between habitats inside MPAs and habitats outside MPAs, is an ongoing information need (MPA Monitoring Enterprise, 2014). CDFW incorporates this number as well as other MPA specific data (e.g., MPA size, adult spillover, fishing effort adjustment due to MPA) into the calculations of the SPR reference point through the Cable-CDFW Model.

A significant number of studies have been dedicated to the effects of MPAs over the past several decades (e.g., Roberts et al., 2003; Grafton et al., 2006). However, information detailing their effects on the CA lobster fishery has been sparse. It is known that MPAs can eliminate fishing mortality inside their boundaries, but displace fishing effort and intensify fishing in the non-MPA areas (Beverton and Holt, 1957; Guenette et al., 1998; Alcala et al., 2005; Shester, 2008; Goñi et al., 2010). Existing research shows that under the right conditions, MPAs can allow lobsters to reach a larger reproductive size before being caught (Diaz et al., 2011). Past research on a related species of spiny lobster, *J. edwardsii*, further shows that larger females carry more eggs and produce stronger larvae (Smith and Ritar, 2007). If CA lobsters exhibit the same type of improvement in fecundity as they age, and if the southern California MPAs are allowing individuals to grow to a larger size before being caught, then the MPAs will contribute to the fisheries through enhanced recruitment.

MPAs have also been shown to contribute to lobster fishery yield in outside unprotected areas through movement (adult "**spillover**"). Whether MPAs will contribute to spillover of a fishery depends on a variety of factors, such as the location and size of the MPAs in relationship to the mobility of individual lobsters (Bevacqua et al., 2010; Moland et al., 2013). Furthermore, in an era of global climate change, MPAs are areas where CA lobsters would not be impacted simultaneously from climate change (Section 3.11) and fishing.

Spillover - The emigration of adults from a protected area to the fishing grounds, and/or larval export from the protected area to surrounding areas.

MPAs can also almost completely eliminate other ecosystem impacts from commercial and recreational fishing within their boundaries. These include bycatch and trap-habitat interactions. Moreover, the elimination of fishing pressure in certain areas can ensure that a portion of the CA lobster stock will grow to a size large enough to enable them to assist with controlling the local urchin population (Section 3.9).

In addition to the MPAs and the new HCR, measures that have been proven to be effective at keeping the CA lobster stocks at a biologically sustainable level (Section 2.4) will remain in place. Existing regulations for the recreational industry include the mandatory reporting requirement, minimum size limit, area closures, bag limit, gear restriction, and season restriction. Existing regulations for the commercial industry include the mandatory reporting requirement, minimum size limit, area closures, limited entry, gear restriction, trap specification, and season restriction. The CA lobster fisheries also adhere to the Marine Protected Areas (MPAs) regulations.

The management measures and strategies this FMP adopts are thus not designed to independently solve every ecosystem-related issue attributed to the CA lobster fisheries. Instead, the FMP management strategies, the MPAs, and existing management measures all have their respective strengths and weaknesses, and they are meant to complement each other. For instance, while the MPAs can eliminate fishing, and thus all bycatch, within their borders, they are not designed to curtail bycatch elsewhere. This is where existing rules such as trap design specifications and new rules like the proposed trap limit would complement the MPAs and reduce the overall ecosystem impact of the CA lobster fisheries. Additionally, the HCR, in conjunction with the proposed trap limit, will help control fishing effort and further buffer against unsustainable harvest of CA lobsters. The HCR will help maintain the role of CA lobster as an important trophic link within the nearshore ecosystem as well as the integrity of the associated benthic habitat, and will also minimize impacts to non-targeted species.

While this FMP and existing management measures will go a long way towards protecting the CA lobster resource and its associated ecosystem, activities of other agencies with jurisdictions over coastal and nearshore areas may affect the lobster fishery. For example, the authority to manage coastal development of the state is vested in the California Coastal Commission (PRC §§ 30000 *et seq.*). The Coastal Commission can use the information within this FMP (Section 3.1) to inform its permitting and other regulatory functions to minimize impact to important lobster habitats. The information will also serve as a starting point for intergovernmental collaborations in important future developments.

5. Fishery Research Protocol – Essential Fishery Information

The MLMA requires CDFW to formulate FMPs with the best available science or other relevant information without delaying plan preparation (FGC § 7072(b)). Certain categories of EFI relate to the socio-economic aspect of a fishery while others relate to the natural history and biology of the fished species. CDFW must outline how it would obtain missing or outdated EFI within an FMP (FGC § 7081).

5.1 Research and Monitoring Needs for Essential Fishery Information

CDFW has primarily relied on its own **fishery-dependent data** to determine the status of the spiny lobster stock and associated fisheries. The need to improve existing data has shaped CDFW CA lobster-related research since 2007. In particular, improving information on the recreational fishery has been a priority with implementation of the recreational report card requirement. Further improvements to that system are needed. CDFW is also increasingly interested in development of reliable and regularly collected fisheries-independent data streams. Table 5-1 describes the future data needs for managing the CA lobster fishery, including the biological EFI category, their importance, current state of knowledge, and methods for improving them.

Fishery-dependent data - Information collected directly from or during the process of fishing, or from fishery landing data. May be collected from commercial and/or recreational sources, and may include catch/effort reported by fishermen, size and age composition of the catch, and biological samples collected at port.

5.1.1 Existing CDFW Research Methods

The following methods are currently employed by CDFW and its partners:

Logbooks

Commercial fishermen have been required to record specific information for each fishing trip in commercial logbooks since 1973. A logbook entry must contain the date, fisherman and crew ID, vessel ID, CDFW fishing block, a landmark (typically a shoreline feature or reef) corresponding to the area fished, the number of legal-size CA lobster retained, and the number of sublegal-size lobsters released. Effort is compiled based on the number of trap pulls or the length of the soak time. Associated landing receipt ID numbers can also be recorded. Each log has room to record 3 days of fishing with up to 5 sets of trap pulls per day. CDFW is working towards a transition from paper to electronic commercial fishing logs and plans for the CA lobster fishery to be the first to implement a voluntary electronic log by the 2019-20 fishing season.

Commercial Landing Receipts

Commercial landings have been recorded since the early 1900s via commercial landing receipts. Landing receipts record the date of sale, species(s) landed, port of landing, fisherman ID, vessel ID, CDFW fishing block from which the catch was taken, the price paid, and weight landed. Landing receipts are filled out by fish dealers or by fishermen permitted to sell their own catch.

Correlating Commercial Logbooks and Landing Receipts

Information such as the weight and number of lobsters landed by a fisherman on a given day is important for both the management and the enforcement of the CA lobster fisheries. CDFW uses this type of information to obtain the annual average size of a landed CA lobster, which is crucial for determining the SPR of the stock. To obtain such information, correlation between commercial logbooks and landing receipts is necessary.

In the mid-1990s, CDFW transitioned from daily logs to new logs that record up to three days of fishing. Unlike the daily logs, which recorded the weights landed on a daily basis, the new logs provide space for the number of legal-size lobsters retained, but not weight. Landing receipts between fishermen and buyers, on the other hand, only record weight and not number of lobsters sold (Appendix IV). In order to determine the weight of the lobsters caught on an individual fishing date, CDFW must first identify the landing receipt ID numbers recorded on the log of that particular date. CDFW must then retrieve the specific landing receipt with the corresponding ID.

This current system of correlating logs with receipts is a complex process. For fishermen that sell all of their catch from a single day to one buyer, correlation is straight-forward. However, CDFW will not be able to determine the precise weight of the lobster caught on a single day for fishermen that sell multiple days' worth of catches to a buyer. CDFW can locate the landing receipt in question, but there is no way of attributing different portions of the landed weight to different days of fishing.

CDFW currently bases its SPR calculation on data taken from only log entries that are tied to one landing receipt. More sophisticated computer programs can also analyze the correlation between catch totals and landed weights from logs with multiple landing receipts per fishing day, but the process is much more complicated. CDFW will seek ways to address this issue such as amending landing receipts to record the total number of lobster landed as part of an up-coming revision process for all logs and landing receipts.

Recreational Lobster Report Cards

Report cards were introduced during the 2008-09 recreational season and must be purchased by every person fishing for lobster in California, including individuals who are not required to possess a valid sportfishing license (e.g., youths under 16, pier fisherman). Initially, the report cards were valid for a single calendar year and captured data for the last half of a given season and the first half of the subsequent season. Because of the mismatched timing, CDFW could not obtain results from a full season until approximately 15-17 months after the season ended. A new seasonal card introduced for the 2013-14 season can shorten the wait time to 3-5 months following season closure.

Report cards record the date, location, gear type, and number of lobster retained. The report cards provide 92 fishing location codes for fishermen to choose from as of the 2013-14 fishing season. The spatial resolution for coastal areas south of Point Conception is relatively high. However, the Channel Islands are each represented by a single location code, and CDFW's ability to analyze fine scale recreational catch patterns is limited. Furthermore, all take north of Surf Beach in Santa Barbara County (up to the California-Oregon border) is represented by a single code (Figure 2-9). CDFW may modify the spatial resolution of the report cards in the future based on management needs.

Recorded gear categories include conical hoop net, flat hoop net, skin diving, and SCUBA diving. However, the cards do not include the number of nets used nor the amount of time spent fishing. In addition, CDFW cannot practically compare the time recreational fishermen spent hoop net fishing directly with the time the community spent diving. Consequently, CDFW uses 'trips', or a single line from the report cards, as the unit of effort. Due to this, as well as uneven report card return rates, only limited effort comparisons are possible between hoop netting and diving using the report card. Refined data collection of effort could be achieved with two additional columns on the card: the number of nets used (zero if diving) and the total time spent fishing.

Accurate estimates of annual catch for the recreational fishery is critical for management and cannot be made when report card return rates are low. One method for improving catch estimates is to implement a telephone survey of report card holders who did not return their card, as is performed by CDFW for the red abalone recreational fishery. Combined report card and telephone survey data would also be necessary for accurate estimation of the proportion of trips employing different gear types.

At- Sea Fishery Sampling

At-sea sampling refers to instances when fishermen gather data during normal fishing operation. Such a program was integrated with other data collection efforts (e.g., observers, **fishery-independent** surveys, tagging studies) to manage the New Zealand rock lobster fishery (Starr and Bentley, 2002; Starr, 2010).

California Sea Grant in collaboration with CDFW conducted a three-year project for CA lobster based on a framework developed for the southern California rock crab fishery (Culver et al., 2010) and an earlier effort by CDFW. The project collected the same general information as the lobster logs but included animal size, sex ratio, reproductive condition, shell condition, and trap density. This has provided important corroboration for CDFW's logbook data (and vice versa) and was used to help refine our estimates of average weight and subsequent calculations of SPR. At-sea sampling programs can also provide more accurate estimates of CPUE. The program required willing and capable fishery participants and employed financial incentives to offset reduced productivity for those participants. Because there is not continued, dedicated funding for the project, the program's successful adoption in the future will depend on fishermen who recognize the value of additional data and voluntarily continue the work or additional mandatory reporting requirements.

Creel Sampling

Two creel surveys were undertaken by CDFW targeting the recreational lobster fishery. The data collected included fishing mode (type of fishing platform), gear, number of hours fished, fishing location, number of CA lobster released, number kept, carapace length, weight, and sex. The surveys involved intercepting fishermen leaving a site after fishing. Survey sites include launch ramps, piers, jetties, and beach access points.

> **Fishery-independent data –** Scientific research to collect information that is independent of commercial or recreational fishing operations. Surveys utilizing commercial fishing gear may provide unbiased estimates of abundance. Surveys may also use other methods (e.g., acoustics, SCUBA, video) to collect other biological or ecological information (e.g., movement, migration, growth rates, natural mortality) relevant to a fishery.
> **California Recreational Fisheries Survey (CRFS) -** The California Recreational Fisheries Survey (CRFS) is the method for estimating total marine recreational finfish catch and effort in California. The CRFS is a coordinated sampling survey designed to gather catch and effort data from anglers in all modes of marine recreational finfish fishing.

The first survey occurred in 1992 and targeted lobster fishing during the first two weekends of the CA lobster season at four sites. The 2007 survey encompassed the entire SCB and was done in preparation for the launch of the recreational lobster report card and sampled three of the four sites sampled in 1992. The 2007 survey also operated at night over the first 12 weeks. The 2007 sites were based on CDFW's long running finfish-oriented **California Recreational Fisheries Survey** (CRFS), which has since incorporated lobsters into its survey program. It is important to note that while most recreational lobster fishermen fish at night, CRFS sampling only occurs during daytime. CDFW has used the results from these creel surveys to compliment data from the recreational report cards as well as other assessment efforts.

Research Trapping

Research trapping programs use lobster traps to sample populations. Research trapping is typically collaborative and takes place onboard commercial fishing vessels. In some instances, scientists trained to use commercial fishing gear can work from research vessels, which can reduce scheduling conflicts among partners, especially when commercial vessels are unavailable (Kay et al., 2010).

Research trapping is a powerful tool because data are collected in a manner that matches fishery-dependent methods, which makes data directly comparable in statistical analyses and stock assessment. Furthermore, traps allow researchers to sample a relatively large number of lobsters not typically possible with traditional research approaches (e.g., SCUBA). These programs have been employed in California to support MPA monitoring efforts as well as lobster tag recovering efforts in the northern Channel Islands (Kay et al., 2011) and in the southern portion of the SCB (Hovel and Neilson, 2011; Hovel et al., 2015).

Dive Surveys

SCUBA diving is an essential method for directly observing CA lobster in their natural habitat. A large number of research groups use SCUBA to monitor reefs in southern California. CDFW scientists collaborated with other academic researchers on a baseline study for CA lobster within southern California MPAs. The study included a research trapping and tag/recapture component, SCUBA surveys, and a habitat mapping/lobster movement component. The SCUBA survey was used to determine abundance, density, den occupancy, habitat type, and other ecological information at key locations inside and outside select MPAs. While this method is uniquely able to estimate animal densities and their association with particular habitat features, it suffers from several drawbacks. SCUBA surveys are typically conducted during the day when lobsters are in dens and may be difficult to observe. Additionally, the patchy spatial distribution of lobsters necessitates that large areas be surveyed in order to count a sufficient number for statistical analysis. While recognizing these challenges, SCUBA surveys may also be used to assess fishery impacts and fisherman behavior. Eggleston et al. (2003) performed SCUBA surveys of Caribbean spiny lobsters (*P. argus*) in the Florida Keys immediately before and after a recreational “mini-season” to demonstrate the magnitude of removal rates and their relationship to initial density. Similar surveys of CA lobster before the recreational season, immediately before the opening of the commercial season, and at the end of the season could provide information on the relative impacts of the fisheries and help optimize management responses. However this would involve a great deal of effort within a short time frame.

5.1.2 Additional Research Methods

The following methods are not currently in use by CDFW to provide lobster EFI. However, CDFW is a research partner in a number of collaborative projects that include some of these methods led by other institutions.

Port Sampling

Port sampling is a method by which samplers meet commercial vessels when they return from fishing and measure some fraction or all of the catch. This is a very efficient and cost-effective method for obtaining large sample sizes. During the 2008-09 fishing season, for example, a single researcher working with commercial lobstermen was able to sample 14 fishing trips from Santa Cruz Island and 17 trips from Santa Rosa Island. The catch sampled during these sampling sessions represented approximately 8.5% and 12.5%

of the total 2008-09 catch from the CDFW fishing blocks encompassing Santa Cruz and Santa Rosa Islands, respectively (Kay et al., 2011). Port sampling is ideal for monitoring length frequencies, sex ratios, mean weight of animals in the catch, and condition of animals.

Larval Collectors

Larval collectors are man-made devices upon which pueruli settle. They are typically constructed to resemble preferred settlement surface, and are usually deployed in nearshore waters. The effectiveness of two puerulus collector designs was tested by Miller (2014b) in California and Arteaga-Rios et al. (2007) noted significant positive correlation between pueruli in collectors and commercial catch in Baja, Mexico five years subsequent. While these studies are encouraging, the utility of puerulus larval collection for CA lobster is still uncertain, and further research on sampling methodology is needed. The California Cooperative Oceanic Fisheries Investigations' (CalCOFI) zooplankton sampling time series has the potential to reveal more information regarding the abundance and distribution of earlier stage phyllosoma larvae across several decades. Koslow et al. (2012) used this time series to identify a relationship between environmental conditions and phyllosoma abundance which were positively correlated. CA lobster landings were also correlated with phyllosoma abundance across much of the time series but the relationship breaks down during recent years under high exploitation rates. This may indicate that recent high removal rates of reproductive individuals is having a negative impact on larval production and potential recruitment. Further work is required to better understand the relationship between phyllosoma abundance and spawning stock abundance before phyllosoma could be confidently used as the basis for a reference point within the HCR. However, the phyllosoma data will be extremely valuable when managers are prompted by the HCR to investigate the underlying causes for the existing reference points crossing their thresholds. The positive correlation between phyllosoma abundance and environmental indicators will help managers to distinguish between fishery and environmental processes impacting the stock and craft appropriate responses. Abundance of earlier stage larvae may serve as an indicator of adult spawning potential while late stage larvae may help forecast changes in stock abundance, identify preferred settlement habitats, and differentiate source and sink areas. CDFW will continue to track the CalCOFI data on phyllosoma and will seek to develop collaborations to model larval transport in the SCB and California Current, which can help determine the sources and the destinations of the lobster larvae across southern California.

Laboratory Studies

Laboratory studies are useful for investigating aspects of lobster biology that cannot be studied in the field. Results of behavioral laboratory studies must be interpreted with caution because conditions in a controlled lab are inherently different from field conditions, though they are often designed to complement field studies.

Oceanography

Oceanography is a broad field within marine science that focuses on the physical properties and processes of the ocean (e.g., water temperature, salinity, depth, nutrient levels, storm activity, currents, and bottom types). This field of study can directly assess the effects of climate change, ocean acidification, and climate-driven hypoxia on future CA lobster population. Oceanography can also relate the physical characteristics of the ocean to biological processes such as productivity, trophic structure, population connectivity, distribution of larvae, growth rate and distribution of fish stocks, disease outbreak, and other management-relevant issues. Oceanographic data are typically collected with instruments deployed from boats and ships or with satellites; complex modeling is often the mainstay of data analysis.

Genetics

Genetics uses the hereditary material in an organism (e.g., genes coded for by DNA) to help understand a large number of biological processes. Because genes in DNA are passed from parents to offspring, and because certain genes are unique to individuals, populations, or species, they are a powerful tool for studying the relatedness of two or more organisms. This information can provide insight into topics like population connectivity, evolution, and disease susceptibility and resistance.

5.2 Biological EFI: Status, Application to Management, and Methods for Obtaining Data

Chapter 4 of the MLMA Master Plan designated this fishery as data rich for several EFI categories (e.g., growth rates and reproduction) and poor in others (e.g., stock distribution, recruitment). Even in areas where the population-wide characteristics are well understood, important details can still be missing or, regional differences have not been thoroughly explored (Table 5-1).

Age and Growth

Accurate age and growth data are essential for CA lobster management. Growth rate can be used to determine the age of maturity or SAM and estimate of the number of spawning seasons a lobster would experience before reaching legal size when coupled with observations of SAM. Published growth rates for *P. interruptus* are highly variable (Section 3.2), and it is unknown whether, or by how much, growth rates might vary through time or from region-to-region in California. Furthermore, decades of fishing have resulted in a scarcity of older lobster that complicates determination of the species' maximum size.

CDFW currently estimates CA lobster growth rates, and subsequently age, using the commonly applied von Bertalanffy growth model with parameters derived by Vega (2003a) for the Mexican stock. Tag-recapture data exists for the CA stock from three studies representing different regions of the SCB and different lobster size classes (see Appendix X). The first of these studies provides information on the growth of juveniles from Santa Catalina Island (Engle, 1979). The second study conducted in the northern Channel Islands provides information on the growth of adults ranging up to relatively large sizes. Third, CDFW collaborated with academic researchers and fishermen to tag CA lobsters in San Diego Bay (Hovel and Nielson 2011) and South Coast Region MPAs (Hovel et al., 2015). These studies rely not only on research trapping to recover tags but also on recovery by recreational and commercial fishermen. Investigations by CDFW into the fit of the von Bertalanffy and other possible models to these data suggest that the von Bertalanffy model may not be the best choice for the CA lobster data. However, less conventional growth modeling options were ultimately rejected during peer review of this FMP, in part because these data contain a gap in information for lobsters in the 30 to 50 mm CL size range. Until that gap is addressed CDFW will continue to use parameters from Vega (2003a) but place a high priority on participating in tagging studies that address these critical knowledge gaps.

Estimating the age of crustaceans has historically been more difficult than aging finfish because crustaceans shed most of their hard structures that might be used for aging each time they molt. Tag-recapture studies only provide an indirect estimate of the age of individual lobsters. New advancements in crustacean aging have recently been made by counting rings in hard parts of the eye stalk and gastric mill that are not shed during molting (Kilada, 2012). Another method measures the concentration of a pigment called lipofuscin, and was found to be a suitable method for aging Caribbean spiny lobster *Panulirus argus* (Matthews et al., 2009). These methods provide a direct measurement of age and the potential for more accurate understanding of growth. CDFW will seek opportunities to investigate the application of these techniques to CA lobster.

MPAs also provide researchers with an opportunity to correct for the maximum-size/age-related biases associated with fished populations. Due to the recent establishment of MPAs in southern California (established in 2012) it is unlikely that CA lobster populations inside the MPAs will show a dramatically different size structure than outside MPAs for many years (possibly 2-3 decades). CDFW participated in the south coast region MPA Baseline Study in an effort to track the effects of MPAs on CA lobster populations. The current status of knowledge related to age and growth EFI ranges from poor to moderate. Obtaining better information related to age and growth is a high management priority (Table 5-1).

Stock Distribution

The MLMA Master Plan defines a stock as "a population unit that is selected for management purposes" and its distribution as "where a stock is found." It is necessary to define the stock distribution because of management implications related to potential biological differences between sub-populations and jurisdictional issues (CDFG, 2001). CDFW currently manages the entire population within the SCB as one population and one stock. The status of knowledge related to where CA lobster are found is currently well-known and genetic evidence generally points to CA lobster within US borders being well-mixed during the larval phase (Section 3). However there has been some recent genetic evidence of either self-recruitment and/or spatially cohesive larval cohorts. CDFW will continue to monitor advancements in genetic work and larval tracking as we seek to confirm CA lobster's place in the spectrum between a single mixed population, a meta-population, or a group of separate sub-populations. The research priority for genetic structure is medium (Table 5-1). Regional differences in other aspects of CA lobster biology (e.g. fecundity, growth, reproductive timing) may also be indicators of sub-structure within the stock that may warrant consideration of regional management in the future (Section 6.2.2). Collection of this information is of medium to high importance as noted throughout this section and Table 5-1.

Ecological Interactions

The ecology of CA lobster is discussed in detail in Section 2.1. The species serves as an important scavenger and predator in the southern California kelp forest ecosystem. Predation on intertidal mussels by CA lobsters can relieve red algae from competition for space (Robles and Robb, 1993), and predation on urchins can relieve giant kelp from urchin grazing (Guenther et al., 2012 and references therein). CA lobster plays an important role in the ecology of rocky reefs, and it is associated with critical habitats such as surfgrass beds. Management should remain aware of information on the ecology and habitat preference of *P. interruptus*, and encourage related ecological research and monitoring.

A number of research programs both independently and in collaboration with CDFW are currently conducting long term monitoring of southern California reefs. These programs provide a valuable service monitoring the condition of CA lobster habitats, prey abundance, predators, water quality, and oceanography. The long list of research groups collecting such data include: the National Park Service Kelp Forest Monitoring Program, the Partnership for the Interdisciplinary Study of Coastal Oceans, Santa Barbara Coastal Long Term Ecological Research Program, the California Current – LTER, individual research laboratories, and Reef Check California. Research protocols and data collected for many of these organizations are available online. This FMP does not link ecological metrics directly to the reference points or the HCR, and future research and monitoring of ecological interactions are a medium level priority for CDFW at this time (Table 5-1).

Indices of Abundance

Indices of Abundance - Measurements of the abundance of an organism made over time; used to make inferences about the abundance of an entire population.

Indices of abundance (catch and CPUE) are used as reference points that link directly to the HCR in this FMP. Indices of abundance are perhaps the most common reference points used in fisheries management, and they are described in detail in Section 4.2.4 and 4.3. CPUE and catch are currently tracked by CDFW and data will be available after each fishing season for the foreseeable future. CDFW is also interested in developing new types of data, making new control rules possible in the future. One example of this is CDFW collaboration on direct visual estimations of CA lobster density and abundance with various academic groups. The knowledge regarding catch and CPUE is rich. Their status as reference points means that the priority for continued monitoring of these parameters is high. CDFW has moderate information on visual surveys on the sea floor; this priority is low (Table 5-1). Larval abundance from CalCOFI as well as settlement studies offers prospective abundance indices that may be linked to spawning biomass and/or recruitment. Ongoing research in these areas is a medium priority.

Movement Patterns

Lobster movements can be divided into two general categories: 1) seasonal movements related to biological or environmental cues, and 2) more frequent foraging excursions (Section 3.6). Both are important to this FMP because they are mechanisms by which lobsters exit MPAs or district closures and become vulnerable to fishing. The spatial scale and frequency of these two movement types require different research approaches.

Lobster movement over longer time periods (i.e., seasonal) can be studied using traditional tag-recapture studies that use individually identifiable tags. CDFW has been involved in such a movement study in San Diego Bay in collaboration with San Diego State University. CDFW was also involved in a study examining spillover rates as part of the South Coast MPA Baseline Study in collaboration with fishermen, San Diego Oceans Foundation, and Scripps Institution of Oceanography.

Unlike seasonal movements, foraging excursions are best studied using "active" (signal-transmitting) tags that are applied to animals and tracked by researchers. CDFW undertook a multi-year tracking study with San Diego State University to look at CA lobster movement around San Diego Bay and the Point Loma kelp bed (Hovel and Neilson, 2011). The level of knowledge on movement patterns is moderate, and their priority is medium (Table 5-1). CDFW will continue to engage in independent and collaborative tagging studies.

Recruitment

Larval recruitment and fishery recruitment are two measures that can be useful in projecting the future trend of the fishery. Data that track larval abundance and recruitment can provide powerful information for fisheries management such as: 1) long term trends that provide direct evidence of a stock's ability to replenish itself, 2) the state of the spawning biomass that produces the observed larval abundance (Jacobson and MacCall, 1995), and 3) annual levels of recruitment to predict future catches (e.g., Phillips, 1986; Caputi et al., 1995; Shanks et al., 2010). Spatial pattern of larval abundance also helps define reef areas that are sources or sinks for reproduction of the stock, which can be invaluable for understanding the role of MPAs as conservation tools. For these reasons, many lobster fisheries have data collection programs that track the abundance of larvae using artificial collectors. California has no collector program for CA lobster larvae, but phyllosoma larvae are collected on annual CalCOFI cruises and have been used to explore patterns and processes related to CA lobster larval abundance and environmental conditions or stock abundance (e.g., Johnson, 1960a, b; Pringle, 1986; Koslow et al., 2012).

Implementation of a formal CA lobster larval monitoring program could provide valuable information regarding the current and future conditions of the CA lobster stock. Abundance of earlier stage larvae may serve as an indicator of adult spawning potential while late stage larvae may help forecast changes in stock abundance. However, puerulus settlement data did not predict stock fluctuations of Australian lobster

(Linnane et al., 2013a). The workload associated with a later stage puerulus larval collection program would be significant because collectors must be sampled frequently (every 1-2 weeks) over the peak settlement period of 4+ months. This sampling includes recovery of the collecting devices and laboratory sorting of the contents to count larvae. Such programs are only valuable if they are run nearly every year and over long time spans. A recent study by Miller (2014b) examined the relative effectiveness of two collector designs, but testing would need to continue to identify the most appropriate type(s) of collectors for CA lobster. Thus, a larval recruitment monitoring program represents a significant long-term investment, and CDFW would need to identify the resources necessary to conduct this monitoring. A larval monitoring program that has the resolution to define larval sources and sinks could aid management, but would require a large number of larval collectors throughout the SCB and the associated cost would be significant. Such an approach would ideally be coupled with genetic studies that help identify the origins of settling larvae. An alternative to larval collection is to use oceanographic models of currents to estimate the locations of the population sources and sinks. Such a model was used to evaluate MPA network designs during the MLPA process in southern California. Development, refinement, and application of such models have not occurred within the context of CA lobster fishery, but CDFW will continue to explore this tool.

Monitoring fishery recruitment (growth of sublegal-size lobsters to legal size) allows for predictions of fishery yield for upcoming seasons, and provides assurance that reproduction has been successful in previous years (i.e., during the year(s) that current fishery recruits hatched and settled). Trends in sublegal-size abundance are used as reference points in some lobster fisheries (e.g., ASFMC, 2009). Obtainment of these data is inexpensive when collected in logbooks, but often do not reveal how many times individual lobsters are caught, released, and recaptured. Fisheries that use sublegal-size abundance to estimate fishery recruitment usually have dedicated survey programs for collecting these data. Current knowledge regarding recruitment ranges from poor to moderate. Obtaining better information on the stock's sublegal-size abundance is one of the highest priorities for management, while information regarding larvae has medium priority (Table 5-1).

Reproduction

Size and age at maturity are important parameters for both the Cable-CDFW model and the MSE model. Determining this parameter has primarily been based on observing berried females found in fishery harvests and research trapping. Recent CDFW measurements during tagging studies suggest that SAM is smaller than previously thought. How this parameter and the timing of reproduction vary regionally is unknown. Fecundity of large female lobsters such as those inside MPAs has also not been thoroughly sampled. For these reasons, determining variability across regions is a future goal. State of knowledge on CA lobster reproduction is moderate, and the priority for obtaining better information is high (Table 5-1).

Total Mortality

Total mortality - Natural mortality and fishing mortality combined.
Natural mortality (M) - The rate at which organisms in a population die due to natural causes.
Fishing mortality (F) - The rate at which organisms in a population die due to fishing.

Total mortality is the rate at which fish die, and it can be separated into two components: 1) **natural mortality** (causes include predation, disease, and old age), and 2) **fishing mortality**. Natural mortality is a critical parameter in biological models used in stock assessment. Several studies have estimated similar natural mortality rates for CA lobster (Chavez and Gorostieta, 2010; Kay, 2011; Nielson, 2011) and they are consistent with estimates for other temperate spiny lobster species (Kay and Wilson, 2012). Little is known about juvenile natural mortality. Factors that affect natural mortality include ocean temperature, oceanographic regimes (e.g., PDO, El Niño), reef-specific ecology, habitat characteristics, and existence of MPAs (Kay and Wilson, 2012). Approaches for estimating natural mortality include tag-recapture and examination of populations in MPAs.

Fishing mortality (*F*) is an estimate of the rate at which fish are caught. A harvest rate (*u*) can be calculated directly from *F*, and it is the percentage of the legally harvestable fish stock that is caught in a fishing season (Section 4.1). Fishing mortality (and harvest rates) lie at the core of this FMP. *F* directly links to the MLMA objectives (Table 5-1), to reference points determined or used by the FMP models, and to any control rule described by the FMP. A major emphasis of this FMP is focused upon the identification and management of harvest rates that avoid/minimize recruitment overfishing, economic overfishing, and ecological impacts. Available estimates for mortality range from poor to moderate and are adequate for modeling purposes. However, accurate and region-specific estimations of fishing mortality rates are central to accurate model runs, and are thus the highest research priorities identified in this FMP (Table 5-1).

Other EFI –Stock Composition

Stock Composition - Any description of the population attributes of a stock (age, size, sex), usually within a spatial context. This commonly refers to the spatial distribution of breeding groups or genetically-related organisms.
Length frequency distribution - A graphical representation of the number of organisms by length.

The models proposed by the CA lobster FMP to produce reference point data would benefit from additional EFI not explicitly listed in the MLMA Master Plan. CDFW may include any biological information that is "necessary to permit fisheries to be managed [sustainably]" as part of a fishery's EFI (FGC § 93). Additional EFI to improve modeling includes **stock composition**. Stock composition generally refers to the size composition (**length frequency distribution**), abundance, and sex ratio of a stock. Better information on the spiny lobsters' stock composition can provide a useful and independent corroboration to CDFW's other assessment efforts.

Length frequency distribution gives CDFW a way to corroborate calculations of growth rate, fecundity, and mortality. However, the assumption that length frequency data derived from commercial landings would accurately represent the length frequencies of natural populations holds true only if lobsters of all sizes have an equal chance of entering and remaining in traps or other fishing/sampling gear. Otherwise, the true population size composition will be misrepresented in any data based on traps. To compensate for potential bias within the landings database, CDFW currently supplements its length-frequency data with samples from research traps, gill nets, and SCUBA surveys that are part of the collaborative South Coast MPA baseline study. California Sea Grant's at-sea sampling pilot project and creel sampling also provide more accurate length frequency distributions. At-sea sampling currently has several advantages over port-sampling: 1) higher spatial resolution; 2) sublegal-size lobsters are measured; and 3) bycatch can be recorded. Currently CDFW does not have a program for collection of individual length frequency data with guaranteed consistency through time. Such a program would expand CDFW's options for calculation of fishing mortality with potentially greater accuracy, distinguishing processes effecting lobster life stages differentially, and tracking cohorts through time. Length frequency data from the recreational fishery would be similarly valuable and is not well represented by lengths in the commercial fishery because recreational fishermen are able to target larger individuals. CDFW does not expect that size information could be accurately collected on recreational report cards and creel surveys would be most effective.

Abundance of the legal-sized individuals can help assess present harvest rate and future catches. CDFW has calculated legal-size lobster abundance based on CDFW-collected commercial catch data in the past, but these estimations have relatively coarse spatial resolution. Finer geographical-scale estimations have also been made (e.g., Hovel and Neilson 2011; Kay et al., 2011; Iacchei et al., 2005). CDFW has participated in new local studies to help fill the gaps between the previous studies, especially those pertaining to the southern portion of the bight.

The number of sublegal-size lobsters captured by the commercial fishery is being recorded in logbooks, and with improved tagging studies, comparisons of sublegal-size abundance across space and time can be adjusted to more accurately reflect the abundance of sublegal-size lobsters. Information on the sex ratio of the stock was recently collected by California Sea Grant's at-sea sampling program and CDFW is not planning any new monitoring effort to directly obtain information on stock sex ratios. Continued sex ratio information could be used to improve population model output and would be important if a sex-selective fishery were considered in the future.

In addition, research that describes invertebrate population changes in California MPAs is also an ongoing priority within CDFW to inform adaptive management of the State MPA network. MPAs affect lobster stock composition by producing large and localized increases in lobster average size and abundance inside reserve borders (Diaz et al., 2011). New information on the cumulative biomass and reproductive potential of the lobsters inside reserves can then be incorporated into the estimates for *F*, SPR, or other measures of stock size used in this FMP. CDFW's information on these parameters ranges from poor to rich, and obtaining better information is of the highest priority. This effort will potentially span decades as various components of the coastal ecosystem rebuild to pre-exploitation level.

Other EFI – Habitat Coverage by Type

An accurate estimation for the total percentage of CA lobster habitat that is contained within MPAs is an important input for the calculation of SPR (Section 4.3.1.3). CDFW obtained the current estimate by calculating the percentage of shallow hard-bottom habitats (0-100 m depth, 0-328 ft) that are protected by MPAs prohibiting both commercial and recreational take. This estimate utilizes the maximum extent of kelp canopy as a proxy for hard-bottom habitat in areas where seafloor mapping data are not available. Incorporation of other habitat types such as tidal flats and eelgrass beds is currently not appropriate either because the extent to which CA lobsters utilize these habitats is unclear, or because there is limited spatial data detailing the extent of these areas. Overall, CDFW possesses a moderate amount of information related to habitat coverage; better assessment of these areas is of the highest priority (Table 5-1). CDFW will continue to incorporate new information to better calculate the current state of the population's spawning potential, as well as to better estimate the baseline condition during the period of stability in the early 2000s, which is necessary to improve the SPRTHRESHOLD.

Table 5-1: Categories of EFI identified by the MLMA Master Plan and specific data types and their priorities for research identified by this FMP.

Biological EFI Category (MLMA)	Specific data types used in fisheries management	Current status of knowledge *(poor, moderate, rich)*	Priority for management and FMP *(low, medium, high, highest)*	Data collection methods												
				Logbooks	Landing Receipts	Rec. report cards	At-Sea Sampling	Port sampling	Creel sampling	Research traps	Research SCUBA	MPA monitoring	Larval collectors	Lab studies	Oceanography	Genetics
Age and growth	Individual growth rates	moderate	high				S	S	S	P		P		S		
	Longevity (max age and size)	poor	high									P				
Stock distribution	Catch relative to fishing blocks	rich	low	P	P					P		S			S	
	Genetic population structure/larval mixing	moderate	medium													P
Ecological interactions	Role as predators (e.g., to control grazers)	moderate	low								P			S		
	Essential habitat (e.g., surfgrass / shelters)	rich	medium								P			S		
Indices of abundance	Catch (per season)	rich	**highest**		P	P			P							
	CPUE	rich	**highest**	P		P	P			P						
	Visual surveys on seafloor	moderate	low								P					
	Larval abundance	moderate	medium										P			P
Movement patterns	Seasonal/annual movement distances	moderate	medium				P			P						
	Nightly foraging distances	moderate	medium							P	P					
Recruitment	Source and sinks for larvae	poor	medium										P		P	P
	Larval abundance and recruitment	moderate	medium										P		P	
	Sublegal-size lobster abundance	poor	**highest**	P			P			P	S		S			
Reproduction	Size at maturity (SAM)	moderate	high				P			P		S		P		
	Fecundity	moderate	high							P		S		P		
Total mortality	Natural mortality	moderate	high							P		P				
	Fishing mortality (harvest rates)	moderate	**highest**	S	S		P			P		P				
	Handling mortality and sublethal impacts	poor	medium							P	P					
Stock composition	Size structure of stock (length frequency)	moderate	**highest**				P	P	P	P		P				
	Selectivity of length frequency sampling gear	poor	**highest**							P		P				
	Mean size of lobsters in catch	rich	**highest**	P	P		P	P		S						
	Effects of MPAs on size and abundance	moderate	**highest**				S			P	S	P				
Habitat coverage	% of a habitat type covered by MPAs	moderate	**highest**				P			P	P				S	

For each data type, descriptions are provided for the current status of knowledge and the priority of improving data collection for management under this FMP (i.e., importance for assessing, monitoring, and maintaining sustainability of the fishery). Finally, data collection methods that are best suited to obtaining each data type are indicated. (P = primary data source; S = secondary data source).

5.3 Socioeconomic EFI: Update on the 2013 Economic Report

The purpose of socioeconomic EFI is to help inform CDFW of the social and economic impacts of potential regulatory actions (CDFG, 2001). The MLMA Master Plan characterized the CA lobster fishery as data poor back in 2001. Various socioeconomic aspects of the fishery have since been analyzed first in a 2009 report and again in 2013 (Hackett et al., 2009; Appendix VI; Section 2.5). CDFW will continue to pursue similar studies in the future to update established knowledge and fill any knowledge gaps. In particular, future survey efforts should track the popularity of hoop nets as well as improve estimates on groups that have been sparsely sampled in previous socioeconomic surveys (Section 2.2).

Employment

The commercial CA lobster fishery was responsible for an estimated 323 full-time equivalent jobs during the 2011-12 fishing season. The commercial fishery was also responsible for a total estimated economic effect of over $22 million in southern California over the same fishing season (Appendix VI). Analysis of the economic effects of the recreational fishery has not been done.

Expenditure

Analysis of the expenditures for both the recreational and the commercial fisheries during the 2011-2012 fishing season indicate that the Commercial fishery expended ~$10.5 million and the recreational fishery expended ~$40.8 million.

Resource Demand

The MLMA master plan defines resource demand as “the relationship between the quantity and quality of a good or service, and demand by the user at various market price or cost” (CDFG, 2001). Neither the 2009 nor the 2013 reports on the CA lobster fishery focused on this particular issue. However, recent increase in foreign demand and the associated rise in ex-vessel value for CA lobster show that better analyses on market demand may become increasingly important for effective fishery management.

Revenue

Revenue includes revenue from both sales conducted within the coastal community and sales through exports (CDFG, 2001). The ex-vessel value of lobsters landed in the 2011-12 fishing season was estimated at ~$12.9 million. The revenue earned by supporting industries (e.g., boatyards, trap makers, etc.) is also part of the economic impact of the commercial fishery, and it has been estimated to be just under $5 million per year between the 2009-10 and the 2011-12 fishing seasons (Appendix VI). However, as with the employment EFI, revenue for the supporting industry of the recreational fishery has not been calculated, and at this point can only be inferred from the sector’s expenditure.

User/Industry Demographics

The demographics of the current commercial fishermen have not been analyzed. However, 86% of the recreational fishermen come from zip codes that are within 50 miles of the coastline (Appendix VI). Sport fishermen from further inland spend a disproportionately higher amount of money on their recreational trips (Appendix VI).

5.4 Cooperation and Collaboration in Fisheries Research

Globally, involvement of multiple stakeholders in fisheries research (e.g., the collection of fishery-dependent EFI) is increasing as researchers, managers, and fishermen expand communications and partnerships. The level and type of this involvement by stakeholders can differ widely. Research that involves stakeholders in some specific aspect of the project is considered cooperative research. In cooperative research, each stakeholder may focus their resources on one aspect of the research or may work jointly on one or several parts of the project (e.g. collecting data aboard a vessel provided by another stakeholder). Collaborative research, like cooperative research, brings stakeholders together to work towards a common goal. However, true collaborative research also involves stakeholders during all phases of research including hypothesis generation, data collection, and interpretation of results (NRC, 2004; Wendt and Starr, 2009).

Wendt and Starr (2009) add the caveat that true collaborative research also includes a joint intellectual effort during all phases of the research. While the distinctions between these two types of research are conceptually distinct, in most cases multi-stakeholder research is neither purely cooperative nor purely collaborative, but a continuum between the two as determined by the specific stakeholder involvement (NRC, 2004).

Cooperative and collaborative fisheries research (CFR) hold significant potential to improve fishery management by increasing the quantity of data collected (Karp et al., 2001; NRC, 2004) as well as improving communication, understanding, and trust between managers and stakeholders (McCay and Jentoft, 1996; Conway and Pomeroy, 2006; Wendt and Starr, 2009). In cases where the knowledge and skill of the stakeholders is successfully incorporated, CFR can also result in increasing the quality of data collected (NRC, 2004; Wendt and Starr, 2009).

While these benefits can be significant, they must also be weighed against the cost of conducting CFR. Elements for evaluating and prioritizing CFR include the expected benefits, the expected research costs, and the expectations for success (NRC, 2004).

Fishery participation in data collection and management is an integral part of some lobster fisheries (Phillips and Kittaka, 2000). In certain fisheries, industry participation focuses mostly upon CFR, in large part because it is cost-effective. However, because of its tight links to co-management, CFR can provide a bridge to locally-based co-management systems that may increase fishery sustainability (Wilson et al., 2003; Gutiérrez et al., 2011). Consequently, industry participation in other fisheries includes co-management arrangements in which industry directly participates in structuring harvest regulations. Important examples of lobster fisheries with CFR and co-management agreements include *P. interruptus* in Baja, Mexico (Scientific Certification Systems, 2011; Phillips et al., 2013), *H. americanus* in Maine (ASMFC, 2009; Acheson and Gardner, 2010), and *J. edwarsii* in some fishing communities in New Zealand (Miller and Breen, 2010).

Collaborative research and/or co-management can also be furthered when members of the commercial fishery and the recreational fishery form organizations to exchange information and perspectives as well as to represent them during government processes. This FMP does not preclude future improvement to the HCR or better management alternatives, and the stakeholder community should encourage initiatives that further sustainability and fisheries performance as long as they adhere to the MLMA objectives. Fishermen are encouraged to collaborate on their own initiatives and to form community organizations to help inform management. An example of this type of arrangement is the California Sea Urchin Commission. Furthermore, interested parties may wish to work with CDFW and the Commission to develop innovations not explicitly mentioned in this FMP. These can include, but are not limited to, gear innovations, monitoring tools, regional management, and other technological advances.

6. Implementation and Amendment Process of the FMP

6.1 Implementation

The implementation of this FMP can be divided into 3 categories: 1) enforcement, 2) research and monitoring, and 3) management.

6.1.1 Enforcement

CDFW Law Enforcement Division (LED) officers patrol the coast and offshore islands off southern California on a daily basis. They also conduct inspections of landings, wholesale and retail facilities, restaurants, and vehicles used to transport fish. These officers serve to ensure compliance with CDFW regulations, including the ones that will result from this FMP, through both education and enforcement actions. They also collaborate with CDFW scientists to conduct research activities, participate in management activities, and provide on-the-ground information to management. Active enforcement is important to help ensure the estimated benefits to the stock from harvest regulations (e.g., MPAs, size limit, etc.) are realized.

6.1.2 Research and Monitoring

Chapter 4.7 outlines and discusses how CDFW will continue to monitor the CA lobster fisheries and to improve upon the existing state of knowledge regarding the fisheries and the species. These efforts include both primary research aimed at obtaining and refining the EFI as well as periodic monitoring of fishery-dependent data, such as information generated from the recreational lobster report cards and commercial landing receipts and logbooks.

6.1.3 Management

The Marine Life Management Act requires that "[f]ishery management decisions are adaptive and are based on the best available scientific information and other relevant information" (FGC § 7056(g)). Furthermore, management systems should be periodically reviewed for their effectiveness and fairness (FGC § 7056(m)). The CDFW will analyze and act on the results of research and monitoring efforts as appropriate to better inform the management framework outlined in the FMP. The ongoing and potential research efforts described in the previous chapter are expected to yield new useful information regarding the CA lobster stock and fisheries.

By design, the HCR is adaptive in nature. The ocean is a dynamic environment; requiring very specific action could lead to improper management responses. The HCR directs CDFW to investigate the underlying causes of any significant change relative to the threshold reference points. Refinement with the most up-to-date information will always be part of this process, as will active solicitation of input from stakeholders in interpreting the data. Once the underlying cause of a change is identified, CDFW will undertake analysis (e.g., using the MSE model, constituent input, etc.) to determine the most appropriate course of action.

CDFW will continue to seek input from the various constituents as appropriate. CDFW will also bear the primary responsibility of conducting other future amendment processes. To facilitate active oversight and proactive management, CDFW projects that CA lobster management will require a minimum of two full-time dedicated scientific staff positions and one scientific aid position in the future. The scientific staff will be responsible for overseeing the commercial data collected from the trap logs and the landing receipts and the recreational data collected from the lobster report cards. The staff will also be conducting and coordinating future research and public outreach efforts. The dedicated scientists will also be responsible for monitoring the threshold reference points and advising CDFW management of the status of the fisheries and the stock.

6.1.4 Cost

Costs associated with lobster management as outlined in this FMP can be divided into two categories: 1) regular and ongoing research and management and 2) investigations that may be prompted by the HCR on an unknown and irregular basis. Ongoing management will include all of the biological and enforcement tasks associated with existing regulations and statutes as well as proposed regulatory changes associated with this FMP. The annual cost estimates outlined in Table 6-1 are a minimum. Estimated personnel costs are based on current rates which will rise in the future.

Monitoring the reference points outlined by this FMP and managing the current data streams will require a minimum of three CDFW Marine Region biological personnel dedicated exclusively to CA lobster. These include one environmental scientist already on staff plus one new environmental scientist and one new scientific aid to be hired. Staff benefits and overhead rates of 47.66% and 35.00% were applied, respectively.

The enforcement costs for the CA lobster fisheries totaled $ 493,463 for the 2013-14 fishing season. Officer hours accounted for $206,792 and $286,671 was attributed to patrol crafts' fuel and maintenance. It is not known how new regulations associated with this FMP will impact costs and therefore past costs should be considered the minimum of what may be required in the future. Aspects of recreational hole-punching of CA lobster tails and the commercial trap limit are likely to both require additional effort from enforcement staff and also improve enforcement efficiency. In total, CDFW expended 3,142 regular officer hours at an average of $47.09 per hour and 833 overtime hours at an average of $70.63 to regulate the commercial and recreational fisheries. Of this, 1,758 regular officer hours and 454 overtime hours were expended to enforce recreational statutes and regulations on shore. Enforcement of statutes and regulations from patrol crafts required 804 regular hours and 279 overtime hours. An additional 581 regular hours and 102 overtime hours were expended to enforce commercial laws and regulations that were not otherwise covered by vessel-based enforcement actions.

When HCR reference points are crossed, investigation of the underlying causes will be required. The scope of those investigations will depend on the number and identity of the reference points below threshold and their position. Scenarios of lesser concern may be investigated by examining existing data streams and require only some additional staff time from Marine Region staff not dedicated to lobster. Scenarios of greater concern may require dedicated field research efforts. This would involve equipment and travel costs, additional staff time, and possibly contracts with outside entities.

Table 6-1: Estimated Annual Implementation Costs.

Biological Personnel	New Environmental Scientist	Existing Environmental Scientist	Scientific Aid	Subtotal
Salaries & wages	72,702	72,702	23,000	
Staff benefits	34,650	34,650	10,962	
General expenses	6,000	6,000	1,500	
Other Expenses	20,000			
Overhead	46,673	39,673	12,412	
Biological personnel total	180,025	153,025	47,874	380,924
Enforcement (personnel & equipment combined)				493,463
ONGOING MANAGEMENT TOTAL				874,387

6.2 Adjustment and Amendment to Administration, Regulations, and the FMP

Under the FGC, each FMP "shall include a procedure for review and amendment of the plan, as necessary" (FGC § 7078). In particular, an FMP shall specify the type(s) of regulations that CDFW can adopt without amendment(s) to the FMP (FGC § 7087(b)). In addition to the type of regulations that can be adopted without an FMP amendment, this section will also prescribe the conditions of changing the FMP. This section does not apply to routine day-to-day CDFW operations.

6.2.1 Regulatory Amendments that Do Not Warrant FMP Amendments

The Commission can adopt new regulation concerning the CA lobster fishery without amendment to the FMP. These may include regulations designed to improve the orderly operation of the fisheries or more efficient conservation of the relevant resources. The LAC recommendations are examples of these regulations. This section does not modify CDFW's and the Commission's authority to promulgate regulations during emergencies (e.g., FGC § 240, GC § 11349.6).

6.2.2 When and How the FMP Will Be Amended

If new, relevant information becomes available, an FMP amendment based on that information may be appropriate. Not all changes to management procedures outlined in this FMP would prompt an amendment. For example, addition of a new or removal of an existing reference point would require amendment but refining parameters or calculations within the Cable-CDFW model using new EFI data would not require amendment. Any amendment that would affect an existing regulation or requires new regulations would be accompanied by a regulatory amendment proposal for the Commission.

CDFW may propose an FMP amendment out of its own initiative and discretion. In this case, CDFW will solicit input from Tribes, stakeholders, and the Commission. CDFW will provide Tribes and stakeholders with the relevant schedule and agenda. They will have at least 30 days to review the proposal prior to the hearing. CDFW may submit the proposal to the Commission after 30 days, or it may hold further public meetings before submission (see also FGC § 7077). Interested parties may also propose plan provisions or amendments to either CDFW or the Commission. Existing CDFW and Commission workload and priorities may affect the timeliness of the Commission's response to petitions.

An FMP amendment can be focused on a particular part of the document; an amendment process should not automatically trigger the amendment of the entire FMP. However, an amendment on one part of the FMP should not contradict another part. Adopting a new type of reference point not contemplated in Section 4.3 HCR is one example. Changing or replacing a threshold reference point should not automatically trigger a review of the entire natural history of the CA lobster, but such a change must not contradict other parts of the HCR that are not being amended.

6.3 List of Inoperative Statutes

The implementing regulations of this FMP will render the following sections of the Fish and Game code inoperative once they are adopted:

1. FGC § 8251: This section dictates the season length for the commercial CA lobster fishery. The HCR prescribed by this FMP incorporates changes to season lengths as a possible management adjustment.
2. FGC § 8252: This section prescribes the size limit for the commercial sector, which is identical to the recreational sector limit found in the CCR. The commercial limit will be moved into Title 14, CCR reflecting the Commission's authority to make adjustment.
3. FGC § 8254(c): This section states an annual lobster permit fee of $265. The permit fee will change due to implementation of the trap tag program.

4. FGC § 8258: This section lists the Districts where commercial lobster traps may be used to take CA lobster. The use of commercial traps to take CA lobster in certain Districts may change if the District closure option within the harvest control rule toolbox is used.

This FMP will render the following sections of the Fish and Game code inoperative as applied to only the CA lobster fisheries once the implementing regulations are in place:

1. FGC § 7857(e): This section prohibits CDFW from issuing more than one of a single type of permit, including a lobster permit, to a single fisherman. The trap limit program envisioned by the FMP may allow fishermen to stack multiple permits, and thus this section will be rendered inactive for lobster operator permits.
2. FGC § 7857(j): This section prohibits the transfer of a commercial fishing license, permit, or other entitlement. This section will be made inoperative to be consistent with the objectives of this FMP related to permit transferability and the acquisition of a second permit as part of the proposed trap limit program.
3. FGC § 8102: This section states the conditions for issuing limited entry permits to a working partner of a permit holder in cases where the permit holder dies, is incapacitated or retires. This section will be made inoperative as it applies to the spiny lobster fishery to be consistent with the commercial spiny lobster limited entry fishery permit program and trap limit program as described in the FMP.
4. FGC § 8103: This section states the conditions for transferring limited entry permits upon the death of the permit holder. This section will be made inoperative as it applies to the spiny lobster fishery to be consistent with the commercial spiny lobster limited entry fishery permit program and trap limit program as described in the FMP.
5. FGC § 9004: This section requires commercial fishermen to service any deployed trap every 96 hours. However, proposed regulations will extend this servicing requirement to every 168 hours. As such, this section will be rendered inoperative as applied to the spiny lobster fishery.

Glossary

Abundance - The total number of animals in a population. This is rarely known, but usually estimated from relative abundance (see **Relative abundance**), although other methods may be used.

Adaptive management - In regard to a marine fishery, means a scientific policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that even if they fail, they will provide useful information for future actions. Monitoring and evaluation shall be emphasized so that the interaction of different elements within the system can be better understood.

Advisory Committee - The Advisory Committee is a body composed of public constituent representatives that provide important advice to the spiny lobster fishery.

Allocation - In the LFMP, allocation means a certain amount of lobster set aside for recreational, commercial, and ecosystem needs.

Bag limits - The total amount of fish or other species that may be captured per person per day by law.

Benthic - On or relating to the region at the bottom of a sea or ocean.

Biomass (B) - The total weight of organisms at a given point in time in a defined stock, area, population, or catch.

Bycatch - Fish or other marine life that are taken in a fishery but are not the target of the fishery. Includes non-target organisms whether or not they are discarded, and includes organisms discarded because they are of an undesirable species, size, sex, or quality, or because they are required by law not to be retained.

Cable-CDFW Model - A simplified and efficient fishery stock model developed for the California spiny lobster by Dr. Richard Parrish. CDFW currently uses this model to calculate the SPR of the stock.

Capacity - The potential ability of a vessel or a fleet of vessels to capture organisms. This ability is based on the number of fishing vessels in the fleet, the size and technical efficiency of each vessel, time spent fishing, and management regulations.

Catch Per Unit Effort (CPUE) - The rate at which fish are caught; typically expressed as a number or weight of fish captured per unit of effort. Units of effort can be assigned many ways, including the time spent fishing (hours or days), the amount of fishing gear deployed (number of vessels, traps, nets, etc.), the number of times that fishing gear is deployed and retrieved (e.g., net hauls, trap pulls), or a combination of these estimates. Because it is difficult and expensive to scientifically measure the number of fish in an area (abundance), CPUE is often used as an index for the relative abundance of organisms across time or space. For CA lobster, CPUE is typically defined as the number of legal (or sublegal-sized) lobsters per trap pull for the commercial fishery, and number of legal lobsters retained per fishing trip for the recreational fishery. Effort is most often described in terms of trap pulls, total traps, and number of active permits for the commercial fishery, and number of fishing trips for the recreational fishery.

Commercial fishery - Describes a group of enterprises and individuals as well as their actions associated with fishing for certain species with the intent of selling the catch.

Commission – California Fish and Game Commission

Conical hoop net - A modified style of hoop net used to catch lobster by the recreational lobster fishing sector in California; it is basket shaped, does not collapse, and does not lie flat on the seafloor.

Creel survey - Catch information gathered from recreational sources.

California Recreational Fisheries Survey (CRFS) - The California Recreational Fisheries Survey (CRFS) is the method for estimating total marine recreational finfish catch and effort in California. The CRFS is a coordinated sampling survey designed to gather catch and effort data from anglers in all modes of marine recreational finfish fishing.

Department - In the context of the LFMP, refers to the California Department of Fish and Wildlife (CDFW).

Depleted/Depletion - Exploitation of a resource down to unsustainable levels.

Depressed fisheries - The condition of a fishery for which the best available scientific information and other relevant information that the Commission or Department possesses or receives, indicates that a declining population trend has occurred over a period of time appropriate to that fishery. With regard to fisheries for which management is based on maximum sustainable yield, or in which a natural mortality rate is available, "depressed" means the condition of a fishery that exhibits declining fish population abundance levels below those consistent with maximum sustainable yield.

Economic output - Represents deliveries of final goods and services by the sector to domestic households, investment, government and non-profit institutions, and net exports outside the local economy.

Economic overfishing - Fishing levels that exceed maximum economic yield.

Ecosystem - The physical and climatic features and all the living and dead organisms in an area that are interrelated in the transfer of matter and energy, which together produce and maintain a characteristic type of biological community. Ecosystems can range in size.

Effort - A measure of some expenditure in pursuing an activity. The measure in CA lobster fishing effort is usually in terms of number of trap pulls, traps fished (in commercial fishery), number of fishing trips, or time spent fishing.

Effort Creep - A phenomenon where technological advancements in a fishery are able to mask the declining efficiency of a fishery caused by stock declines.

El Niño - A periodic warming of the ocean surface waters in the eastern Pacific Ocean. It is characterized by a lack of upwelling of cold, nutrient-rich waters nearshore.

Essential fishery information (EFI) - With regard to a marine fishery, means information about fish life history and habitat requirements; the status and trends of fish populations, fishing effort, and catch levels; fishery effects on fish age structure and on other marine living resources and users; and any other information related to the biology of a fish species or fishery that is necessary to inform management.

Ex-vessel price/Ex-vessel value - The value of fish at first sale by fishermen at the dock, distinguished from wholesale or retail value.

Fecundity - The reproductive capacity of an individual female animal during a reproductive event or breeding season, generally expressed as the number of eggs or larvae per unit weight or per individual.

Finfish – Any species of bony fish or cartilaginous fish (sharks, skates and rays). Finfish do not include amphibians, invertebrates, plants or algae.

Fishery - Fishing for, harvesting, or catching one or more populations of marine fish or marine plants that may be treated as a unit for purposes of conservation and management and that are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics.

Fishery-dependent data - Information collected directly from or during the process of fishing, or from fishery landing data. May be collected from commercial and/or recreational sources, and may include catch/effort reported by fishermen, size and age composition of the catch, and biological samples collected at port.

Fishery-independent data – Scientific research to collect information that is independent of commercial or recreational fishing operations. Surveys utilizing commercial fishing gear may provide unbiased estimates of abundance. Surveys may also use other methods (e.g., acoustics, SCUBA, video) to collect other biological or ecological information (e.g., movement, migration, growth rates, natural mortality) relevant to a fishery.

Fishing mortality (F) - The rate at which organisms in a population die due to fishing.

Growth overfishing - Fishing in which yield per recruit is lower than theoretical maximum values due to the removal of small and rapidly growing fish.

Habitat - The physical, chemical, and biological features of the environment where an organism lives.

Harvest control rules (HCR) -Harvest control rules are plans of action that prescribe adjustments in harvest regulations (e.g., fishing effort, total allowable catch, minimum legal size) which are activated when the calculated amount of a resource that can sustainably be taken (known as a "reference point threshold") is reached or surpassed. Harvest control rules must be based on objective, measurable criteria (reference points) such as population size, productivity, density, or other inputs.

Harvest rate (u) - The percentage of legally harvestable individuals in a population that are removed each year due to fishing.

Harvest regulations - The rules that define how fishermen are allowed to harvest fish. Harvest regulations are diverse and include restrictions on size of animals harvested, effort, total catch, gear types, season, or location where fishing is permitted.

Hoop net - A round net used to catch lobster by the recreational lobster fishing sector in California; it traditionally lies flat on the seafloor and assumes a basket shape upon retrieval to the surface.

Indices of Abundance - Measurements of the abundance of an organism made over time; used to make inferences about the abundance of an entire population.

Individual transferable quota (ITQ) - A program which limits the catch allowed per license or individual as well as the number of individuals who participate.

Input (from **stock assessment models) -** The numerical parameters provided to a stock assessment model; these can be a biological parameter such as the growth rate of the species, or it can be a management parameter, such as the legal size limit.

Intertidal - The part of the shore that lies between the low and high water lines.

Instantaneous Fishing mortality (F) - The rate at which organisms are harvested or killed due to fishing; F is an instantaneous rate that reflects the rate at which a proportion of a population is being lost, whereas the harvest rate (*u*) is an annual rate that reflects the rate at which a number of fish from a population is being lost.

Landing receipt - A document provided by the Department to commercial fish markets for recording landing information. Information required includes date, port of landing, species or market category of fish, pounds landed, and price paid.

Landings - The number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the points where fish are brought to shore.

Length frequency distribution - A graphical representation of the number of organisms by length.

Life history - The history of changes an organism passes through in its development from egg, spore, or other primary stage until its natural death.

Limited entry program - Regulatory program that restricts the total number of permitted fishing licenses or vessels.

Lobster Advisory Committee - A committee composed of representatives for the recreational fishery, the commercial fishery, environmental interest groups, scientific experts, non-consumptive recreational interest groups, and federal resource managers; the committee was responsible for providing crucial constituent inputs during the drafting process of this FMP in the form of a consensus recommendation.

Logbooks - Records of fishing activity and catch maintained by commercial fishermen. Typically used to estimate CPUE in assessment models.

Management strategy evaluation (MSE) - For the purposes of the CA lobster FMP, the MSE is a computer model that simulates lobster population dynamics, designed by a team led by Dr. Yong Chen, University of Maine. The MSE was designed to allow CDFW to monitor and evaluate the effects of management measures and the lobster fisheries on the lobster population. The model will not be ready for use until CDFW adapts its scripts to the state's fishery management framework.

Marine Life Management Act (MLMA) - The Marine Life Management Act (MLMA), which became California law January 1, 1999, calls for using several tools to meet its goals of conserving entire ecosystems, placing value on non-consumptive benefits, sustainability, habitat conservation, restoring depressed fisheries, limiting bycatch, and recognizing the interests of people dependent on fishing. FMPs are one of those tools.

Marine Life Protection Act (MLPA) - The MLPA, enacted in 1999, required the California Department of Fish and Wildlife to develop a Marine Life Protection Program, including a Master Plan for a network of Marine Protected Areas (MPAs) within state waters. The network of MPAs includes an improved State Marine Reserve (complete no-take areas) component and other classifications of MPAs (State Marine Parks and State Marine Conservation Areas). The goals of the MLPA are varied and include protecting portions of ecosystems in a variety of habitats, preserving biodiversity, and helping to sustain and protect populations of fished species.

Marine protected areas (MPAs) - Areas closed to all fishing, or to specific user groups, or to the take of certain species; they are used to geographically limit effort and to protect portions of stocks as well as various ecosystem services and non-consumptive uses.

Maximum economic yield (MEY) - The maximum possible revenue after accounting for the costs of fishing that may be achieved in a fishery. MEY typically is reached at smaller catches than MSY.

Maximum sustainable yield (MSY) - In a marine fishery, means the largest catch that can be taken from a stock continuously over time that does not result in a continuing reduction in stock abundance, assuming constant environmental conditions. MSY is generally presented as a maximum annual catch that can be maintained indefinitely; however, MSY can change with fluctuations in abundance and environmental variability (e.g. shifts in ocean regimes), requiring adjustments in allowable harvest.

Natural mortality (M) - The rate at which organisms in a population die due to natural causes.

Nearshore - All oceanic state waters within 0-3 miles from shore or less than 100 fathoms deep, whichever is greater.

Nocturnal - Relating to, or occurring at night.

Non-consumptive uses - Activities which involve the specified resource but no harvest is involved.

Offshore - All oceanic waters outside state waters or deeper than 100 fathoms (for comparison see **Nearshore**).

Optimum Yield (OY) - With regard to a marine fishery, means the amount of catch taken in a fishery that: 1) provides the greatest overall benefit to the people of California, particularly with respect to food production and recreational opportunities, and takes into account the protection of marine ecosystems; 2) is the maximum sustainable yield of the fishery, as reduced by relevant economic, social, or ecological factors; and 3) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing maximum sustainable yield in the fishery. Optimum yield should be no greater than maximum sustainable yield.

Output (of stock assessment models) - The substantive predictions of a model; for this FMP, it usually corresponds to the reference points.

Overfished - A stock that is at unacceptably low levels because it has experienced overfishing and a reduction of take in the fishery is the principal means for rebuilding the stock.

Overfishing - Means a rate or level of take that the best available scientific information indicates is not sustainable or that jeopardizes the capacity of a marine fishery to produce the maximum sustainable yield on a continuing basis. The depletion of fish stocks to unacceptably low levels. See **Growth overfishing, Recruitment overfishing, and Economic overfishing**.

Pelagic - Of or relating to aquatic organisms that live in the ocean without direct dependence on the shore or bottom.

Physiological - Of or relating to the normal functioning of an organism.

Plankton - Very small organisms that passively drift with tide and current.

Planktonic - Of or related to **plankton.**

Population - A species, subspecies, geographical grouping, or other category of fish capable of management as a unit.

Productivity - Describes the birth, growth, and death rates of a stock. A highly productive stock is characterized by high birth, growth and mortality rates, and as a consequence has a high turnover. Such stocks can usually sustain higher exploitation rates and, if depleted, could recover more rapidly than comparatively less productive stocks.

Proxy - A number that is used as a substitute for another number. In fisheries management, landing information is often used as a proxy for other types of information not yet available.

Recreational fishery - Describes a fishery associated with taking of any fish for any purpose other than profit.

Recruit - An organism entering the exploitable stage of its life cycle; or a larval or juvenile organism as it settles or appears in the adult ecological niche. See **Recruitment**.

Recruitment - The process, event, or rate by which individuals enter new life stages or segments of a population. *Larval recruitment* refers to the process or event by which larvae of marine species exit the planktonic life stage. *Fishery recruitment* (or, recruitment to the fishery) refers to the moment that an animal becomes vulnerable to capture in a fishery – usually because it has attained some minimum size or age for harvest.

Recruitment overfishing - Fishing that depletes the mature adult population (spawning stock) to low levels at which reproduction (and subsequent recruitment) is inadequate to replenish the population.

Reference points (biological reference points) - Reference points are quantitative (numerical) values that inform managers about the current status of a stock. Two important types must be considered, target and threshold (or limit) reference points. *Target reference point* is a numerical value that indicates that the status of a stock is at a desirable level; often management is geared towards achieving or maintaining this target. *Threshold (limit) reference point* is a numerical value that indicates that the status of a stock is unacceptable (e.g. overfished or too small), and that management action should be taken to improve stock status.

Relative abundance - Usually measured with indices that track trends of a population biomass (e.g., CPUE) over time. It is not a direct or (usually) precise estimate of biomass.

Report card - A mean of collecting fishery-dependent data on the recreational lobster fishery in California. Lobster report cards collect information on the number of people recreationally fishing for lobster each year, the gear they use, and their harvest and success rates. Required since 2008 for all persons fishing recreationally for lobster in California.

Scavengers - Animals that feed on dead or decaying organisms.

SCUBA - "Self-Contained Underwater Breathing Apparatus" utilized by the recreational lobster fishing sector in California to catch lobster by hand. **Settlement -** In marine ecology, it means the process by which organisms change from a pelagic larval life history phase to assume a new mode of life as a member of a sea-floor community. For CA lobster, it is the stage at which pueruli (late-stage larvae) settle to nearshore, surfgrass habitat.

Size at maturity (SAM) - The size at which 50% of animals in a population have reached sexual maturity and are capable of reproduction.

Size limit - The minimum size a fish or other organism must be for it to be possessed.

Skin diving - Breath hold diving (freediving) utilized to catch lobster by hand by the recreational CA lobster fishing sector in California.

Southern California Bight (SCB) - The coast and its immediate offshore areas between Point Conception to the north and the U.S. – Mexico border to the south. The curvature of the coastline and the relatively shallow depth of the area lead to oceanographic and biological characteristics that are clearly distinguishable from the central California coast.

Spawning potential ratio (SPR) - A ratio of the number of eggs produced during the lifetime of an average female in a fished population to the number of eggs produced during the lifetime of an average female in an unfished population; used to characterize the amount of impact fishing has on a population's ability to reproduce.

Spillover - The emigration of adults from a protected area to the fishing grounds, and/or larval export from the protected area to surrounding areas.

Stock - A group of fish of the same species in a given management area. A single stock may be comprised of multiple populations or be a portion of a single larger population.

Stock assessment - An evaluation of the status of a stock, including past and current stock levels and information to help guide future harvest. Assessments may integrate many different biological data, including growth rates of fish, mortality rates, age at first reproduction, fecundity, size classes present in the catch, and selectivity of fishing gear.

Stock Composition - Any description of the population attributes of a stock (age, size, sex), usually within a spatial context. This commonly refers to the spatial distribution of breeding groups or genetically-related organisms.

Stock Size - Total estimated number or biomass of fish within a stock.

Substrate - The surface or medium on or in which an organism lives (i.e., mud, sand, rocks).

Sustainable, Sustainable use, and Sustainability - With regard to a marine fishery, means both of the following: 1) continuous replenishment of resources, taking into account fluctuations and environmental variability; and 2) securing the highest possible present and long-term social and economic benefits, maintaining biological diversity, and managing fisheries in a way that does not exceed **optimum yield**.

Thresholds (threshold reference points) - For the purpose of this FMP, the levels of stock size or reproductive potential that are not sustainable.

Total allowable catch (TAC) - A specified numerical catch (including discard mortality) for each fishing season, the attainment (or expected attainment) of which may cause closure of the fishery.

Total allowable effort (TAE) - A specified numerical effort objective for each fishing season. This can be expressed in number of boats, amount of gear used, etc.

Total economic output - The total amount of economic output that does not take into account the amount of intermediate goods consumed during the harvest/production process. For CA lobsters, this means the amount of money generated before costs such as trap cost are considered. Also known as Gross Economic Output.

Total economic value added – Total economic output less the goods and services used up to create that output. For the CA lobster fishery, it means the net value after costs like trap purchases are accounted for. Also known as Net Economic Output.

Total mortality - Natural mortality and Fishing mortality combined.

Traps - Generally, a wire basket or cage used for trapping certain types of organisms.

Trap limit - A type of regulatory measure that restricts the number of traps a fisherman may simultaneously utilize within a given season.

Unfished biomass - The unfished or pristine biomass.

Upwelling - On the California coast, upwelling is the upward movement of deep waters into the nearshore ecosystem due to springtime winds moving the topmost layers of water away from land.

Yield - The total number or biomass of fish captured.

Yield per recruit (YPR) - A theoretical value that describes the yield to a fishery that is contributed by a given number of recruits (usually a single recruit).

Zooplankton - Small animals passively carried along with water currents and other water movement.

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<u>Personal Communication</u>

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Appendix I: Letter to Tribal Representatives

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State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Santa Barbara Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

October 10, 2013

Name
Title
Business
Street Address
City, STATE Zip

Dear Honorable [FILL IN FULL NAME], Chairperson:

The California Department of Fish and Wildlife (Department) would like to inform you as a tribal representative that its Marine staff will be writing and compiling a Spiny Lobster Fishery Management Plan (FMP) over the next several months. The Department would like to know if spiny lobster is a culturally significant species to your Tribe, and, if so, if you would like to provide input into the development of the FMP or to seek government-to-government consultation with the Department about the FMP and the management of the spiny lobster fishery.

The Marine Life Management Act requires that the fishery management plan shall form the primary basis for managing California's commercial and sport marine fisheries. The spiny lobster supports important commercial and sport fisheries in southern California, and this FMP will ensure the continued health of the lobster fisheries in California.
The FMP will summarize all the readily available information on spiny lobster and its fisheries including: lobster natural history and population dynamics; fishery landings, regulations, and participants; current management and conservation measures; monitoring of the fisheries; essential fisheries information that is still needed; and a harvest control rule(s) should the lobster resource show signs of being overfished.

The Department has received suggestions and recommendations from various stakeholder groups, and has worked with a Lobster Advisory Committee that was created last year to develop recommendations. The lobster FMP website is: http://www.dfg.ca.gov/marine/lobsterfmp/ .

The Department understands that the spiny lobster fishery may be of interest to some tribes in California, and the Department is soliciting input from tribes. The Department is also committed to understanding tribal interests, if any, relating to the spiny lobster fisheries in southern California before the draft FMP is completed. Next year, the draft lobster FMP will be peer reviewed both scientifically and by the general public. While tribes can provide comments on the spiny lobster FMP at that time, the Department would like to understand tribal interests early in the process.

The Department would welcome your preliminary input on southern California's spiny lobster resource and fisheries by November 15, 2013, so that it might be considered when writing the draft FMP. Please send your comments to Ms. Kristine Barsky, Senior Marine Biologist and Lobster FMP Coordinator, via email at Kristine.Barsky@wildlife.ca.gov or to the address above. If you would like more information on the lobster FMP, or would like to set up either an informal informational meeting or a formal government-to-government consultation, please contact Ms. Barsky at (805) 985-3114.

We look forward to receiving your comments.

Sincerely,

Craig Shuman
Manager of the Marine Region

ec: Steven Ingram, Senior Staff Counsel and Tribal Liaison
Office of the General Counsel
Department of Fish and Wildlife

Sonke Mastrup, Executive Director
California Fish and Game Commission

Tribes contacted for the Lobster FMP process

Tribe Contacted
Costanoan Ohlone Rumsen Carmel Tribe
Fernandeno Tataviam Band of Mission Indians
Gabrieleno/Tongva San Gabriel Band of Mission Indians
Gabrielino Tongva Nation
San Fernando Band of Mission Indians
Tehachapi Indian Tribe
Juaneño Band of Mission Indians
Juaneno Band of Mission Indians Acjachemen Nation
Juaneno Band of Mission Indians Acjachemen Nation
Barona Group of the Capitan Grande
Campo Kumeyaay Nation
Ewiiaapaayp Tribal Office
Inaja Band of Mission Indians
Jamul Indian Village
Kwaaymii Laguna Band of Mission Indians
La Jolla Band of Mission Indians
La Posta Band of Mission Indians
Los Coyotes Band of Mission Indians
Manzanita Band of Kumeyaay Nation
Mesa Grande Band of Mission Indians
Pala Band of Mission Indians
Pauma Band of Yuima
Rincon Band of Mission Indians
San Luis Rey Band of Mission Indians
San Pasqual Band of Mission Indians
Santa Ysabel Band of Diegueno Indians
Sycuan Band of the Kumeyaay Nation
Northern Chumash Tribal Council
Salinan Tribe of Monterey & San Luis Obispo Counties
Coastal Band of the Chumash Nation
Santa Ynez Band of Mission Indians
Viejas Band of Mission Indians

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Santa Barbara Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

October 19, 2015

Contact name
Tribal group name
Address

Dear Honorable Tribal Representative:

The California Department of Fish and Wildlife (Department) would like to inform you as a tribal representative that several items are under development regarding the management of California's spiny lobster fisheries, and we are inviting your Tribe to provide input before these items are submitted to the Fish and Game Commission (Commission) for their possible consideration. In particular, the Department will be delivering two principle items to the Commission during 2015 and 2016: 1) a California Spiny Lobster Fishery Management Plan (FMP), and 2) new spiny lobster commercial and recreational fishery regulations. We anticipate proposing the first item at the Commission's December 2015 meeting and the second item at the Commission's February 2016 meeting. The Department would like to know whether your Tribe is interested in providing input on one or both of these proposed management items. At your discretion, your Tribe's input could be provided during the established provisions under the Commission process for public input beginning in December 2015, or through discussions or formal government-to-government consultation prior to December.

The California Spiny Lobster FMP
The Marine Life Management Act requires that fishery management plans (FMPs) shall form the primary basis for managing California's commercial and sport marine fisheries. The California spiny lobster resource supports important commercial and recreational fisheries in southern California, and this FMP sets a management framework for the fishery to ensure the continued health of the fisheries in California.
The FMP summarizes all the readily available information on spiny lobster and its fisheries including: lobster natural history and population dynamics; fishery landings, regulations, and participants; current management and conservation measures; monitoring of the fisheries; essential fisheries information that is still needed; and a harvest control rule to provide for a sustainable harvest.
The Department has received suggestions and recommendations from various stakeholder groups, and has worked with a Lobster Advisory Committee that was created to develop recommendations. The draft California Spiny Lobster FMP is currently available on the Departments spiny lobster FMP website at http://www.dfg.ca.gov/marine/lobsterfmp/ .

Amending Spiny Lobster Commercial and Recreational Regulations

The Department is scheduled to request authorization to publish notice of intent to amend regulations associated with the FMP at the Commission's February 2016 meeting. Proposed commercial spiny lobster regulation amendments that will be considered by the Commission include: a commercial trap limit; increasing the trap service requirement from 4 to 7days; extending the period (from 6 to 9 days) for deploying and retrieving traps before and after the season; and reporting of commercial trap loss. Proposed recreational amendments include: requiring the hole-punching or fin-clipping of all retained lobsters; changing the timing of the recreational season opener from 12:01 am to 6 a.m. on the first Saturday of the season; require hoop net operators to mark hoop net floats with GO-ID numbers; and clarifying methods of take for crustaceans.

If you would like more information on the California Spiny Lobster FMP or the proposed regulatory amendments, or to request a printed copy of the draft FMP, please contact Mr. Tom Mason, Senior Environmental Scientist, by email, tom.mason@wildlife.ca.gov, or by phone, (562) 342-7107. If you would like to request formal government-to-government consultation, please contact Steven Ingram, Tribal Liaison, by email, tribal.liaison@wildlife.ca.gov, or by phone, (916) 651-7401.

We look forward to receiving your input.

Sincerely,

Craig Shuman, D. Env.
Regional Manager, Marine Region

ec: Steven Ingram, Senior Staff Counsel and Tribal Liaison
Office of the General Counsel
Department of Fish and Wildlife

Sonke Mastrup, Executive Director
California Fish and Game Commission

Tribe Contacted
Agua Caliente Band of Cahuilla Indians
Augustine Band of Cahuilla Mission Indians
Barona Group of the Capitan Grande
Cabazon Band of Mission Indians
Cahuilla Band of Indians
Campo Band of Mission Indians
Chemehuevi Reservation
Colorado River Indian Tribe
Ewiiaapaayp Tribal Office
Fort Mojave Indian Tribe
Iipay Nation of Santa Ysabel
Inaja Band of Diegueño Mission Indians
Jamul Indian Village
La Jolla Band of Mission Indians
La Posta Band of Mission Indians
Los Coyotes Band of Mission Indians
Manzanita Band of Kumeyaay Nation
Mesa Grande Band of Diegueño Mission Indians
Morongo Band of Mission Indians
Pala Band of Mission Indians
Pauma Band of Luiseño Indians
Pechanga Band of Mission Indians
Ramona Band of Cahuilla Mission Indians
Rincon Band of Mission Indians
San Manuel Band of Mission Indians
San Pasqual Band of Diegueño Mission Indians
Santa Rosa Band of Cahuilla Indians
Santa Ynez Band of Mission Indians
Soboba Band of Mission Indians
Sycuan Band of the Kumeyaay Nation
Torres-Martinez Desert Cahuilla Indians
Twenty-Nine Palms Band of Mission Indians
Viejas Band of Kumeyaay Indians

Appendix II: Executive Summary of the Constituent Involvement Plan

This Constituent Involvement Plan details the activities that will be conducted to involve constituents and participants in the development of the Spiny Lobster Fishery Management Plan (FMP). The FMP is being developed for the spiny lobster fishery by the California Department of Fish and Game as required under the Marine Life Management Act of 1998. An important part of the act is the good faith effort to involve all interested parties in resource management decisions through the dissemination of accurate information and collaboration.

I. Points of Input for Constituents

The Department uses a number of avenues to engage the public in development of the Spiny Lobster Fishery Management Plan (FMP).

Lobster Advisory Committee

- The Advisory Committee is a collaborative body of representatives from major constituencies that provides the Department with advice, recommendations, and feedback regarding actions that need to be taken during the development of the FMP. The Advisory Committee will give guidance on FMP objectives and end products, as well as provide ideas on content and management options that address the key issues put forth by constituents, members of the public, and our contractors. The Committee will review draft documents generated during the FMP process, and will provide feedback on content.

- CDFW ensured that the composition of the Lobster Advisory Committee reflects the diversity of interests and complexity of the California spiny lobster fishery. The Committee is made up of twelve members and five alternates, as follows:

- Rodger Healy (Commercial Fishing Member)
- Jim Colomy (Commercial Fishing Member)
- Shad Catarius (Commercial Fishing Member)
- Josh Fisher (Commercial Fishing Alternate Member)
- Jim Salazar (Recreational Fishing Member)
- Michael Gould (Recreational Fishing Member)
- Al Stasukevich (Recreational Fishing Member)
- Paul Romanowski (Recreational Fishing Alternate Member)
- Lia Protopapadakis (Marine Science Member)
- Kevin Hovel (Marine Science Member)
- Jono Wilson (Marine Science Alternate Member)
- Sarah Sikich (Environmental Organization Member)
- Huff McGonigal (Environmental Organization Alternate Member)
- Sean Hastings (Federal Agency Member)
- David Kushner (Federal Agency Alternate Member)
- Claudette Dorsey (Non-Consumptive Recreational Member)
- Chris Grossman (Non-Consumptive Recreational Member)

Lobster Advisory Committee Schedule

Meeting Dates:

- **June 20, 2012, Los Alamitos (9:00 AM to 4:00 PM)** – LAC Charter and Ground Rules development, Timeline for FMP, List of Lobster FMP Issues, FMP Conceptual Framework, Comments from Public Meetings, and Review of Draft Fishery Overview Chapter
- **August 1, 2012** –Review Summary of Management Options.
- **December 5, 2012** – Discuss findings of Economic Profile Report, and Comments on Draft Fishery Management and Conservation Chapter.
- **April 10, 2013** – Discuss poaching issues and recreational fishery management
- **June 12, 2013** – Review Comments from Public Management Options Meetings.
- **July 10, 2013** – Discuss and evaluate fishing management options
- **August 15, 2013** – Review Management Strategy Evaluation Results.
- **September 11, 2013** – Finalize consensus for recreational fishing management measures, discuss and evaluate the harvest control rule, and identify monitoring and research priorities and funding mechanisms

Schedule for Public Meetings

Public Information Meetings

Description (both dates and locations): The purpose is to introduce the Lobster Fishery Management Plan (FMP) process, and explain what an FMP is and what it is not. CDFW will also discuss the general timeline for FMP completion. The majority of this meeting will focus on gathering information from members of the public regarding the issues or management concerns that need to be addressed during the FMP process.

Dates and Locations:
Wednesday, April 18, 2012
Oxnard Performing Arts and Convention Center
800 Hobson Way
Oxnard, CA 93030
http://www.oxnardpacc.com/directions.html

Thursday, April 19, 2012
Grand Pacific Palisades Hotel
Auditorium
5805 Armada Dr.
Carlsbad, CA 92008
http://www.grandpacificpalisades.com/map-directions

Agenda (both dates and locations):

6:00 p.m.	Open House Workshop (no pre-registration required)
6:30 p.m.	Public meeting begins
6:45 p.m.	Highlights of the FMP Process and how to contribute
7:00 p.m.	Public Questions and Comments
8:00 p.m.	Open House Workshop
9:00 p.m.	Meeting concludes

Management Options Meetings

The purpose is to receive comments on potential management options, the impact of each option, and preferred options or suites of options.

- Dates: **April 23-24, 2013**
- Locations: **Ventura and Orange counties**

Fish and Game Commission Regulator Process

The formal regulatory process will begin in February 2015.

Written Comments

- The Spiny Lobster Fishery Management Plan Web Site has the ability to receive written comments. Web Site address: http://www.dfg.ca.gov/marine/lobsterfmp/
- Written comments can also be mailed to:
  Department of Fish and Game
  Attn: Spiny Lobster FMP
  1933 Cliff Drive, Suite 9
  Santa Barbara, CA 93109

II. Methods for Providing Constituents with Information

Since communication and participation are crucial to a successful FMP process, the Department will provide information through a range of options.

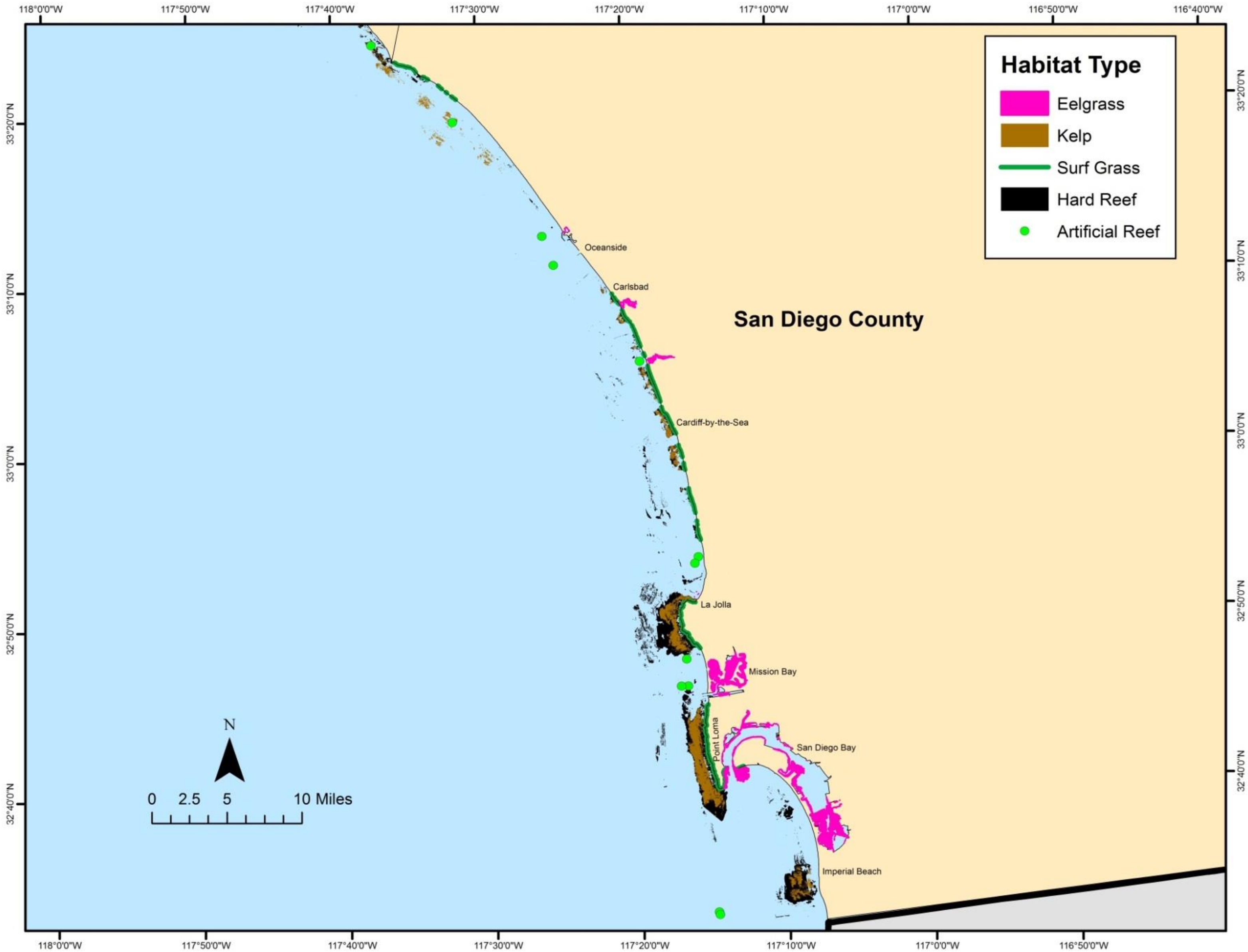
Available Resources

- The Spiny Lobster Fishery Management Plan Web Site: http://www.dfg.ca.gov/marine/lobsterfmp/
- Electronic notices. Constituents can sign up for the Lobster FMP News Service through the Spiny Lobster Fishery Management Plan Web Site. The News Service will distribute electronic notices about future events. Once you are signed up, you can expect to receive emails that:
  - Announce the debut of a fully populated Lobster FMP website that includes informative background documents on lobster.
  - Keep constituents informed of news and public meeting information during the Lobster FMP process.
  - Announce the availability of Lobster FMP draft documents
- For those who cannot receive email, the Lobster FMP team will send the identical announcements via the U.S. Postal Service. To sign up to receive the Lobster FMP News Notices via mail, please contact Ms. Rosalyn McFarland at (805) 568-1231 to provide your mailing address.
- Flyers available at Fish and Game offices, and posted at strategic locations.
- Marine Management Newsletter

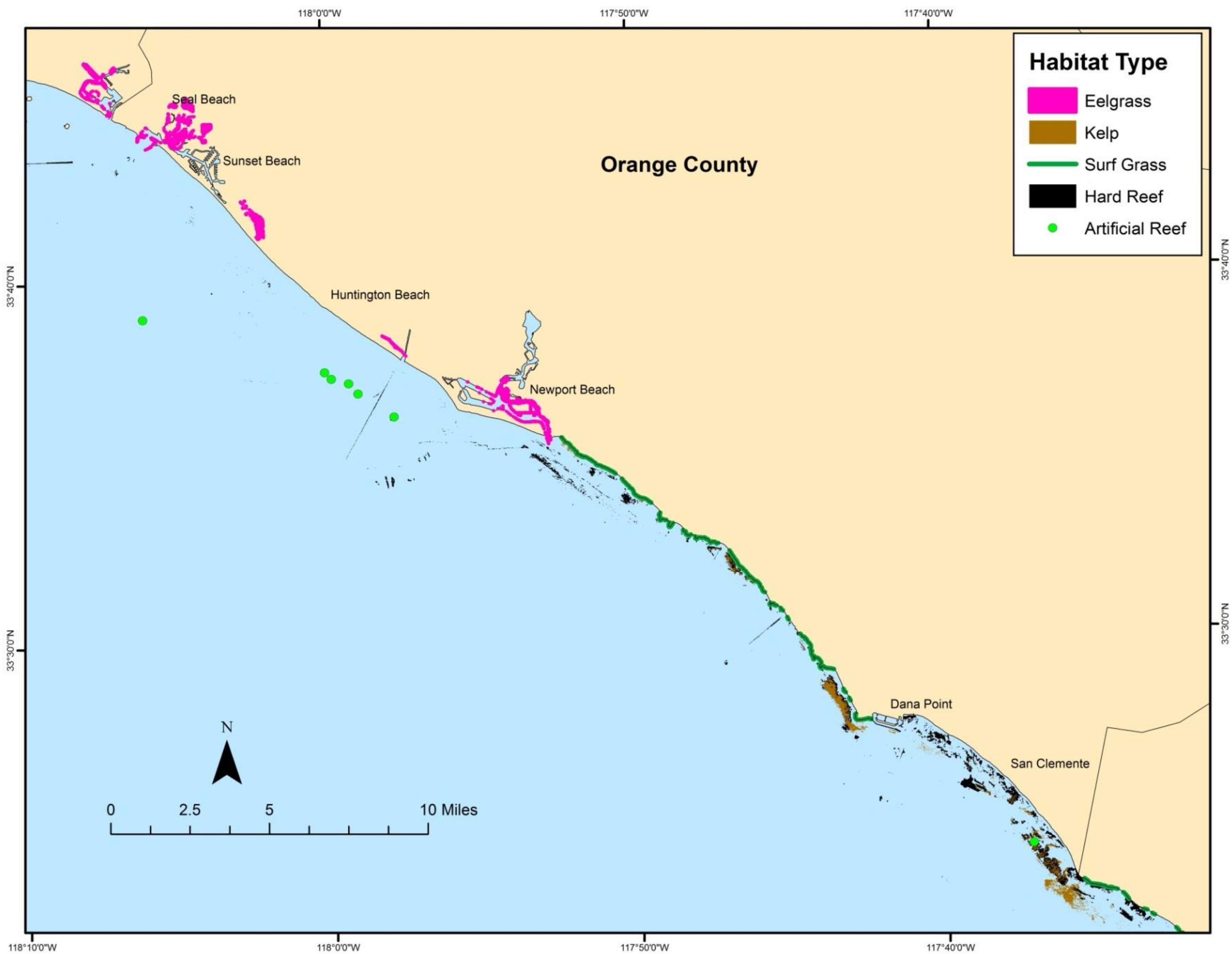
Special Publications

- Spiny Lobster Stock Assessment
- Technical Panel Review Publication of Stock Assessment

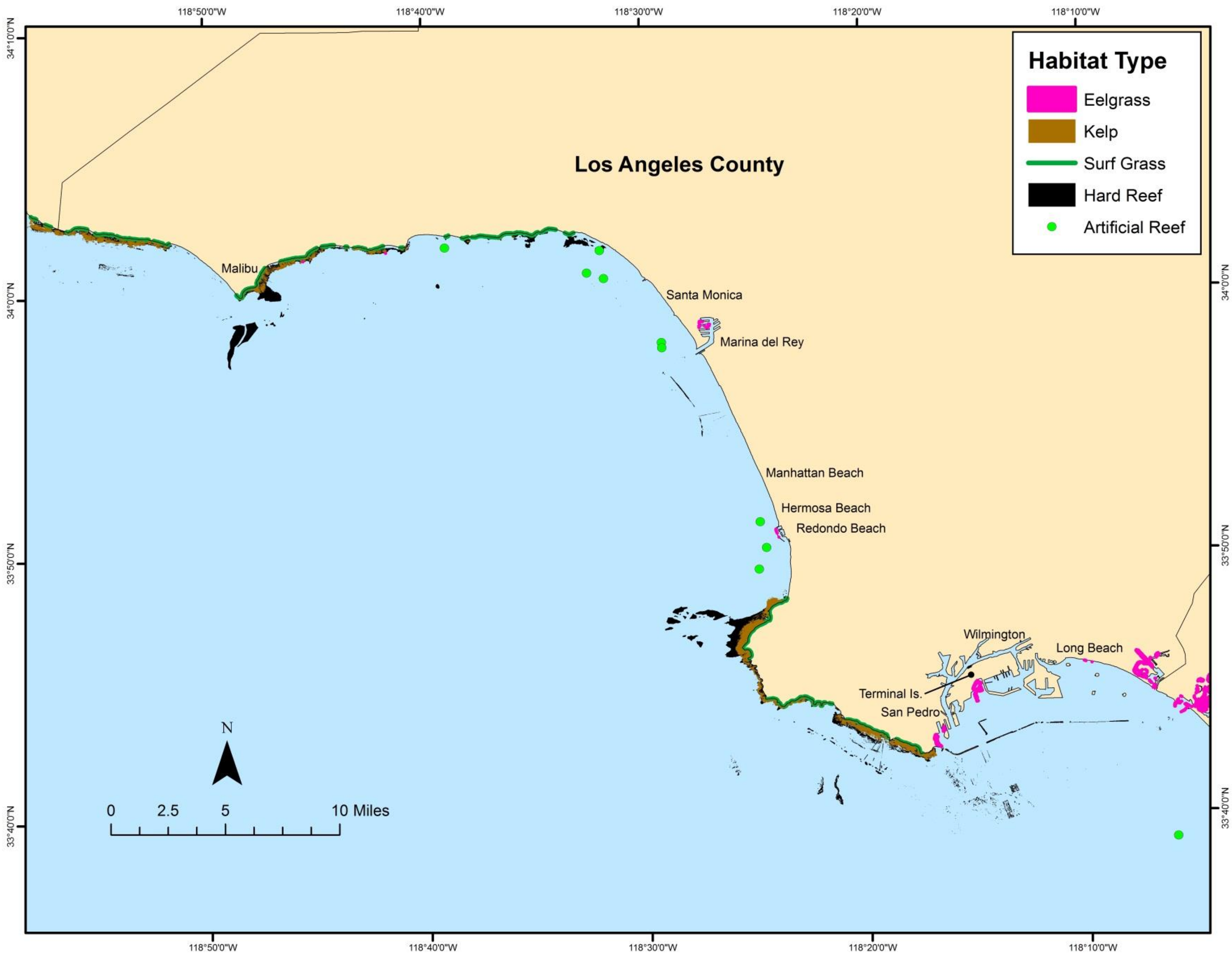
Appendix III: Habitat Maps by Areas



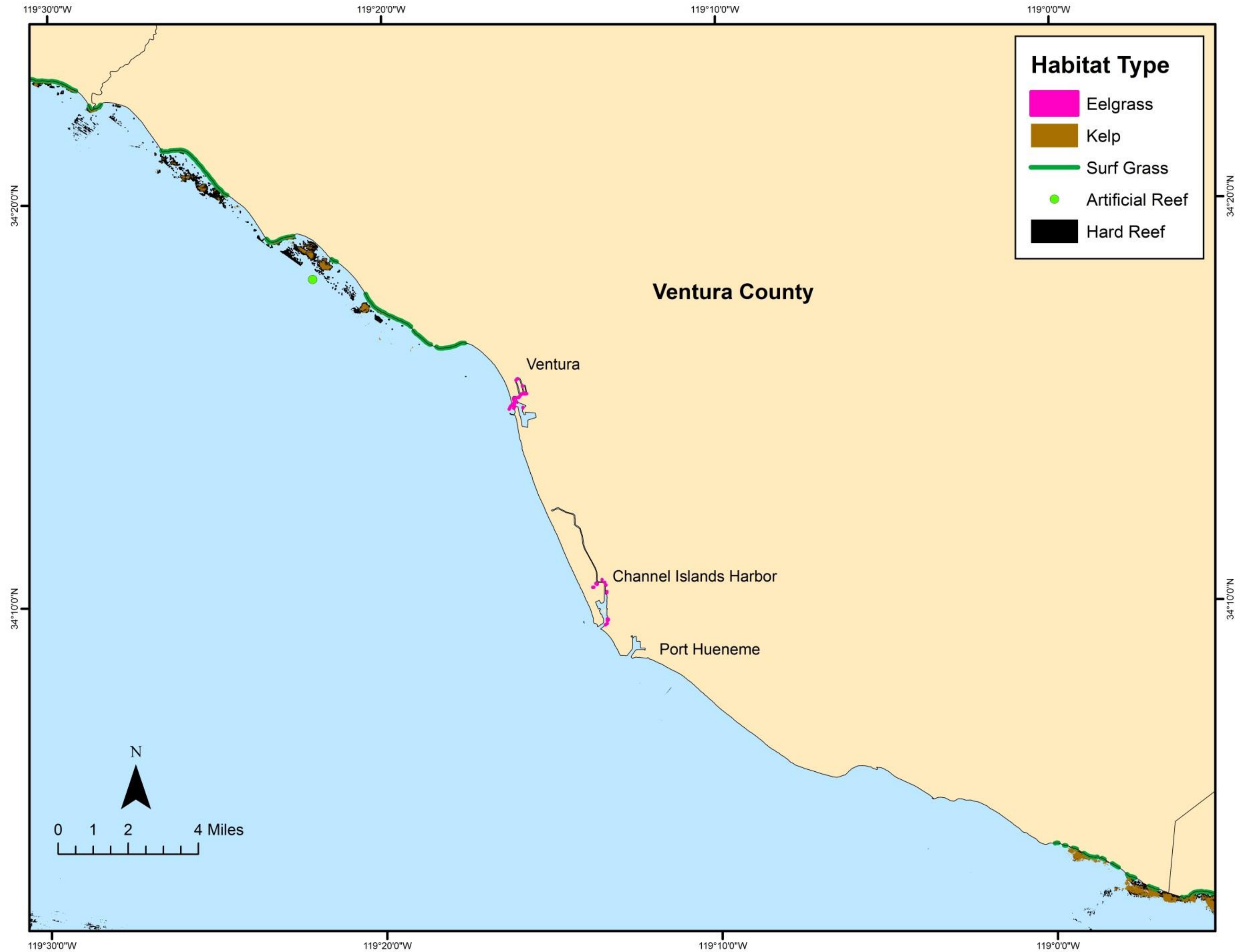
Critical CA lobster habitats along San Diego County



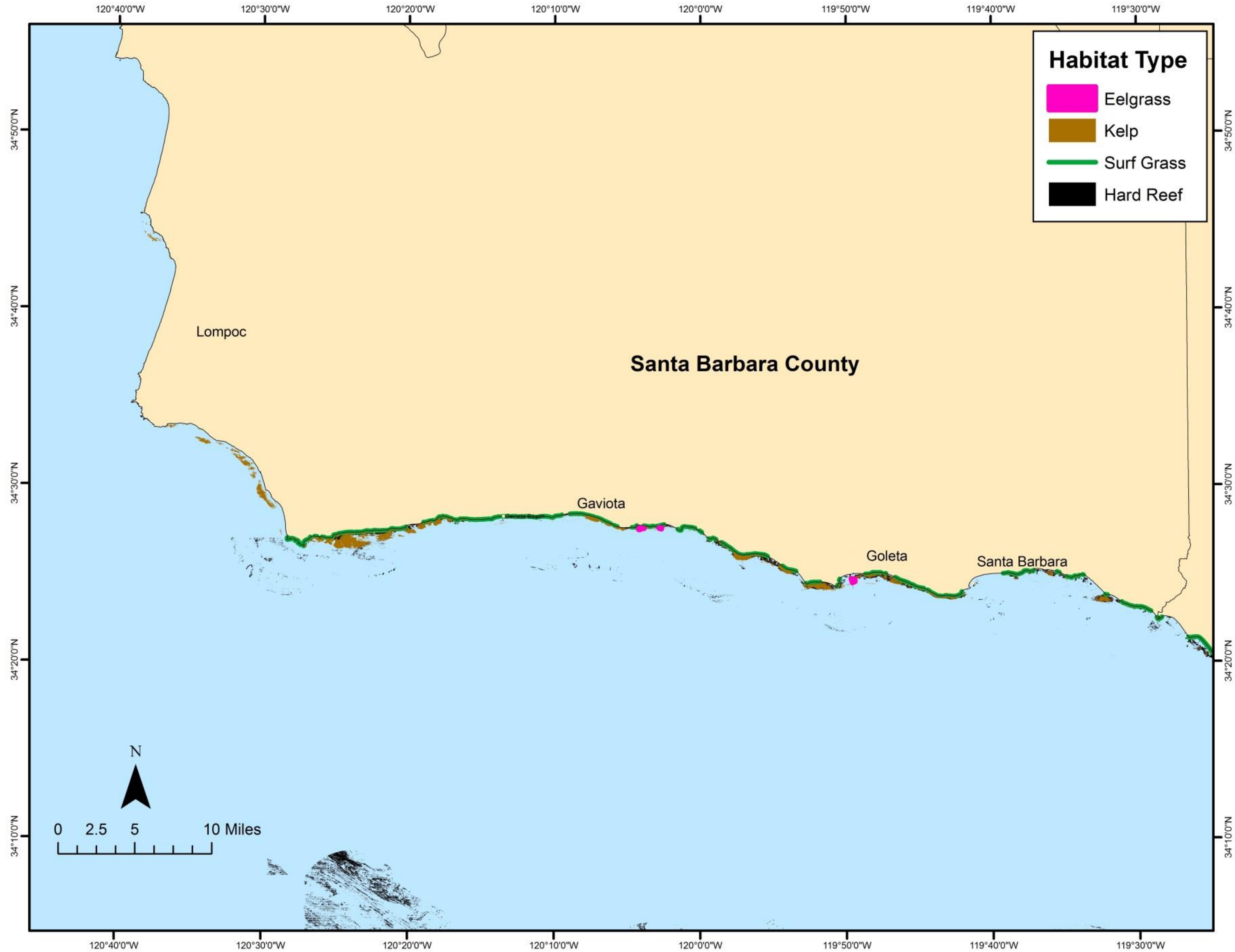
Critical CA lobster habitats along Orange County



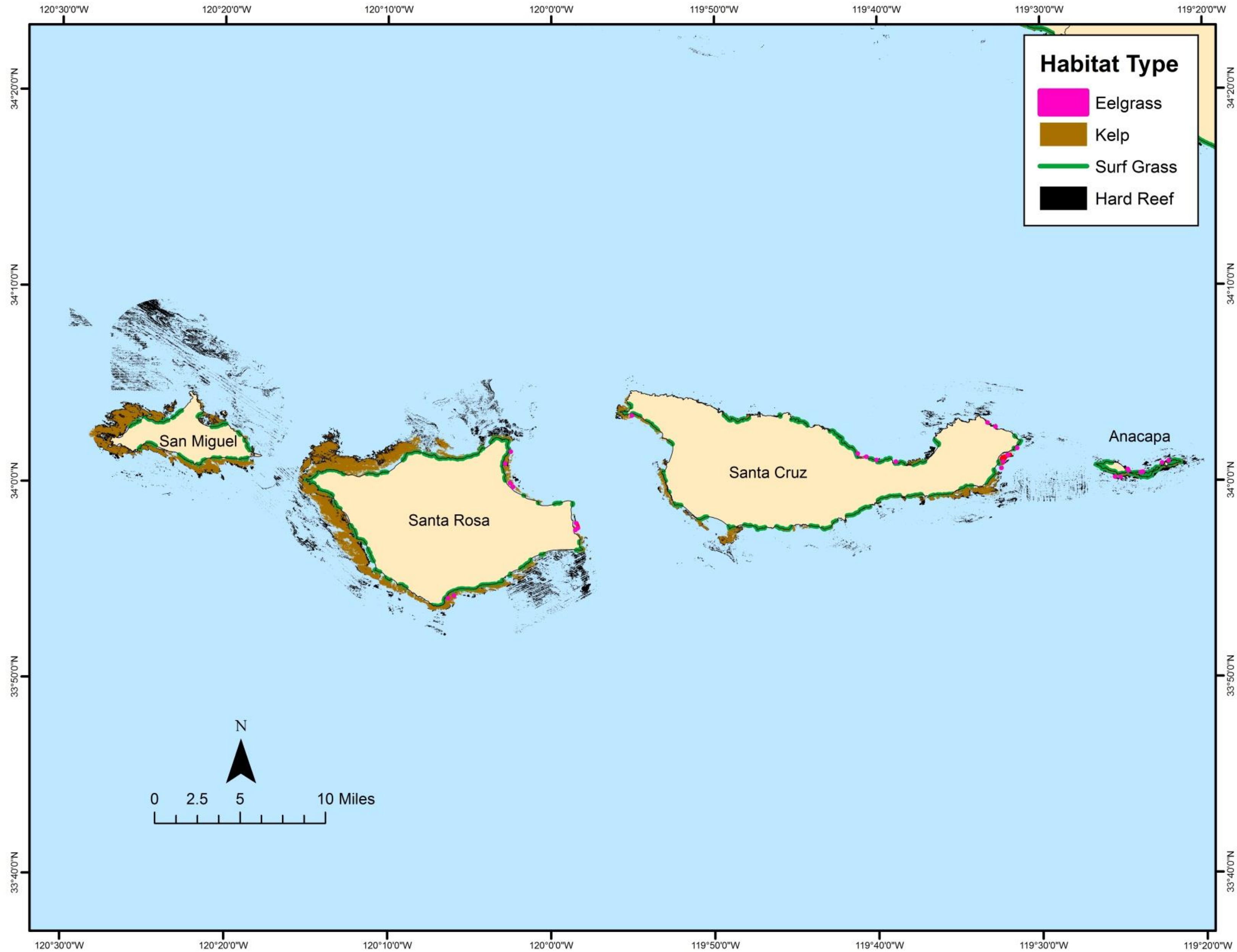
Critical CA lobster habitats along Los Angeles County



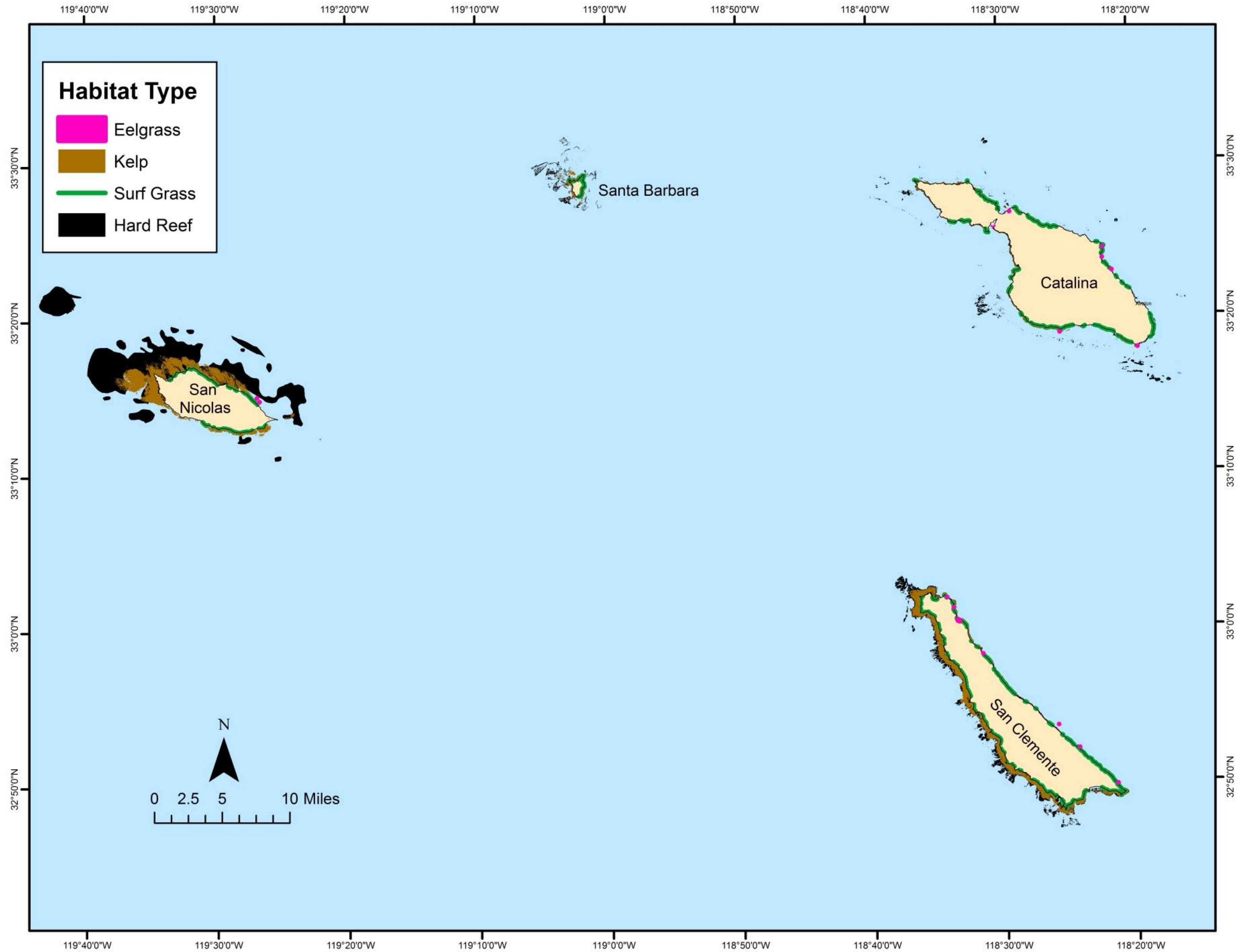
Critical CA lobster habitats along Ventura County



Critical CA lobster habitats along Santa Barbara County

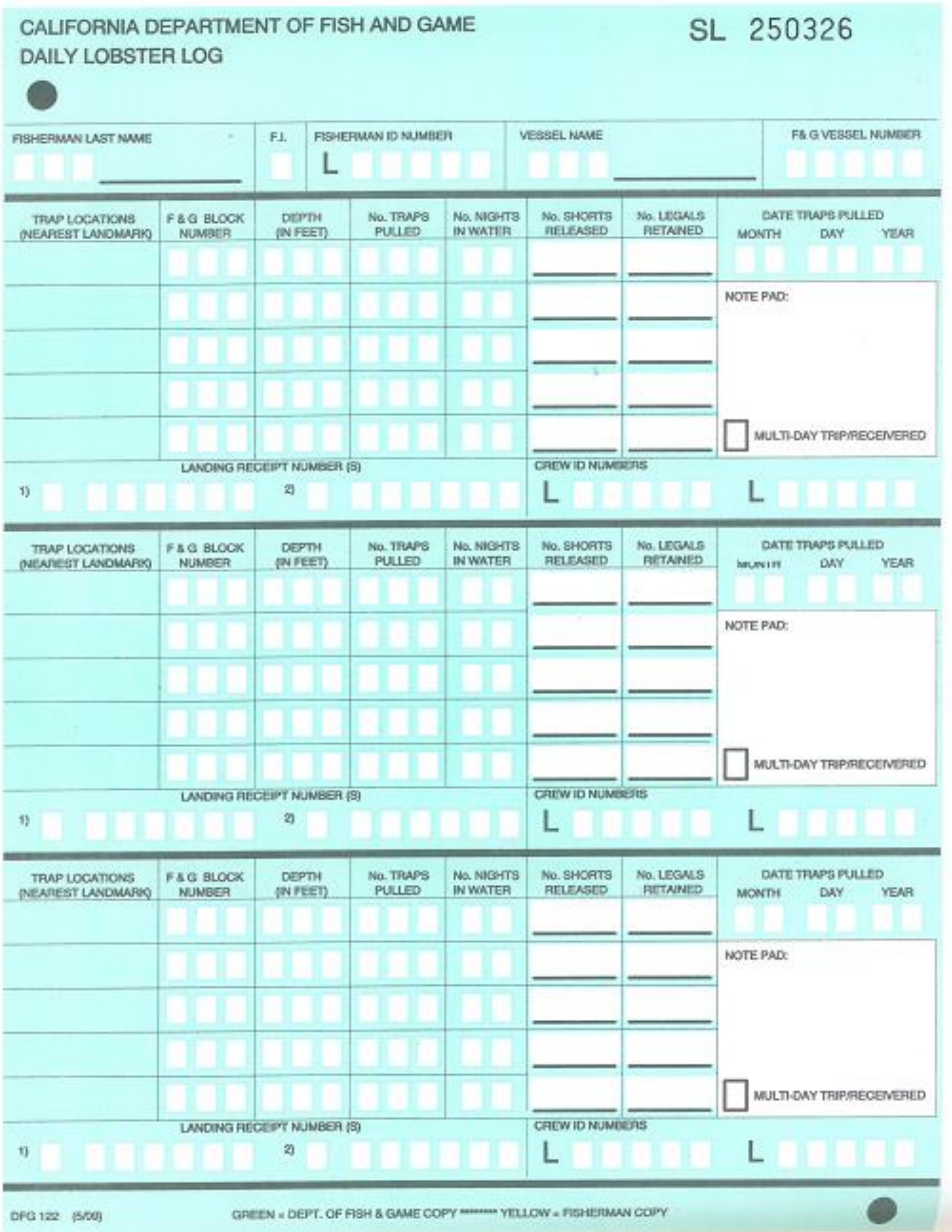


Critical CA lobster habitats around the Northern Channel Islands



Critical CA lobster habitats around the southern Channel Islands

Appendix IV: Current Commercial Logs and Landing Receipts



CALIFORNIA DEPARTMENT OF FISH AND GAME
DAILY LOBSTER LOG

SL 250326

FISHERMAN LAST NAME	F.I.	FISHERMAN ID NUMBER	VESSEL NAME	F& G VESSEL NUMBER
		L		

TRAP LOCATIONS (NEAREST LANDMARK)	F & G BLOCK NUMBER	DEPTH (IN FEET)	No. TRAPS PULLED	No. NIGHTS IN WATER	No. SHORTS RELEASED	No. LEGALS RETAINED	DATE TRAPS PULLED MONTH DAY YEAR
							NOTE PAD:
							MULTI-DAY TRIP/RECEIVERED

LANDING RECEIPT NUMBER (S) 1) 2)

CREW ID NUMBERS L L

TRAP LOCATIONS (NEAREST LANDMARK)	F & G BLOCK NUMBER	DEPTH (IN FEET)	No. TRAPS PULLED	No. NIGHTS IN WATER	No. SHORTS RELEASED	No. LEGALS RETAINED	DATE TRAPS PULLED MONTH DAY YEAR
							NOTE PAD:
							MULTI-DAY TRIP/RECEIVERED

LANDING RECEIPT NUMBER (S) 1) 2)

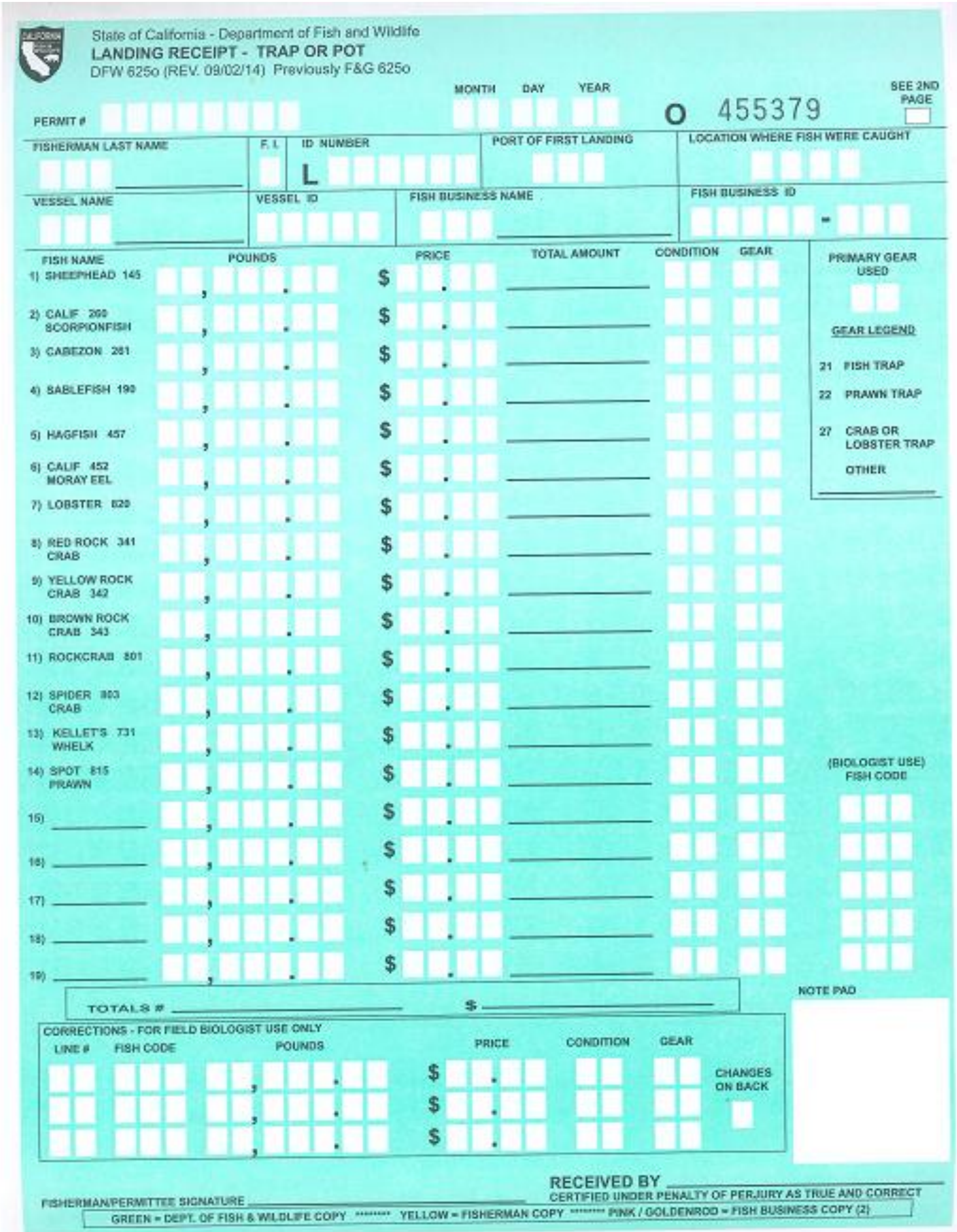
CREW ID NUMBERS L L

TRAP LOCATIONS (NEAREST LANDMARK)	F & G BLOCK NUMBER	DEPTH (IN FEET)	No. TRAPS PULLED	No. NIGHTS IN WATER	No. SHORTS RELEASED	No. LEGALS RETAINED	DATE TRAPS PULLED MONTH DAY YEAR
							NOTE PAD:
							MULTI-DAY TRIP/RECEIVERED

LANDING RECEIPT NUMBER (S) 1) 2)

CREW ID NUMBERS L L

DFG 122 (5/06) GREEN = DEPT. OF FISH & GAME COPY ******** YELLOW = FISHERMAN COPY



State of California - Department of Fish and Wildlife
LANDING RECEIPT - TRAP OR POT
DFW 625o (REV. 09/02/14) Previously F&G 625o

PERMIT # | MONTH | DAY | YEAR | O 455379 | SEE 2ND PAGE

FISHERMAN LAST NAME | F. I. | ID NUMBER L | PORT OF FIRST LANDING | LOCATION WHERE FISH WERE CAUGHT

VESSEL NAME | VESSEL ID | FISH BUSINESS NAME | FISH BUSINESS ID

FISH NAME	POUNDS	PRICE	TOTAL AMOUNT	CONDITION	GEAR
1) SHEEPHEAD 145	, .	$.			
2) CALIF 260 SCORPIONFISH	, .	$.			
3) CABEZON 261	, .	$.			
4) SABLEFISH 190	, .	$.			
5) HAGFISH 457	, .	$.			
6) CALIF 452 MORAY EEL	, .	$.			
7) LOBSTER 820	, .	$.			
8) RED ROCK 341 CRAB	, .	$.			
9) YELLOW ROCK CRAB 342	, .	$.			
10) BROWN ROCK CRAB 343	, .	$.			
11) ROCKCRAB 801	, .	$.			
12) SPIDER 803 CRAB	, .	$.			
13) KELLET'S 731 WHELK	, .	$.			
14) SPOT 815 PRAWN	, .	$.			
15)	, .	$.			
16)	, .	$.			
17)	, .	$.			
18)	, .	$.			
19)	, .	$.			

PRIMARY GEAR USED

GEAR LEGEND
21 FISH TRAP
22 PRAWN TRAP
27 CRAB OR LOBSTER TRAP
OTHER

(BIOLOGIST USE) FISH CODE

TOTALS # $

NOTE PAD

CORRECTIONS - FOR FIELD BIOLOGIST USE ONLY

LINE #	FISH CODE	POUNDS	PRICE	CONDITION	GEAR
		, .	$.		
		, .	$.		
		, .	$.		

CHANGES ON BACK

FISHERMAN/PERMITTEE SIGNATURE
RECEIVED BY
CERTIFIED UNDER PENALTY OF PERJURY AS TRUE AND CORRECT
GREEN = DEPT. OF FISH & WILDLIFE COPY ******** YELLOW = FISHERMAN COPY ******** PINK / GOLDENROD = FISH BUSINESS COPY (2)

Appendix V: Climate Change Vulnerability of the CA Spiny Lobster

By Dr. Douglas J. Neilson

The science of climate change (CC) involves the study of climatic stressors (e.g., atmospheric air temperature) affected by increasing man-made atmospheric greenhouse gas (GHG) concentrations, and their associated environmental responses. An exhaustive discussion of all the potential stressors is beyond the scope of this chapter and only a small portion, deemed to have obvious potential impacts when applied to the California spiny lobster fishery, will be covered. For the most part, these impacts are restricted to those acting directly on the lobster or fishery. There are understood to be indirect impacts as well, where CC affects some aspect of the environment that cascades down to the lobster. While changes to lobster habitat included in ecosystems that also include lobster will be briefly discussed, the larger topic of how ecosystem interactions are affected by CC is beyond the scope of this chapter. As our understanding of CC evolves, and direct or cascading responses in the environment are newly recognized or better resolved, this chapter should be revisited. As such, this chapter should be considered an initial step in an ongoing effort to addressing lobster-related CC issues.

This chapter will briefly discuss the life history and associated habitats for the California spiny lobster which will be important to understand as we discuss CC vulnerabilities. What CC is, and the underlying cause – GHG, and specifically changes in CO_2 - will then be discussed. Since CC is understood to be a global phenomenon and is being driven at this scale, this chapter will first lay out how the selected climate variables are expected to change over time. The relatively local response to CC in California will then be discussed, followed by how the spiny lobster population, habitat, and fishery, are potentially affected. Finally, ocean acidification will be briefly addressed. Ocean acidification is not a result of CC but rather is caused by the same rise in atmospheric CO_2 that contributes to CC.

Spiny Lobster Life History and Habitats

The California spiny lobster is endemic to the west coast of North America from Monterey, California southward at least as far as Magdalena Bay, Baja California (Wilson, 1948; Schmitt, 1921), with a small isolated population in the northwestern corner of the Gulf of California (Kerstitch, 1989). The main portion of the population resides in Mexico, and relatively few lobsters are found north of Point Conception. In U.S. waters, spiny lobsters are commercially fished from Point Conception south to the Mexican Border. Lobsters spend their larval phase, which can last up to ten months, as part of the plankton (Mai & Hovel, 2007; Mitchell 1971). Carried by currents, lobster larvae have been found as far as 530 km offshore and at depths as deep as 137 m (California Department of Fish and Game, 2001). The final, puerulus, stage is a strong swimmer and moves inshore in search of shallow, vegetated habitats such as eelgrass or surfgrass beds (Mai & Hovel, 2007) in which to settle. Survival of the individual is therefore dependent on both the starting distance offshore of the pueruli and its ability to locate suitable habitat. Sub-adult and adult lobster are bottom dwellers and found at depths ranging from the intertidal to 64 m (California Department of Fish and Game, 2001)

Spiny lobster are found in rocky areas often with plant communities dominated by giant kelp (*Macrocystis* sp.), feather boa kelp (*Egregia* sp.), coralline algae (*Corallina* sp.), and surf grass (*Phyllospadix* sp.) (Lindberg, 1955). They are also associated with eel grass (*Zostera* sp.) which flourishes in sandy areas (California Department of Fish and Game, 2001). Spiny lobsters are a major predator of benthic invertebrates and act as a keystone species preying on mussels along rocky shores (Robles et al., 1990) and on sea urchins in kelp forests (Tegner and Levin, 1983; Lafferty, 2004).

Climate Change

Climate Change is occurring as evidenced by observations of increasing global air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC, 2007). The scientific consensus is that the driving force behind this change is man-made sources of greenhouse gases (GHG) – carbon dioxide (CO_2), methane, and nitrous oxide - and globally the average net effect of human activities since pre-industrial times has been one of warming. While methane and nitrous oxide concentrations are significant contributors to climate change, CO_2 is the currently the primary contributor and will be the focus of this discussion. The primary source of CO_2 is fossil fuel consumption.

In 2005, global atmospheric CO_2 levels were measured at 379 ppm, far exceeding the range observed over the last 650,000 years, and emissions grew by approximately 80% between 1970 and 2004 (IPCC 2007). In 2012, average atmospheric CO_2 levels had grown to 392.6 ppm globally, and exceeded 400 ppm for the first time at several arctic sites (Blunden and Arndt, 2013).

Responses to Climate Change

Local responses to climate change may not follow the global trend in either magnitude or direction of response. Because of this, global trends will be discussed briefly to introduce each climate stressor and lay the foundation on which to compare and contrast the local, California responses.

Global Responses

The IPCC (2007) reported that eleven of the twelve years from 1995 to 2006 ranked among the twelve warmest years since 1850. All of the ten warmest years on record have occurred since 1998 including 2012 (Blunden and Arndt, 2013), and 1998 was the only year in the 20th century hotter than 2012 (NOAA 2012). The trend appears to be continuing; July 2013 was the 37th consecutive July and 341st consecutive month with a global temperature above the 20th century average (Osborne and Lindsey, 2013). The rate of warming has also increased. Since 1880, the decadal rate of increase has been 0.11°F increasing to 0.28°F per decade since 1970 (NOAA, 2012).

Global average sea level rise (SLR) has occurred at an average rate of 1.8 mm yr^{-1} since 1961, increasing to 3.1 ± 0.7 mm yr^{-1} since 1991 (IPCC, 2007). Estimations of future global sea rise are on the order of 8-23 cm (3.15-9.06 in) by 2030, 18-48 cm by 2050, and up to 140 cm by 2100, all relative to sea level in 2000 (NRC 2012). These estimates vary however based upon which models are used and which variables are included; the NRC values, for instance, are higher than the IPCC (2007) estimation (18-59 cm) for the year 2100.

California Responses

Air temperatures are expected to increase more over continental land masses than over the oceans (Bakun, 1990). Along the California coastline, this will result in atmospheric pressure gradients leading to intensification of winds (Field et al., 1999). Stronger winds, in turn, are expected to intensify upwelling along the west coast of the US. Under normal conditions, intensification of upwelling would lead to cooler water temperature. However, higher air temperature can also lead to stronger thermal stratification and a deepening of the thermocline (Roemmich and McGowan, 1995), reducing the cooling effect of, and nutrient delivery by, the upwelling. On millennial timescales, upwelling has been positively correlated to air temperatures (Pisias et al., 2001), and upwelling along the California coast has increased over the last 30 years (Snyder et al., 2003). Previous warm periods were associated with reduced current flow in the California Current system (Pisias et al., 2001).

SLR will vary depending on a number of factors both long-term and short term. These include storm events, melting ice and glaciers, circulation patterns, climate variations, and tectonics. (NRC, 2012). Modeled SLR at west coast tide gage locations predicted relative sea level rises of around 0.35 ± 0.25 mm yr^{-1}. Total SLR off Los Angeles, relative to 2000, is projected at 14.7 ± 5.0 cm (5.79 ± 1.97 in) by 2030, 28.4 ± 9.0 cm by 2050, and 93.1 ± 24.9 cm by 2100.

The primary force behind year-to-year variability along the California coast is the El Niño Southern Oscillation (ENSO) (Field et al., 1999). The name refers to coupled ocean-atmospheric processes where the Southern Oscillation is a flip-flop of atmospheric pressure over the south Pacific, and where El Niño refers to the in-water response. El Niños result in rapid warming events in California, increased storminess, and drops in phytoplankton and kelp productivity. Strong El Niño events can increase sea levels 10 to 30 cm (3.94 – 11.81 in), raise sea surface temperature (SST) an average of 2.7 °F, increase stratification, and decrease nutrient delivery into surface waters, all over a few winter months. El Niño events persist for a few months to a year with some extreme El Niños lasting for two years. La Niña displays an equally abrupt and short-lived effect on California coastal ecosystems. However, in the case of La Niña, SST is suppressed (-1.8 °F on average). Currently it is unknown whether ENSO activity will be enhanced, or damped, or whether the frequency of ENSO events will change (Collins et al., 2010)

Lobster

Increased SST conditions will likely favor the spiny lobster fishery since behavioral changes related to warm temperatures, increase harvest (Pringle, 1986; Koslow et al., 2012). Also, California is situated at the northern edge of the lobster's current domain range; lower numbers of lobster north of Point Conception are generally attributed to the cooler water found there. Increasing SST could therefore result in a general extension northward of lobster, particularly during El Niño years or times of enhanced Davidson Current northward flow. These latter two conditions are also thought to provide episodic transport of larvae north from Mexico which would also increase the spiny lobster abundance over time. (Pringle, 1986).

As SST increases, assemblages within southern California kelp forests will shift to more dominance of southern species – such a shift has already been observed in some kelp forests (Field et al. 1999). Kelp itself may be impacted by increasing SST and reduced nutrients, although it is unclear at this point exactly what response, positive or negative, kelp forests will have relative to climate change. Likewise, It is unclear if the California spiny lobster, being more tropical, would be directly (i.e. physiologically) affected negatively by increasing SST.

There is an increased likelihood of disease with higher water temperatures. As an example, the bacterial infection, epizootic shell disease, is present in American lobster stocks on the east coast of the US and is possibly linked to higher water temperatures. Catchability increases with increasing temperature. Considered alone, this could lead to higher harvests in the future. Even if countered by other climate change factors, variations in catchability would still need to be understood and addressed in stock assessment and modeling efforts for accurate results.

It is still unclear whether increased stratification or upwelling, countering stratification, will be the dominant response to climate change. Increased stratification, however, is projected to lead to declines in zooplankton abundance (Roemmich and McGowan, 1995) which could adversely affect the zooplankton larval phase of the spiny lobster directly or indirectly by reducing food sources. Conversely, upwelling and alongshore transport are strong determinants of dispersal and recruitment (Gaylord and Gaines, 2000; Connolly et al., 2001). Harley et al. (2006) cited modeling work that suggested increased offshore movement (e.g., upwelling) can be negatively correlated with population size in benthic species. Very strong upwelling, therefore, could reduce the ability of lobster to maintain adult populations in some areas. This is probably more applicable to regions north of Point Conception and, as such, would act to reduce northward movement of the lobster range rather than impact the southern California population.

Increasing SLR will lead to coastal inundation and increased coastal erosion, in particular when accompanied by expected higher intensity storm events coinciding with high tidal periods. Coastal erosion can lead to silting of coastal habitat necessary for the lobster, in particular seagrass beds used for settlement and adult foraging. Even in areas spared from excessive silting, seagrass beds would still be sensitive to changing wavelengths of light brought about by increased turbidity and water depth. The fishing industry could also experience flooding at dock and harbor facilities. This would potentially affect both the fishermen and dealers.

Seagrass beds could be impacted by more frequent, higher intensity storm events damaging part of a bed, or completely destroying it. These events could also become relatively common occurrences. Damage or destruction of seagrass beds would impact lobster through reduction in suitable habitat for puerulus settlement. This could result in adult mortality exceeding recruitment leading to local loss of populations. Similarly, kelp beds could be damaged or destroyed at more frequent intervals. Lobsters are considered, along with urchins and kelp, to be necessary for the health of the kelp forest ecosystem. If kelp is lost at higher frequencies the result could be an imbalance in the kelp/lobster/urchin relationship leading ultimately to loss of the ecosystem (and by extension, the lobster located there). In terms of the fishery, these storm events could also affect the fishermen economically by hindering their ability to fish, and by the destruction of gear.

Changes to the lobster stock may also occur via altered larval distribution and settlement, loss or gain of coastal nursery habitats, and altered abundances of strongly interacting species (e.g. predators and prey) (Pecl et al. 2009). Though first-stage larval abundance generally is correlated with SST (Fig. 5), changes in wind patterns and storm frequency may alter larval dispersion and settlement (Caputi et al. 2010). Because spiny lobster larvae spend up to 10 months in the plankton stage, and the final larval stage actively swims from offshore to coastal nursery habitats, settlement success is dependent on the planktonic larvae's distance offshore at the time of final molt. Any change in currents and storms that result in farther offshore dispersion will have an adverse effect on harvest in the future.

Ocean Acidification

Although not specifically caused by climate change, ocean acidification is a separate phenomenon also related to increasing amounts of atmospheric CO_2. The ocean absorbs CO_2 from the atmosphere naturally and acts as a buffer for atmospheric CO_2. The pH of the oceans, however, is affected by the level of absorbed CO_2. With increasing levels of atmospheric CO_2, the ocean's CO_2 level also rises and the water becomes more acidic. It has been estimated that the oceans have absorbed half of the anthropogenic-induced CO_2 from the atmosphere (Pecl et al., 2009), and this has resulted in a more acidic ocean. (Caldeira and Wickett, 2003; Royal Society, 2005; Pecl et al, 2009). As acidity continues to increase, there will be increasingly adverse effects on many organisms that use calcium carbonate for their shells and skeletons since calcium carbonate will dissolve as acidity increases. Water corrosive enough to dissolve seashells has been observed off California and similar occurrences are expected to become more frequent (Feely, 2008). The types of organisms potentially affected include snails and mussels, corals, and many phytoplankton species. It is unclear if there will be any adverse effects of acidification directly on lobster (Pecl et al., 2009). Also, distribution, extent, and composition of coastal vegetated habitats that house lobster all may change due to altered dissolved CO_2 concentrations.

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Appendix VI: Economic Report

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H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

An Economic Report on the Recreational and Commercial Spiny Lobster Fisheries of California


Photo Courtesy of: California Department of Fish and Wildlife

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3 April 2013

We are grateful for the participation of many recreational and commercial spiny lobster fishermen in the data-gathering component of this report. We thank Kristine Barsky and Kai Lampson of CDFW for their support and assistance. We also acknowledge the extensive assistance provided by staff at H. T. Harvey & Associates and at CDFW.

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Executive Summary

- The project scope was to update annual expenditure estimates associated with commercial spiny lobster fishing in California from Hackett et al. (2009); to use the California Ocean Fish Harvester Economic (COFHE) model from Hackett et al. (2009) to estimate the economic impacts associated with ex-vessel commercial landings in California; to develop a spiny lobster recreational fishing sampling design and survey questionnaire; and to use the survey results to estimate recreational fishing expenditures in California.
- Based on 2012 interview data and prior "bottom-up" expenditure modeling from Hackett et al. (2009), we estimate that commercial fishermen targeting spiny lobster in California spent ~$10,555,000 on fishing- and vessel-related expenditures in the 2011-12 fishing season.
- Based on the mean of total ex-vessel revenue from the 2009-10 through 2011-12 commercial fishing seasons in California, we estimate that the multiplier effect associated with commercial landings resulted in total annual statewide economic output of ~$22,523,000 and 323 jobs. Of the California counties in which spiny lobster landings occurred, San Diego County experienced the largest share of statewide output and jobs. Based on 2012 survey data we estimate that annual expenditures in the recreational fishery in California were ~$37,093,000. Note that not all of these expenditures necessarily occur in California. Also note that these are expenditures and not total economic impact, which is beyond the scope of this report.
- The average recreational fisherman has fished spiny lobster for nearly 9 years and spends an average of just over 2/3 of a day on a typical fishing trip. Spiny lobster fishing constitutes an average of just over 1/3 of a recreational fisherman's total fishing effort in a given year. Private vessels provided just over 1/2 of all access to the recreational fishery, and on average about 8% of a vessel's annual usage was estimated to be targeted at spiny lobster fishing.

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Section 1.0 Introduction

The California spiny lobster, *Panulirus interruptus* (hereafter spiny lobster), occurs in shallow, rocky coastal areas from Point Conception (Santa Barbara County) into Mexico, including offshore islands and banks (Barsky 2003). A significant commercial and recreational fishery exists for spiny lobster, and the season in California runs from early October to mid-March, with approximately 2/3 of landings usually being made from October through December. Commercial fishermen targeting spiny lobster set baited, wire traps from vessels that usually range between 22 to 49 feet in length. Spiny lobster has been a relatively lucrative fishery. A total of 751,000 pounds of spiny lobster was landed by commercial fishermen in 2011 in California at a total ex-vessel value of ~$12,910,000, yielding an average price per pound of ~$17.00 (CDFW 2013). In 2012, preliminary data indicate roughly similar landings as 2011. Price per pound fluctuates throughout the season, and in the 2012/13 fishing season it ranged from $12 to $25 per pound. Export markets (e.g., China) have helped drive higher prices in the commercial fishery in recent years (Barsky, pers. comm., 2013).

This economic report provides an update of direct expenditure information by commercial fishermen described in Hackett et al. (2009). Commercial expenditure updating occurred by way of interviewing a set of commercial spiny lobster fishermen and identifying the extent to which mean expenditure levels by category have changed since 2007. This report also utilized the California Ocean Fish Harvester Economic (COFHE) commercial fishery economic impact model from Hackett et al. (2009) to estimate total economic impact. This was done by applying the COFHE multipliers (available at http://www.dfg.ca.gov/marine/economic structure.asp) to the mean of total seasonal ex-vessel revenue averaged over the 2009-10, 2010-11, and 2011-12 fishing seasons. Commercial fishery economic impacts were estimated at the county, region, and statewide scales. Note that in Hackett et al. (2009) the spiny lobster fishery was grouped with crab in the "Lobster and Crab" operational configuration (OC). In contrast, this report focuses entirely on the targeted spiny lobster fishery.

This report also includes an estimate of the direct expenditures made by recreational fishermen targeting spiny lobster in the recreational fishery off the coast of California. These direct expenditures were estimated from survey data gathered in collaboration with California Department of Fish and Wildlife (CDFW) using the spiny lobster report card database. It is beyond the scope of this study to estimate economic impact. To do so one would need to "margin" the retail expenditures to get a wholesale estimate, group expenditures by appropriate economic sector category, and apply multipliers (e.g., RIMS II) or use economic impact software (e.g., IMPLAN).

In Section 2 below we summarize commercial expenditures in the spiny lobster fishery. In Section 3 we describe economic impacts associated with the mean of the last 3 season's worth of ex-vessel revenue from commercial spiny lobster harvest. In Section 4 we summarize estimated expenditures in the spiny lobster recreational fishery. The survey instruments used to elicit commercial and recreational fishing data are provided in the Appendices to this report.

Section 2.0 Estimated Commercial Expenditures in the Spiny Lobster Fishery

The overall goal for this portion of the report was to update the expenditure information for the "lobster and crab" operational configuration (OC) from Hackett et al. (2009). Due to resource constraints, we were unable to reproduce the comprehensive survey methodology used in Hackett et al. (2009). Instead we used a key-informant interview methodology in which we asked commercial spiny lobster fishermen the extent to which (inflation-adjusted) expenditures by category (averaged at the individual fisherman level) reported in Hackett et al. (2009) reflected expenditures for a "typical" commercial fisherman. We asked contacts at CDFW to identify commercial fishermen who were likely to have a broad, industry-wide perspective and who would thus be able to reflect on the expenditures made by a typical commercial spiny lobster fisherman.

Annual average fixed and variable cost information from the lobster and crab OC in Hackett et al. (2009) was provided to the interviewees in numerical and pie-chart format (see Appendix A for an example used for the small-vessel stratum). These "cost sheets" were adjusted for inflation (2007 nominal expenditures from Hackett et al. (2009) were adjusted to 2012 values). Interviewees were asked to determine a percentage by which those expenditures should be increased or decreased to reflect the expenditure experience of a "typical" spiny lobster commercial fisherman. Some expenditure categories from Hackett et al. (2009) such as "electrical gear" and "other gear" purchases and repairs were consolidated into a "gear purchases" and "gear repairs" category. The cost sheets were stratified into vessel size classes used in Hackett et al. (2009) – small (< 26 feet), medium (26 to 36 feet), and large (> 36 feet). Cost sheets for a given size class were given to selected fishermen with vessels of the same size class, and afterwards personnel from H. T. Harvey & Associates called to interview the commercial fishermen and complete the questionnaire component of the cost sheets.

A total of 10 commercial fishermen participated in the interviews. We use the term "interviewee" below to refer to these commercial spiny lobster fishermen who were interviewed in 2012 to help us update Hackett et al. (2009) expenditures circa 2007. Of the 10 interviewee responses, 8 were determined to be useable, while 2 were not (addressed below). When participants reported a range of values (e.g., "bait expenses from the cost sheet need to be increased by 10-30%"), then the mean of the range (in this instance, 20%) was coded and used in the analysis. If a fisherman simply indicated that costs should "increase" or "decrease", those data were treated as a blank (unanswered) and not used in the following analysis (there were very few of these responses). Percentage changes for each cost category were averaged within each vessel size class (small size class and a combined medium-large size class).

As noted above, we asked interviewees to report a "typical" commercial fisherman's expenditures within a vessel size class in the spiny lobster fishery, and to indicate the percentage increase or decrease that should be made to the 2007 expenditure information from Hackett et al. (2009). Many of the interviewees indicated that expenditures we reported from the 2007 study were far too low, even after the figures were inflated to current dollars, and suggested very large expenditure increases. When such expenditure increases were implemented fleet-wide, net revenues (e.g., ex-vessel revenue less reported expenditures) were estimated to be negative. Conversations with CDFW contacts indicated that negative net revenues were very unlikely for this lucrative fishery. We then turned to an analysis of activity level. An analysis of trip frequency determined that the interviewees selected by CDFW were more active fishermen than the average commercial fisherman. As a result it is likely that the interviewees were reporting "typical" expenditures that actually reflected the experience of the top 10-20% of commercial fishermen. As many categories of estimated expenditures increase with activity level, applying percentage increases from these highly active fishermen would result in a substantial over-estimate of fleet-wide expenditures. To correct for this likely overestimate of expenditures, we developed an "activity-based" weighting system.

First we used the expenditure estimation models by category from Hackett et al. (2009) and applied those to each commercial fisherman in the commercial spiny lobster fishery based on their vessel type, home port, and number of trips. Next we inflated these expenditures to current dollars. We then adjusted these expenditures using the mean percentage change by expenditure category provided by the commercial spiny lobster interviewees (one set of mean percentage change values was calculated from small-vessel interviewees, and another set was calculated from combined medium and large vessel interviewees). This percentage change is likely to be too high for most commercial spiny lobster fishermen, for reasons described in the preceding paragraph. Accordingly, we then applied the activity-based weight to each expenditure category for each commercial spiny lobster fisherman in a given vessel size class. The activity-based weight is a quotient equal to the individual fisherman's total number of fishing trips in 2011 divided by the mean number of fishing trips by the relevant interviewee group in 2011. The effect of this activity-based weight is to deflate (inflate) the percentage change from the interviewee group when an individual fisherman's level of activity is less than (greater than) that of the interviewee group. This weighting system was not applied to expenditure categories that are unlikely to be related to activity level – slip fees, member association fees, harbor fees, and interest.

Note that responses from 2 interviewees remained inexplicable and substantial outliers even after consideration of their vessel size, number of trips, and other observable characteristics. This raised concern about their reliability, ultimately resulting in those interviewee responses not being included in the analysis.

We also discovered that while we asked participants to provide an annualized value for engine, hull, and other major capital purchases, the responses were consistent with reporting an actual purchase price rather than an annualized "debt service" type value. For example, we might receive a reported annual expenditure of $16,000 for engine purchase, when what we wanted was the "annualized" cost (which might be ~ $1,800 per year as debt service on a 10 year loan). We thus needed to annualize these capital expenditure percentage change values from the interviewee group. To do so, we used data on frequency of capital purchases from Hackett et al. (2009) to develop an additional "annualized capital purchase" weighting system. The annualized capital purchase weight simply equals the frequency of non-blank and non-zero capital expenditure responses from the commercial fisherman survey in Hackett et al. (2009). Annualized engine and hull purchase expenditures for each commercial spiny lobster fisherman were thus estimated the same way as other expenditure categories described in the preceding paragraph, except that the additional annualized capital purchase weight was also applied.

Commercial license, permit, and boat registration expenditures were calculated from CDFW 2011/12 fees. Once we estimated all expenditure categories for each individual commercial spiny lobster fisherman as described above, a fleet-wide expenditure total was built from the bottom up by summing expenditures estimated for each commercial fisherman. The resulting annual expenditure estimates for the commercial spiny lobster fishery are provided in Table 1. We estimate that commercial spiny lobster fishermen spent $10,555,000 in expenditures related to spiny lobster fishing for the 2011-12 fishing season. Nearly one half of this figure was estimated to derive from crew wages, bait, and fuel.

Table 1. Annual Estimated Expenditures for the California Spiny Lobster Commercial Fishing Fleet for Fishing Season 2011-12

	Estimated Total Expenditures			
Vessel Size Categories	**< 26**	**26 - 36**	**> 36**	**Grand Total**
Fixed Expenditures				
Hull Repair	51,754	191,515	129,482	**372,751**
Hull Purchase	37,380	100,317	32,348	**170,045**
Engine Repair	116,752	216,295	65,951	**398,997**
Engine Purchase	65,139	152,793	10,490	**228,423**
Gear Repair	195,973	216,341	161,195	**573,509**
Gear Purchase	116,509	217,036	119,781	**453,326**
Insurance	73,819	169,990	102,172	**345,981**
Storage	110,863	69,906	24,653	**205,422**
Interest	0	79,243	78,019	**157,262**
Registration and License Fees	54,582	57,890	20,675	**133,147**
Slip	181,581	317,976	142,250	**641,807**
Variable Expenditures				
Bait	733,113	590,865	282,964	**1,606,941**
Food	54,218	126,005	69,993	**250,217**
Fuel	496,234	508,249	325,447	**1,329,930**
Crew Wages	603,042	900,017	366,229	**1,869,287**
Harbor Fees	0	9,434	3,322	**12,756**
Transportation	250,753	139,917	65,304	**455,974**
Member Fees	3,398	10,869	3,827	**18,094**
Federal Tax	238,043	618,720	263,595	**1,120,359**
State Tax	44,170	117,054	50,045	**211,268**
		Total		
Grand Total Expenditures	3,427,322	4,810,431	2,317,742	**10,555,495**

Section 3.0 Economic Impact Estimates for the Commercial Spiny Lobster Fishery

3.1 Overview of Economic Impact Assessment

The material below draws closely from Hackett et al. (2009). Firms in every industry are linked through their purchases and sales with firms in other industries and with households. Inter-industry linkages and the impact of activities in one industry on overall household income, employment, business sales, tax revenues, and other economic conditions are important but not always apparent by examining direct industry statistics. Input-output models display direct, indirect, and induced economic linkages, and measure impacts of changes or proposed changes in industrial activity or in government policies that are expected to change industrial activity. Direct impacts are associated with the direct purchases of inputs (e.g., labor and intermediate inputs) by an industry to support an increase in industry output. Indirect impacts are associated with additional "rounds" of inter-industry purchases and sales that are generated as a result of direct impacts. Induced impacts are from increases in household expenditures that result from increases in household income associated with direct and indirect impacts.

Input-output models form the core of modern economic impact assessment decision support tools. Hackett et al. (2009) offers economic impact assessment models for California's commercial fisheries. To build these models, Hackett et al. (2009) collected statewide commercial fishing expenditure and earnings data in 2007 for 20 different OCs or fishery sectors that reflect vessel and gear types and the associated commercial fishing expenditures for target species groups. These expenditure data, combined with CDFW landings and revenue data, were used to develop input-output models with 20 detailed OCs for the state of California, 4 coastal regions within California, and 22 individual counties that make up those coastal regions. These 27 models, collectively called the COFHE Model, were developed by King and Associates, Inc. (coauthors in Hackett et al. 2009) from a widely used and respected regional economic modeling tool called the IMPLAN (IMpact Analysis for PLANning) system (MIG 2013).

The COFHE models are designed to show the economic linkages and impacts of California's commercial fish harvesting industries and how they are affected by external economic, regulatory, or environmental changes that affect ex-vessel revenues. These models show how each commercial fishing OC is linked with other industries and with households. The models were then used to develop economic "multipliers" that show the "ripple" effects of changes in fisheries and fisheries management decisions on the California economy. The multipliers developed through the COFHE model are presented per million dollars of direct sector output.

The most typical use for the COFHE model is to assess the economic impact associated with a regulatory change that has known impacts on ex-vessel revenues due to changes in landings. In this report we apply the COFHE model multipliers to total ex-vessel revenue at county, region, and statewide scales. The resulting economic impact is associated with the existence of the commercial spiny lobster fishery in California. If, hypothetically speaking, this fishery were newly opened, then the economic impact figures provided below would provide an estimate of the additional economic activity associated with opening the fishery at different geographical scales. Key economic impact terms are defined in Table 2 below.

Table 2. Definitions of Economic Impact Terms Used in this Report

IMPLAN Term	Definition
Direct Effects	The impacts associated with the direct purchases of inputs (e.g., labor and intermediate inputs) by an industry to support a $ 1 increase in industry output.
Indirect Effects	The impacts associated with additional "rounds" of inter-industry purchases and sales that are generated as a result of direct impacts. Indirect impacts include the direct impacts of purchases of inputs (e.g., labor and intermediate inputs) by industries that sell to the industry responsible for the direct impacts, and by the industries that sell to those industries, and so on.
Induced Effects	The impacts associated with increases in household expenditures that result from increases in household income associated with direct and indirect impacts. The inclusion of induced impacts based on "income effects" is what distinguishes Type II multiplier Effects from Type I multiplier effects.
Total Effects	The total of all direct, indirect, induced impacts.
Industry Output	Total industry production, equal to shipments plus net additions to inventory.
Jobs	Annual average number of full time-equivalent jobs, including self-employed individuals.
Employee Compensation	Total payroll costs, including wages and salaries plus benefits.
Indirect Business Tax	Sales, excise fees, licenses and other taxes paid during normal operation. This includes all payments to the government except for taxes based on income.
Labor Income	Sum of Employee Compensation and Proprietor's Income.
Other Property Income	Includes corporate income, rental income, interest and corporate transfer payments.
Proprietor Income	Income from self-employment.
Total Value Added	The value added during production to all purchased intermediate goods and services. This is equal to employee compensation plus proprietor's income plus other property income plus indirect business taxes.

*Source: Adapted from IMPLAN User Guide, Version 2.0

3.2 Economic Impacts Associated with the Mean Value of Ex-Vessel Landings over the 2009-10 through 2011-12 Fishing Seasons

Below we provide economic impact estimates at the county, region, and state-wide scales. Note that these economic impact estimates are based on the mean value of ex-vessel landings over the 2009-10, 2010-11, and 2011-12 spiny lobster commercial seasons. We estimate that the multiplier effect associated with commercial landings resulted in total annual statewide economic output of ~$22,523,000 and 323 FTE jobs (Table 3). Of the California counties in which spiny lobster landings occurred, San Diego County experienced the largest share of statewide output and jobs (Table 4).

Table 3. Economic Impacts for the State of California

	California			
	Direct Effects	**Indirect Effects**	**Induced Effects**	**Total Effects**
Output	$11,188,354	$4,992,389	$6,342,309	$22,523,052
Employee Compensation	$695,893	$1,401,744	$1,778,367	$3,876,004
Proprietor's Income	$3,831,866	$208,003	$293,616	$4,333,496
Labor Income Effect	$4,527,770	$1,609,747	$2,071,983	$8,209,500
Other Property Type Income	$198,604	$691,843	$1,315,695	$2,206,142
Indirect Business Taxes	$750,257	$337,810	$373,031	$1,461,110
Total Value Added	$5,476,632	$2,639,411	$3,760,708	$11,876,751
Jobs	241.4	34.8	46.7	322.8

Table 4. Economic Impacts by County: Los Angeles, Orange, Santa Barbara, San Diego, and Ventura

	Los Angeles				Orange			
	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Output	$1,943,905	$882,078	$1,098,382	$3,924,364	$1,650,987	$676,320	$790,676	$3,117,983
Employee Compensation	$120,907	$243,046	$310,368	$674,321	$102,688	$197,796	$216,747	$517,231
Proprietor's Income	$665,764	$38,835	$52,973	$757,571	$565,442	$29,148	$40,142	$634,732
Labor Income Effect	$786,671	$281,882	$363,343	$1,431,894	$668,130	$226,945	$256,889	$1,151,963
Other Property Type Income	$34,506	$120,716	$228,897	$384,119	$29,307	$102,006	$173,631	$304,944
Indirect Business Taxes	$130,354	$58,824	$64,413	$253,590	$110,710	$48,917	$49,292	$208,919
Total Value Added	$951,530	$461,423	$656,651	$2,069,603	$808,147	$377,868	$479,811	$1,665,826
Jobs	41.9	6.1	8.2	56.2	35.6	4.8	5.8	46.3

	Santa Barbara				San Diego			
	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Output	$2,353,173	$659,931	$899,510	$3,912,615	$3,643,257	$1,303,157	$1,665,442	$6,611,856
Employee Compensation	$146,363	$205,255	$259,506	$611,126	$226,603	$394,015	$472,866	$1,093,487
Proprietor's Income	$805,931	$32,763	$44,623	$883,317	$1,247,768	$56,011	$76,763	$1,380,543
Labor Income Effect	$952,296	$238,019	$304,129	$1,494,443	$1,474,375	$450,026	$549,629	$2,474,027
Other Property Type Income	$41,771	$103,191	$205,634	$350,597	$64,671	$193,329	$370,064	$628,061
Indirect Business Taxes	$157,797	$53,097	$58,194	$269,088	$244,306	$100,142	$107,902	$452,350
Total Value Added	$1,151,864	$394,307	$567,957	$2,114,128	$1,783,352	$743,494	$1,027,595	$3,554,438
Jobs	50.8	6.0	7.7	64.4	78.6	10.8	13.3	102.8

	Ventura			
	Direct Effects	**Indirect Effects**	**Induced Effects**	**Total Effects**
Output	$1,597,033	$517,177	$582,053	$2,696,263
Employee Compensation	$99,332	$160,609	$166,446	$426,387
Proprietor's Income	$546,963	$18,479	$26,436	$591,880
Labor Income Effect	$646,295	$179,088	$192,883	$1,018,267
Other Property Type Income	$28,349	$76,490	$135,721	$240,560
Indirect Business Taxes	$107,092	$41,226	$39,983	$188,301
Total Value Added	$781,738	$296,804	$368,587	$1,447,128
Jobs	34.5	4.2	4.9	43.5

Section 4.0 Estimated Expenditures in the Spiny Lobster Recreational Fishery

We developed a recreational survey instrument that, like other recreational fishing surveys, seeks expenditure information associated with spiny lobster fishing. Capital expenditures on vessel and non-specific gear are weighted by the reported percentage of targeted usage in the spiny lobster recreational fishery. The survey instrument is provided in Appendix B of this report. A stratified random sampling design was also developed for CDFW. In order to preserve confidentiality, CDFW conducted the telephone surveys and provided us with tabulated results. We begin with an overview of the survey methodology, and then provide demographic summary information and expenditure estimates drawn from the tabulated results of the survey.

4.1 Survey Methodology

A stratified random sampling design was developed for sampling spiny lobster recreational fishermen, as it is likely that there are substantially different levels and types of expenditure across groups of fishermen. Stratified sampling takes advantage of the ability to create groups where the target of interest (i.e., angler expenditures) is most similar among units (i.e., recreational fishermen) within a stratum, which helps reduce variation of the overall estimate (Thompson 1992, see Cochran 1977, for greater detail on stratified sampling). In this case we use strata that delineate groups based on home origin (i.e., the fisherman's residence), catch location, and gear type.

Stratification based on home origin regions was used in an attempt to account for potential differences in expenditure incurred by geographic area. Home origin is defined as the location where people live, and was determined based on the zip codes provided on spiny lobster report cards. The rationale for home origin groups is based on the likelihood that fishermen traveling to the catch location from further away have an increased likelihood of incurring a lodging expense. Catch location pertains to the area fished, as indicated by the location codes on the report cards. The rationale for catch location groups is based on the likelihood that fuel and related expenditures linked to additional vessel transit distance to the fishing grounds will vary across catch locations. This is especially the case for offshore and island catch locations where transit expenditures are expected to be considerably higher than catch locations that are closer to the coast.

We based our final decision on appropriate home origin regions on sample size considerations, geographical breaks related to population density (extent of urbanization), and graphical analyses. As illustrated in Figure 1 the majority of returned cards are from coastal zip codes immediately adjacent to the coast (1,174 of 4,640), or zip codes for locations outside the immediate coastal strip but within 50 miles of the coast (2,834 of 4,640). There was a large drop-off in the number of returned report cards beyond 50 miles from the coast (632 of 4,640), suggesting a substantial decrease in activity from fishers further than 50 miles from the coast, assuming that reporting rates do not differ with distance from the coast. In addition, most of the population lives within 50 miles of the coast, and are more likely to take day trips to go fishing with reduced expenditures per fishing trip compared to those who would travel from further away and make longer trips.

In summary, we utilized the following home origin regions:

1. Coastal (zip codes directly adjacent to the coast)
2. Regional (i.e., close enough to the coast for reasonable day trip, < 50 miles, but beyond coastal)
3. Beyond (> 50 miles from the coast)

Figure 1. Map of Potential Home Origin of California Spiny Lobster Recreational Fisherman. Note that "Within 50 miles to Coast" includes zip code areas that are partially within this zone

In addition to home origin regions, we also pre-stratified based on catch location regions. Fishing grounds in coastal waters off San Diego, Los Angeles/Orange County, and Santa Barbara/Ventura were grouped into a "Not Offshore" category (3,679 of 4,640 report cards). Due to the potential for greater trip expenditures associated with catch locations in the Channel Islands and more distant offshore grounds, a second category, "Offshore and Islands" (961 report cards) was created.

Finally, gear type is an important consideration for pre-stratification in that the focus of the trip and behavior patterns/investment in the recreational fishery may differ a great deal. Anglers targeting spiny lobster generally utilize either some type of diving gear, or deploy some form of hoop net. The equipment associated with each method also differs, as does the expenditure of the equipment.

For the purposes of pre-stratification, we collapsed the 2 types of hoop netting (traditional basket-style hoop nets and rigid conical-style hoop nets) into one category, "hoopers", and the 2 types of diving (skin and scuba) into another category, "divers" (Barsky 2003). Overall there were a greater number of returned report cards for hoopers (2,840) than divers (1,800). The CDFW's 2007 creel survey of recreational lobster fishermen found that 80% used hoop nets and 20% were divers.

We had considered finer breaks in categories (e.g., between traditional and rigid hoop nets, or between scuba and skin diving), but concluded that differences in net technology did not warrant further stratification. Due to sample size considerations (i.e., relatively few skin divers), and the large degree of overlap between the 2 activities for many fishermen, we opted for a single comprehensive "divers" category.

Analysis of activity patterns also showed the strongest differences between gear types (see Figure 2), supporting the idea that the expenditures between hoopers and divers may be considerably different. Distributions of activity patterns were plotted using kernel smoothing techniques (Bowman and Azzalini 1997) to allow graphical comparisons among gear types. Kernel smoothing was used to estimate probability densities for the range of values of activity patterns found in the dataset. These probability densities were plotted against the number of trips to graphically represent distributions of activity patterns. In general, divers tended to take more trips per year than hoopers, and were more likely to make > 5 trips in a year/season.

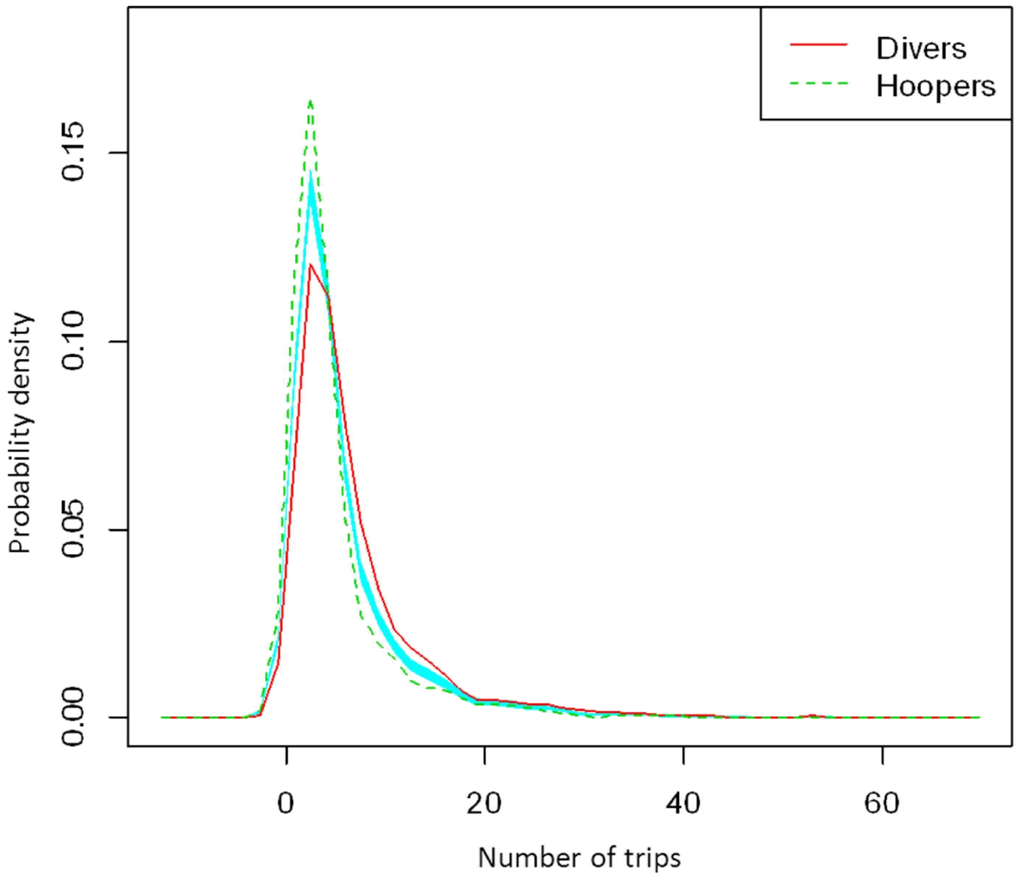

Figure 2. Smoothed Probability Density Distribution Curves for Activity Patterns by Gear Type. The turquoise band is a reference band of equality (see Bowman and Azzalini 1997); if both lines fall within the band, there is no difference between the 2 distributions.

To classify the data, we designated a dominant gear type used by a fisherman (defined as > 50% of trips, i.e., > 50% of trips diving resulted in classification as "divers"; > 50% of trips hooping resulted in classification as "hoopers"; 50/50% of trips for "divers"/"hoopers" resulted in classification as "both" (1 report card)). If no one category represented > 50% of the trips (27 report cards), we evaluated the detailed record of trips to determine the appropriate gear category (23 of 27 were deemed "both"). Due to the small number of fishermen in the "both" category however, we decided to lump this category with the category that had the most similar pattern of activity, the "hoopers."

We developed stratum-specific sample sizes that are proportional to the stratum size (i.e., proportional allocation). If we had more information regarding variance of expenditures within each stratum, we could try to achieve optimal allocation of sampling effort using different sampling proportions per stratum, minimizing variance for a given expenditure; however, this information does not currently exist. Proportional allocation is the same as the optimal allocation scheme in that it minimizes variation for a given expenditure under certain conditions (i.e., when the stratum variances are equal and the costs of sampling each unit within a given stratum are equal) (Chambers and Clark 2012). For the purpose of this study, we are assuming that both conditions hold. Although it would be desirable to allocate more effort to those strata that have greater variance, there are no data to support that allocation at this time. In addition, it is reasonable to assume that calling an angler from one stratum will have a similar cost to calling a fisherman in any other stratum. Table 5 provides the proposed stratum sizes and the sample sizes by stratum.

Table 5. Sample Sizes by Stratum

Home Origin	Location	Gear Type	Stratum Size	Proportion of Total	Proposed Sample Size	Actual Sample Size
< 50	Not offshore	Hoopers	1,711	0.37	111	140
< 50	Not offshore	Divers	708	0.15	46	64
< 50	Offshore	Hoopers	236	0.05	15	20
< 50	Offshore	Divers	179	0.04	12	17
Beyond	Not offshore	Hoopers	198	0.04	13	18
Beyond	Not offshore	Divers	114	0.02	7	10
Beyond	Offshore	Hoopers	44	0.01	3	4
Beyond	Offshore	Divers	276	0.06	18	24
Coastal	Not offshore	Hoopers	537	0.12	35	47
Coastal	Not offshore	Divers	411	0.09	27	37
Coastal	Offshore	Hoopers	114	0.02	7	10
Coastal	Offshore	Divers	112	0.02	7	10
Total			4,640		300	401

A minimum proposed sample size per stratum of 3 was selected, as this is the absolute minimum required to generate a reasonable estimate of variance. For the vast majority of strata, proposed sample sizes are much greater than 3 (see Table 5). The strata selected were a balance between the idea of lumping strata to provide the greatest sample sizes possible per stratum, and making sure that we had enough strata to capture the groups most likely to have relatively large differences in expenditures with similar expenditures within each group. This approach resulted in a recommendation of a total sample size of 300 completed interviews, which amounts to picking the sample size that allows us to use 3 at a minimum for any given stratum under proportional allocation.

Interviews were conducted by telephone by CDFW personnel based on a list of randomly selected spiny lobster report card identification numbers. CDFW personnel then linked the selected identification numbers to the appropriate phone numbers before making the telephone calls. Potential survey participants were selected from recreational fishery participants who returned a 2011 spiny lobster report card. Interviewers would call a number, and if they were unsuccessful with the target interviewee (no answer, refusal to participate, language barrier), then they would move on to the next contact on the list. If they completed the list for a particular stratum and still had not met the target number of completed surveys, then they would start over from the top of the list in an attempt to reach target interviewees who did not answer the first time (skipping prior refusals, language barriers, and completed interviews). Under this procedure the maximum number of times that a contact could be called was twice. In contrast meeting the sample size for some of the stratum groups was easier (more people answered the phone, fewer refusals, language barriers, etc.) and interviewers did not have to call all of the contacts on the list. A few contacts were obviously erroneous or didn't have phone numbers: Interviewers did not attempt to contact these people. CDFW generally found anglers to be willing to participate, and as a result CDFW elected to increase sample size by about 1/3 overall, with increases spread as evenly as possible across all strata. The column "actual sample size" in Table 5 indicates the number of recreational fishers interviewed by CDFW.

4.2 Expenditure Estimates for the Spiny Lobster Recreational Fishery

4.2.1 Estimation Methods

Estimates of the mean expenditures were generated using a bottom-up approach, taking estimates of the mean expenditure from respondents and extrapolating to the total number of report cards that were sold. Estimates of expenditures (mean, standard deviation) were first generated by stratum in accordance with the stratified sampling design used to select participants for the telephone survey. Mean expenditure for each stratum was generated based on the following formula for stratified estimators from Cochran (1977):

$$\bar{y}_{st} = \sum \frac{N_h}{N} \cdot \bar{y}_h,$$

where N_h is the number of spiny lobster report cards in stratum h, N is the total number of spiny lobster report cards sold in 2011 adjusted by the % of returned cards that did not fish (13.5%), N = 28,868, and $\bar{y}_h$ is the estimated mean expenditure for stratum h. Once this estimate was obtained, the total was simply calculated as:

$$\hat{Y} = N \cdot \bar{y}_{st}.$$

Estimates of the 95% confidence interval for total expenditures were calculated based on the estimated sampling variance as:

$$\hat{Y} \pm t \cdot \sqrt{\hat{V}\left(\hat{Y}_{st}\right)},$$

where t is the appropriate t-value, and the sampling variance is estimated as:

$$\hat{V}\left(\hat{Y}_{st}\right) = \sum \frac{N_h(N_h - n_h)(s_h^2)}{n_h},$$

where N_h is as defined previously, n_h is the stratum sample size, and s_h^2 is the stratum variance (Cochran 1977).

All trip-related expenditures were attributed to spiny lobster fishing expenditures, as the survey instrument specifically asked for typical expenditures associated with spiny lobster fishing trips. In contrast, annual boat-related costs, which included items such as boat insurance and gear replacement, were attributed to spiny lobster fishing based on the percentage of annual boat or water craft usage that was reportedly dedicated to spiny lobster fishing in 2011. Note that these costs are subject to potential inestimable inaccuracies of the interviewee's perception of the percentage of their boat usage for spiny lobster fishing. The exceptions to the calculations based on the percentage of annual boat or water craft usage for spiny lobster fishing were fishing gear and related expenditures specifically linked to spiny lobster fishing. In calculating the average annual expenditure for the "other" costs (Question 10 of the annual, seasonal, one-time expenditure section), we assumed that these costs were strictly related to spiny lobster due to the way the question was worded (i.e., "…related to recreational lobster fishing…"), and so these costs were not adjusted based on vessel usage in the spiny lobster fishery.

In their 2006 estimation of the economic contribution of marine angler recreation in the U.S., Gentner and Steinback (2008) utilized a mail survey methodology applied to a sample of anglers originated from the Marine Recreational Information Program (MRIP) intercept survey to elicit angler expenditure information. As with the present study, Gentner and Steinback (2008) used a license-based random survey frame for their California angler expenditure estimates. They report the potential for avidity bias that could affect certain categories of durable expenditures, based on prior experience, and corrected for avidity bias using weights developed by Thomson (1991). One can argue that mail surveys such as those employed by Gentner and Steinback (2008) require an elevated level of commitment and initiative on the part of the angler to complete and return, and this commitment and initiative may be correlated with their level of avidity. In contrast, our telephone interview methodology at least partially addresses this issue and we therefore do not believe there is a strong case for avidity bias in our data, and consequently do not apply avidity weights.

For total annual travel expenditures, most categories of responses were multiplied by the respondent's number of trips (extracted from a separate CDFW database). We also applied \$0.55 per mile to reported spiny lobster fishing-related ground transportation based on the federal rate from 2011. To determine total annual respondent expenditures on dive or party boat trips, we multiplied the reported cost per trip fare by the reported number of such trips in 2011.

For the calculation of the 95% confidence interval (CI) for total cost for a particular expenditure category, we used a weighted average of the degrees of freedom based on the effective "n" (see Satterthwaite 1946, as cited in Cochran 1977) for each cost type (i.e., annual boat purchase cost, boat insurance, etc.) to find the appropriate t-value; weights were based on the contribution of the cost type to the total annual cost.

4.2.2 Demographic Information and Estimated Expenditures in California's Recreational Fishery for Spiny Lobster

Means, totals, and standard deviations (SD) for expenditures are presented in Tables 6 through 10. The average recreational fisherman has fished spiny lobster for nearly 9 years and spends an average of just over 2/3 of a day on a typical fishing trip (Table 6). Spiny lobster fishing constitutes an average of just over 1/3 of a recreational fisherman's total fishing effort in a given year (Table 6). Private vessels provide just over 1/2 of all access to the recreational fishery (Table 7), and on average about 8% of a vessel's annual usage was estimated to be targeted at spiny lobster fishing (Table 8A).

Annual expenditures in the recreational fishery for spiny lobster in California are estimated to be $37,093,000 (Table 9). The largest sources of expenditures were non-coastal residents who live within 50 miles of the coast who fished spiny lobster along the coast, and those who live more than 50 miles from the coast who dove for spiny lobster offshore (Table 9). Spiny lobster gear, boat/gear maintenance, and boat purchases were the largest annual expenditure categories (Table 8), while transportation, vessel fuel, meals and beverages, and dive/party boat fees were the largest trip-based expenditure categories (Table 10). Note that not all of these expenditures necessarily occur in California. Also note that these are expenditures and not total economic impact, which is beyond the scope of this report.

Table 6. Demographic Estimates for the Spiny Lobster Recreational Fishery, Means and Standard Deviations

Home Origin	Location	Gear Type	Years Fishing for Spiny Lobster		Spiny Lobster Fishing Trip Duration (Days)		Fraction of Total Fishing Effort (Lobster)	
			Mean	SD	Mean	SD	Mean	SD
<50	Not offshore	Hoopers	3.91	5.95	0.31	0.40	0.26	0.30
	Not offshore	Divers	18.18	13.45	0.31	0.35	0.43	0.29
	Offshore	Hoopers	8.10	11.17	1.28	0.82	0.26	0.26
	Offshore	Divers	12.88	11.76	0.81	0.97	0.57	0.33
Beyond	Not offshore	Hoopers	2.12	1.41	0.57	1.24	0.34	0.42
	Not offshore	Divers	7.70	13.00	1.73	1.43	0.41	0.47
	Offshore	Hoopers	2.50	1.29	2.38	1.49	0.37	0.44
	Offshore	Divers	9.46	11.15	3.90	2.77	0.49	0.43
Coastal	Not offshore	Hoopers	9.91	16.38	0.18	0.07	0.28	0.32
	Not offshore	Divers	11.57	11.35	0.24	0.35	0.47	0.34
	Offshore	Hoopers	2.60	0.94	0.79	1.35	0.30	0.38
	Offshore	Divers	21.70	16.73	1.41	1.55	0.45	0.29
		Overall	8.75	3.86	0.68	0.25	0.35	0.13

Table 7. Proportion of Recreational Fishermen who Fish for Spiny Lobster by Access Type

			Proportion by Access Type											
Home Origin	Location	Gear Type	Beach	Beach/ Boat	Boat	Charter Boat	Jetty	Kayak	Launch from Beach	Party Boat	Pers. Water-Craft	Pier	Private Boat	Shore
<50	Not offshore	Hoopers	0.03	0.00	0.00	0.00	0.01	0.04	0.01	0.05	0.00	0.22	0.64	0.00
	Not offshore	Divers	0.50	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.44	0.00
	Offshore	Hoopers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.95	0.00
	Offshore	Divers	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.41	0.00
Beyond	Not offshore	Hoopers	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.28	0.56	0.00
	Not offshore	Divers	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.10	0.00	0.00	0.30	0.00
	Offshore	Hoopers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	Offshore	Divers	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.17	0.00
Coastal	Not offshore	Hoopers	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.06	0.02	0.15	0.70	0.00
	Not offshore	Divers	0.68	0.03	0.11	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.11	0.03
	Offshore	Hoopers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	Offshore	Divers	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.30	0.00
		Mean	0.18	0.00	0.01	0.00	0.01	0.02	0.02	0.10	0.00	0.11	0.54	0.00

Table 8A. Estimated Annual Recreational Fisherman Expenditure Estimates

Home Origin	Location	Gear Type	Boat or Water Craft		% of Annual Boat or Water Craft Usage (for Lobster)		Boat Insurance		Slip Fees	
			Total	SD	Mean	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$996,904	$6,358,197	0.08	0.17	$132,034	$331,774	$159,637	$979,413
	Not offshore	Divers	$823,356	$3,560,214	0.13	0.25	$119,658	$303,138	$307,318	$1,198,819
	Offshore	Hoopers	$0	$0	0.08	0.12	$94,743	$168,694	$247,802	$850,070
	Offshore	Divers	$0	$0	0.09	0.18	$81,912	$246,970	$263,756	$820,755
Beyond	Not offshore	Hoopers	$369,600	$1,083,138	0.09	0.20	$116,458	$435,255	$246,640	$1,045,327
	Not offshore	Divers	$0	$0	0.10	0.32	$56,720	$179,364	$10,635	$33,631
	Offshore	Hoopers	$0	$0	0.04	0.07	$4,829	$9,119	$0	$0
	Offshore	Divers	$0	$0	0.00	0.01	$486	$2,383	$0	$0
Coastal	Not offshore	Hoopers	$24,880	$147,694	0.12	0.23	$64,926	$209,046	$80,596	$264,884
	Not offshore	Divers	$62,197	$378,331	0.08	0.20	$22,446	$85,459	$74,844	$362,830
	Offshore	Hoopers	$177,250	$560,514	0.02	0.03	$53,459	$168,057	$116,560	$236,388
	Offshore	Divers	$0	$0	0.06	0.08	$55,412	$135,934	$170,068	$402,831
		Overall	$2,454,188	$7,399,602	0.08	0.08	$803,083	$781,569	$1,677,855	$2,303,579

Table 8B. Estimated Annual Recreational Fisherman Expenditure Estimates

Home Origin	Location	Gear Type	DMV Registration Fees (Boat and Trailer)		Boat Taxes		Annual Maintenance or Replacement of Boat Gear and Equipment	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$88,976	$524,967	$32,809	$124,490	$743,664	$2,074,209
	Not offshore	Divers	$30,517	$105,277	$44,115	$139,018	$1,320,574	$3,934,693
	Offshore	Hoopers	$3,242	$6,473	$55,775	$97,186	$375,212	$708,445
	Offshore	Divers	$13,171	$48,453	$11,795	$48,633	$156,615	$488,614
Beyond	Not offshore	Hoopers	$5,041	$17,584	$704,978	$2,900,032	$162,610	$359,090
	Not offshore	Divers	$2,127	$6,726	$19,143	$60,535	$141,800	$448,411
	Offshore	Hoopers	$1,199	$1,968	$103	$206	$10,275	$20,550
	Offshore	Divers	$236	$865	$347	$1,495	$1,216	$5,273
Coastal	Not offshore	Hoopers	$19,001	$60,846	$24,197	$88,904	$489,314	$1,228,024
	Not offshore	Divers	$6,256	$19,150	$1,555	$6,971	$85,438	$264,160
	Offshore	Hoopers	$2,184	$6,709	$28,360	$89,682	$52,466	$133,029
	Offshore	Divers	$1,046	$3,306	$33,805	$92,672	$183,311	$548,287
		Overall	$172,996	$541,800	$956,982	$2,912,914	$3,722,496	$4,769,842

Table 8C. Estimated Annual Recreational Fisherman Expenditure Estimates

Home Origin	Location	Gear Type	Electronic Gear		Spiny Lobster Fishing Gear		Other Expenditures	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$102,838	$421,853	$1,237,232	$2,089,914	$49,765	$251,005
	Not offshore	Divers	$105,514	$461,687	$956,023	$1,616,749	$310,185	$896,550
	Offshore	Hoopers	$371,829	$1,598,685	$128,267	$167,942	$0	$0
	Offshore	Divers	$0	$0	$441,668	$916,559	$6,553	$27,018
Beyond	Not offshore	Hoopers	$34,393	$145,152	$142,638	$301,803	$34,222	$53,711
	Not offshore	Divers	$0	$0	$138,539	$163,857	$9,217	$29,147
	Offshore	Hoopers	$8,220	$16,440	$22,263	$32,311	$0	$0
	Offshore	Divers	$179	$876	$223,925	$351,706	$114,467	$507,369
Coastal	Not offshore	Hoopers	$47,201	$180,077	$436,463	$595,724	$99,306	$205,614
	Not offshore	Divers	$8,120	$34,446	$587,765	$950,450	$40,322	$126,447
	Offshore	Hoopers	$13,294	$39,024	$14,180	$29,894	$1,418	$4,484
	Offshore	Divers	$6,970	$22,041	$59,594	$108,607	$0	$0
		Overall	$698,557	$1,733,168	$4,388,555	$3,059,985	$665,455	$1,089,486

Table 9. Estimated Total Recreational Fisherman Annual, Trip, and Grand Total Expenditures, with 95% Confidence Intervals

Home Origin	Location	Gear Type	Annual			Trip			Grand Total		
			Total	95% CI		Total	95% CI		Total	95% CI	
<50	Not offshore	Hoopers	$3,543,861	$2,361,061	$4,726,661	$3,834,313	$3,150,282	$4,518,343	$7,378,174	$6,011,104	$8,745,243
	Not offshore	Divers	$4,017,260	$2,599,456	$5,435,064	$3,985,715	$2,738,220	$5,233,210	$8,002,975	$6,114,130	$9,891,820
	Offshore	Hoopers	$1,276,869	$415,100	$2,138,638	$980,949	$680,996	$1,280,902	$2,257,818	$1,344,622	$3,171,015
	Offshore	Divers	$975,471	$333,234	$1,617,707	$1,548,263	$834,119	$2,262,408	$2,523,734	$1,563,307	$3,484,161
Beyond	Not offshore	Hoopers	$1,816,581	$273,546	$3,359,615	$1,965,233	$730,433	$3,200,033	$3,781,813	$1,804,999	$5,758,628
	Not offshore	Divers	$378,181	$57,898	$698,463	$1,212,433	$629,897	$1,794,968	$1,590,613	$926,116	$2,255,110
	Offshore	Hoopers	$46,888	$4,951	$88,826	$301,277	$168,425	$434,128	$348,165	$208,946	$487,384
	Offshore	Divers	$340,857	$93,260	$588,453	$4,446,683	$3,417,064	$5,476,301	$4,787,540	$3,729,359	$5,845,720
Coastal	Not offshore	Hoopers	$1,285,883	$872,100	$1,699,667	$1,064,607	$759,732	$1,369,482	$2,350,490	$1,836,345	$2,864,636
	Not offshore	Divers	$888,944	$524,635	$1,253,253	$1,470,411	$956,378	$1,984,444	$2,359,354	$1,729,461	$2,989,248
	Offshore	Hoopers	$459,170	$53,438	$864,901	$362,971	$161,455	$564,488	$822,141	$368,839	$1,275,443
	Offshore	Divers	$510,204	$69,977	$950,431	$379,741	$198,481	$561,001	$889,945	$413,520	$1,366,370
		Overall	$15,540,168	$12,752,113	$18,328,223	$21,552,594	$19,103,798	$24,001,390	$37,092,762	$33,381,291	$40,804,233

Table 10A. Estimated Recreational Fisherman Trip Expenditures

Home Origin	Location	Gear Type	Dive/Party Boat		Trip Duration (Days)		Dive Gear Rental		Gas for Boat	
			Total	SD	Mean	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$344,214	$2,738,838	0.01	0.06	$0	$0	$1,145,767	$2,382,055
	Not offshore	Divers	$138,689	$573,076	0.11	0.39	$56,439	$311,032	$1,866,268	$4,559,396
	Offshore	Hoopers	$58,720	$262,604	0.05	0.22	$0	$0	$482,671	$512,848
	Offshore	Divers	$357,791	$498,163	0.74	1.03	$14,416	$41,824	$424,303	$1,041,751
Beyond	Not offshore	Hoopers	$110,196	$262,896	0.22	0.55	$0	$0	$586,432	$2,013,328
	Not offshore	Divers	$41,831	$111,676	1.30	2.75	$15,385	$27,500	$111,313	$186,151
	Offshore	Hoopers	$0	$0	0.00	0.00	$0	$0	$37,675	$46,627
	Offshore	Divers	$960,447	$762,612	2.31	1.41	$15,024	$73,601	$233,226	$804,117
Coastal	Not offshore	Hoopers	$45,104	$188,994	0.34	1.13	$28,789	$197,371	$340,833	$590,418
	Not offshore	Divers	$289,563	$920,521	0.22	0.58	$21,424	$74,856	$427,157	$931,467
	Offshore	Hoopers	$0	$0	0.00	0.00	$0	$0	$211,353	$279,208
	Offshore	Divers	$76,670	$181,309	0.35	0.75	$12,546	$26,653	$129,642	$185,872
		Overall	$2,423,223	$3,118,636	0.30	0.19	$164,024	$387,211	$5,996,639	$5,820,325

Table 10B. Estimated Recreational Fisherman Trip Expenditures

Home Origin	Location	Gear Type	Bait		Lodging		Meals and Beverages	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$550,088	$1,202,154	$29,350	$208,747	$606,951	$951,956
	Not offshore	Divers	$100,145	$401,754	$69,516	$406,371	$788,712	$1,611,999
	Offshore	Hoopers	$40,084	$61,474	$0	$0	$258,148	$338,814
	Offshore	Divers	$0	$0	$199,865	$809,822	$123,195	$184,072
Beyond	Not offshore	Hoopers	$131,687	$290,395	$99,929	$294,769	$357,964	$1,098,757
	Not offshore	Divers	$0	$0	$120,530	$226,806	$156,689	$172,392
	Offshore	Hoopers	$2,466	$2,882	$21,920	$26,846	$75,350	$51,867
	Offshore	Divers	$7,512	$20,770	$263,989	$527,002	$413,869	$729,396
Coastal	Not offshore	Hoopers	$189,079	$275,496	$0	$0	$269,793	$715,548
	Not offshore	Divers	$57,360	$221,558	$31,099	$189,166	$172,494	$274,195
	Offshore	Hoopers	$1,702	$4,474	$0	$0	$105,641	$130,282
	Offshore	Divers	$0	$0	$0	$0	$86,428	$115,243
		Overall	$1,080,122	$1,349,124	$836,197	$1,147,645	$3,415,234	$2,458,166

Table 10C. Estimated Recreational Fisherman Trip Expenditures

Home Origin	Location	Gear Type	Transportation		Harbor Fees		Other Expenditures	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$953,741	$1,073,774	$125,505	$296,981	$78,697	$286,990
	Not offshore	Divers	$674,139	$1,075,725	$138,386	$537,214	$153,421	$372,181
	Offshore	Hoopers	$79,690	$62,024	$40,737	$69,441	$20,900	$71,281
	Offshore	Divers	$349,141	$416,393	$25,163	$42,923	$54,389	$201,778
Beyond	Not offshore	Hoopers	$666,020	$1,259,517	$13,004	$33,400	$0	$0
	Not offshore	Divers	$713,013	$858,995	$15,953	$31,850	$37,719	$89,981
	Offshore	Hoopers	$153,591	$111,652	$8,905	$12,925	$1,370	$2,740
	Offshore	Divers	$2,474,852	$2,122,295	$52,726	$115,647	$25,040	$76,783
Coastal	Not offshore	Hoopers	$131,013	$306,673	$15,923	$63,522	$44,073	$135,831
	Not offshore	Divers	$318,532	$701,644	$57,152	$269,856	$95,630	$280,999
	Offshore	Hoopers	$36,477	$97,904	$7,799	$17,189	$0	$0
	Offshore	Divers	$62,203	$53,579	$3,346	$10,580	$8,906	$20,991
		Overall	$6,612,411	$3,150,726	$504,599	$690,215	$520,145	$615,246

Section 5.0 References

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Appendix A. Commercial Expenditure Update Survey

Following is the cover letter and the questionnaire used in the key-informant interviews with commercial spiny lobster fishermen. We produced fixed and variable cost questionnaires for each of 3 vessel size class strata – large, medium, and large. Included below are the cover letter and questionnaire used for informants with small vessels.

H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

15 August 2012

Name of Recipient
1234 Street
City, CA 12345

Dear Commercial Lobster Fisherman:

A fishery management plan is in progress for the spiny lobster fishery, and we are updating expenditure information so that we better understand the positive economic contribution of commercial lobster fishermen to the state and to local economies in California.

In 2007 we did an economic survey of all commercial fishermen in California in order to generate expenditure information and to demonstrate their positive economic contribution. In this brief survey, we are providing you with average annual expenditures by category based on the 2007 survey results. We are asking you whether you feel that these averages are still a reasonable estimate of typical annual costs for a commercial lobster vessel less than 26 feet in length.

As you complete the survey, please note that we are not asking you to compare your expenditures to the averages, as each individual's annual expenditures on categories such as engine purchase will vary quite a bit. Instead we ask whether these averages are a reasonable estimate of typical annual costs for a commercial lobster vessel less than 26 feet in length.

If the answer is yes, then simply indicate that on the sheet. If they are not reasonable, then for a given cost category (such as bait or engine repair), please indicate to us how much higher or lower (in percentage terms) the typical annual expenditure should be.

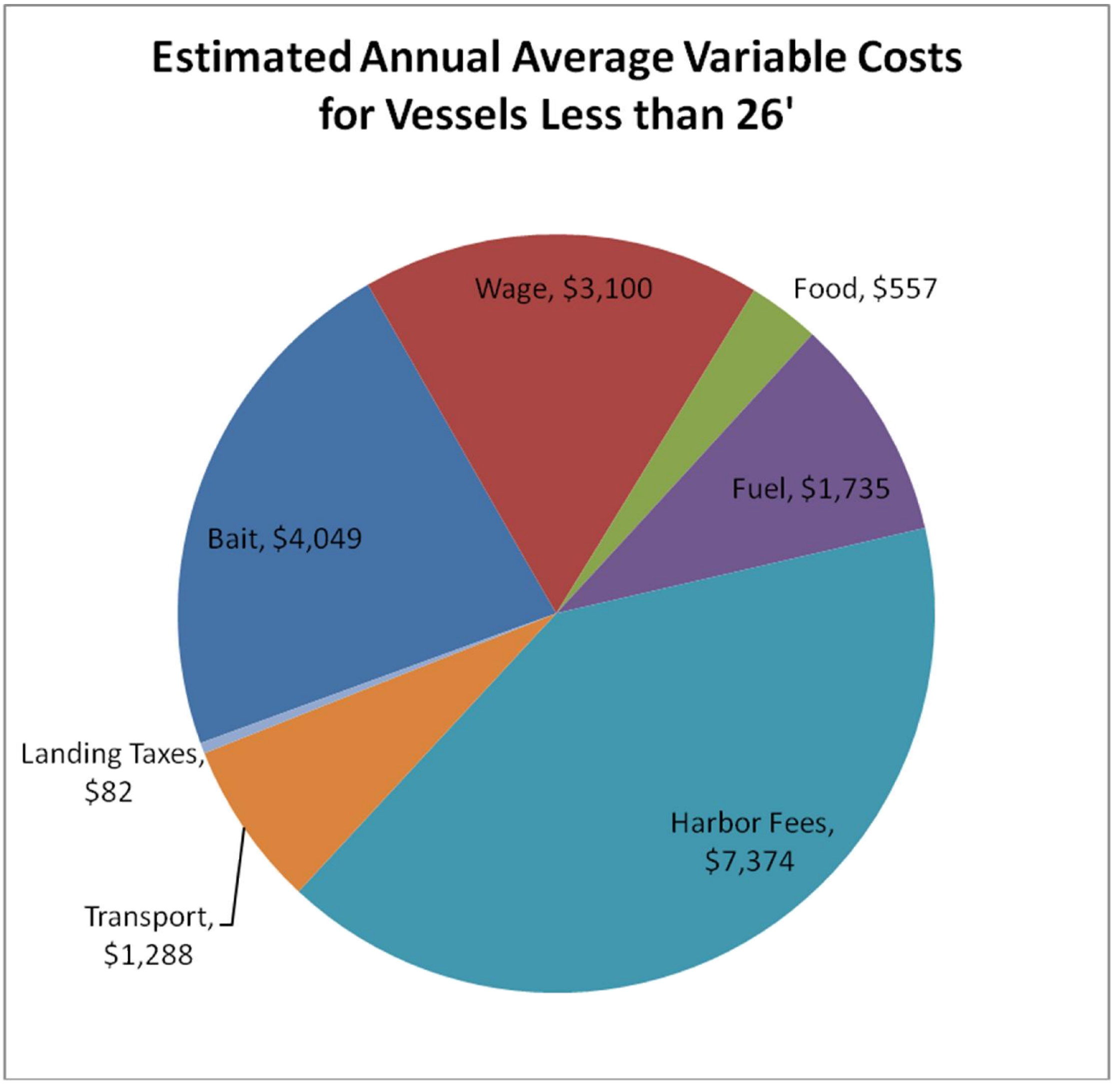
We will call you within the next two weeks to get your responses. If you have any questions, please contact Sharon Kramer at skramer@harveyecology.com or (707) 822-4141 ext 101.

Please note that your individual responses will be kept confidential, and will be aggregated along with those from others to develop an updated estimate of total expenditures by all commercial lobster fishermen. Our goal is to generate an accurate estimate of the total positive economic contribution from commercial lobster fishing in California.

Thank you,

Dr. Steven C. Hackett
Humboldt State University

Dr. Sharon Kramer
H. T. Harvey & Associates



Variable Costs are costs that increase or decrease based on how much you fish. The above estimated annual variable costs (adjusted for inflation) are averaged across all responses to our 2007 survey. These costs imply an average per-trip cost of $849.

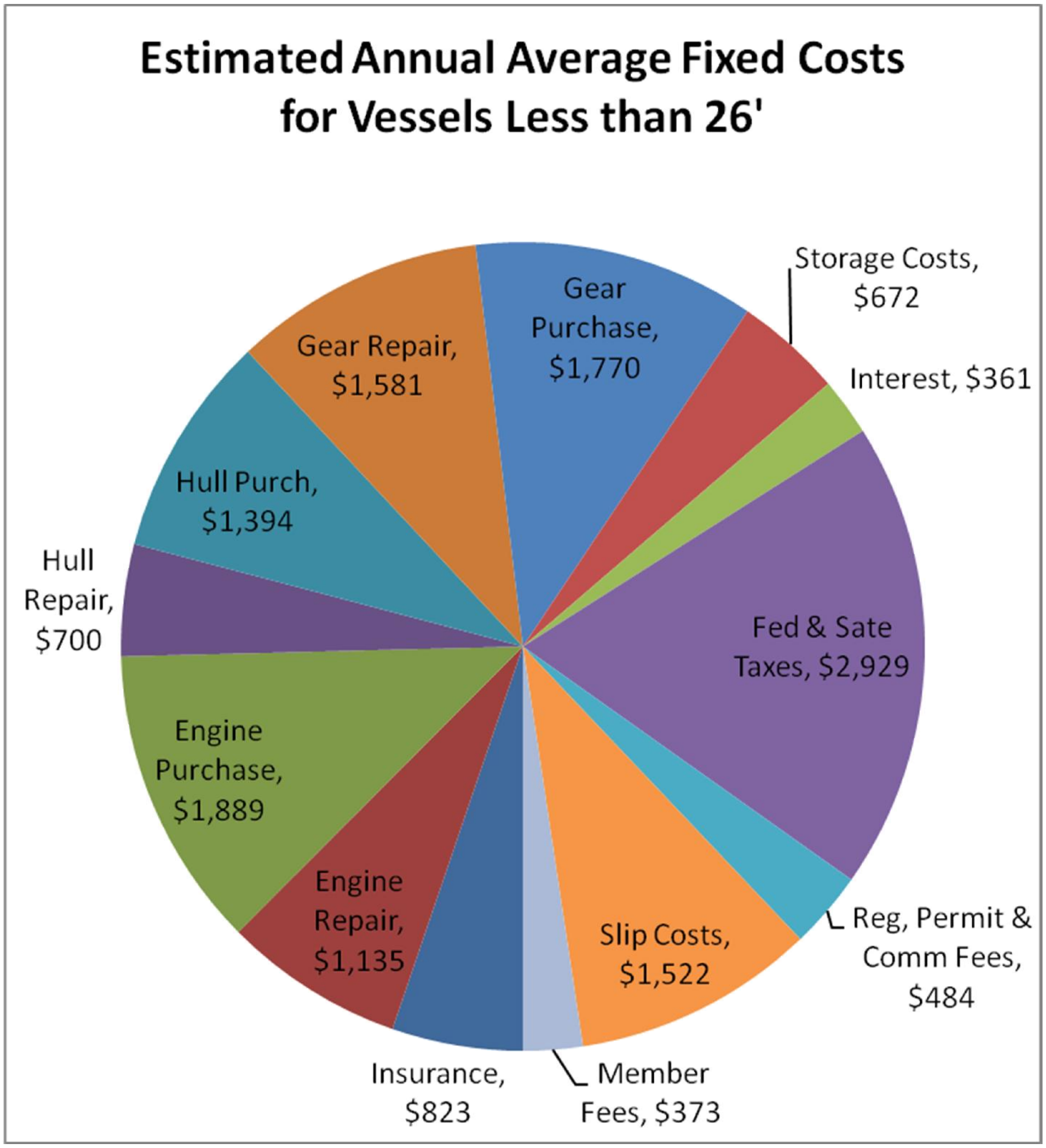
Do you feel that these are a reasonable estimate of typical annual variable costs for a lobster vessel less than 26 feet in length? **Yes / No** (circle one).

If **not**, then please correct the cost categories below. Circle whether the cost should increase or decrease, and indicate the correct percentage increase or decrease with an X.

Bait	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $4,049	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Crew Wages/Comp.	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $3,100	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

Food (fishing-related)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $557	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Fuel & Lube (vessel)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,735	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Harbor Fees (ex: hoist)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $7,374	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Transportation*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,288	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Landing Taxes	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $82	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

* Transportation related to fishing (truck and auto)



Fixed Costs are costs that commercial fishermen incur whether they fish or not. The above estimated annual fixed costs (adjusted for inflation) are averaged across all responses to our 2007 survey.

Do you feel that these are a reasonable estimate of typical annual fixed costs for a lobster vessel less than 26 feet in length? **Yes / No** (circle one).

If **not**, then please correct the cost categories (ex. "Engine Purchase") needing adjustment. Circle whether the cost should increase or decrease, and indicate the correct percentage increase or decrease with an X.

Insurance (vessel)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $823	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

Engine Repair (vessel)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,135	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Engine Purch. (vessel)*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,889	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Gear Repair	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,581	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Gear Purchase*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,770	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Hull Repair	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $700	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Hull Purchase*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,394	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Storage (vessel, gear)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $672	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Interest (vessel)*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $361	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Member/Assoc. Fees	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $373	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Federal & State Taxes	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $2,929	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Permit, License, Reg.	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $484	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

Slip Costs	increase / decrease	by:				
Ann. Avg. = $1,522	(circle one)		___	0% - 20%	___	60% - 80%
			___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

* The annual average cost reported for engine and hull purchases come directly from our 2007 survey. As these expenditures only occur infrequently (thankfully), the cost reported here can be thought of as an annualized cost, somewhat like an annual loan payment absent the interest. Vessel-related interest expenditures from vessel-related loan payments are listed separately above.

Appendix B. Recreational Fishery Expenditure Survey

Following is the telephone interview script used to gather demographic and expenditure information from participants in the spiny lobster recreational fishery. The sample frame was derived from CDFW's spiny lobster report card database of recreational fishery participants. Due to CDFW's confidentiality agreement associated with the report card database, the research team provided a survey methodology and sampling design and the calls were conducted by CDFW personnel.

RECREATIONAL LOBSTER PARTICIPANT SURVEY

Opening Script:

Introduce yourself
Describe purpose of call and of the project
DFG is trying to determine how much money is being generated by the recreational lobster fishery in the state of California. The information that we are interested in collecting goes beyond license sales. This survey will help DFG to accurately characterize the economic contribution of the fishery.

Responses will be protected, interviewee can contact Kristine Barsky for questions or comments [kbarsky@dfg.ca.gov, tel.# (805)985-3114]

Basic Questions Script:

I would like to start with some basic questions about your fishing history and how you fish. I will then turn to the economic questions.

1. How many years have you been fishing for lobster?
2. What is your most common type of access when you fish for lobster?
   Do you fish from a Pier/dock, launch from a beach, use a private boat, go on a party boat, or use a personal watercraft (kayak, etc.)?
3. On average, how many hours or days does the average lobster fishing trip take you, including travel time to and from fishing grounds (fraction of day is ok). I'm only asking about trips that you just fished for lobster. *Please tabulate as days (or fraction of days – xx hrs/24).*
   Trip definition = the time period in which a fisherman travels to the fishing grounds, seeks lobster, concludes fishing, and returns home
4. Approximately what percentage of your total fishing effort (including all fishing trips) was dedicated to lobster fishing in 2011?

Expenditure Questions Script:

Moving on to the economic questions. The first questions will address **annual, seasonal, or one-time expenditures** you have made that are linked to your lobster fishing activity. After that I'll ask about typical trip-related expenditures.

Do you own a boat or other water craft that you use for lobster fishing or diving?
If they answered yes, start with question 1, otherwise skip to question 9.

1. Did you purchase your boat or water craft this past year? If so, then how much did you spend?
2. What percentage of your annual boat or water craft usage was for fishing for lobster?
3. How much do you spend per year on boat insurance?

4. Do you keep your boat in the water, (If yes) then how much do you spend in total cost annually on slip fees?
5. How much do you spend annually on DMV registration fees for your boat and trailer?
6. How much do you spend annually on taxes (e.g., property or luxury taxes) on your boat?
7. How much did you spend last year on maintenance (like hull cleaning) or replacement of boat gear & equipment (boat, engine, equipment)?
8. If you own a boat or other water craft, did you purchase any electronic gear (GPS, radio, fish finder, radar, etc) this past year that was used for fishing lobster? If so, then how much did you spend?
9. Did you purchase any lobster fishing gear (dive gear, hoop nets, other lobster equipment) this past year? If so, then how much did you spend?
10. Excluding the cost of fishing licenses and report cards, are there any other annual, seasonal, or one-time expenditures related to recreational lobster fishing that you would like to add in?
    Ask for $$ and category

I would like to finish the survey with some questions about your **typical expenditures** associated with **lobster fishing trips**.

1. Did you purchase a spot on a dive boat or a party boat for lobster this last year (2011)?
2. If so, then how much do you typically spend on a single boat trip (just the cost of the trip fare)?
3. Did you rent dive gear for lobster fishing last year? If so, then how much do you typically spend on dive gear rentals per lobster fishing trip?
4. How much do you typically spend on gas for the boat you use (yours or a shared boat) on each lobster fishing trip?
5. How much do you typically spend on bait on a lobster fishing trip?
6. How much do you typically spend on lodging during a lobster fishing trip?
7. How much do you typically spend on meals and beverages during a lobster fishing trip?
8. How many miles (one-way) did you drive to a port, dock, or beach for each lobster fishing trip? [*Note: Researchers will double on-way miles you record and multiply by the average total cost per mile driven from the Department of Transportation to get $$ expenditure*]
9. If you trailer a boat to a launch facility for lobster fishing trips, then how much do you typically spend on harbor fees (boat launch, docking, or parking) per trip? (Includes smaller craft if relevant (kayak, paddle or surf board….).
   This should be entered as $0 if (i) the fisherman keeps a boat in the water and already provided a cost earlier in the survey, or (ii) they don't use a boat to fish
10. Are there any other expenditures you usually make on a typical recreational lobster fishing trip you would like to add?
    Ask for $$ and category; Examples = power wash, SCUBA tank air refills

Appendix VII: Ocean Science Trust External Scientific Peer Review

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Final Report of the Scientific Review Committee

Scientific review of the reference point thresholds prescribed in the draft Fishery Management Plan for California Spiny Lobster (*Panulirus interruptus*)

Convened by the California Ocean Science Trust

Supported by the California Ocean Protection Council and the California Ocean Science Trust

CALIFORNIA OCEAN SCIENCE TRUST

May 2015

Review Participants

CALIFORNIA OCEAN SCIENCE TRUST

California Ocean Science Trust is a boundary organization. We work across traditional boundaries, bringing together governments, scientists, and citizens to build trust and understanding in ocean and coastal science. We are an independent non-profit organization established by the California Ocean Resources Stewardship Act (CORSA) of 2000 to support managers and policymakers on the U.S. West Coast with sound science, and empower participation in the decisions that are shaping the future of our oceans.

Ocean Science Trust served as the independent appointing agency in alignment with the Procedural Guidelines for the California Department of Fish and Wildlife's Ad Hoc Independent Scientific Advisory Committees. Ocean Science Trust convened the review committee and designed and implemented a scientific review process that promoted objectivity, transparency, and scientific rigor (see Appendix C).

SCIENTIFIC REVIEW COMMITTEE

John Field (chair)
Research Fishery Biologist, Fisheries Ecology Division, Southwest Fisheries Science Center, National Marine Fisheries Service (NOAA)

Michel Comeau
Head of the Lobster Section, Department of Fisheries and Oceans Canada

Robert Muller
Assessment and Modeling, Florida Fish and Wildlife Conservation Commission, Florida Wildlife Research Institute

Pete Raimondi
Chair/Professor, Department of Ecology and Evolutionary Biology, University of California, Santa Cruz

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

The Mission of the Department of Fish and Wildlife is to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public.

California Department of Fish and Wildlife staff were engaged throughout the review process. They delivered presentations to the review committee and supplied additional data, information, and feedback to Ocean Science Trust as necessary throughout the review process.

Travis Buck	Tom Mason
Julia Coates	Carlos Mireles
Kai Lampson	Anthony Shiao

The California Department of Fish and Wildlife Marine Region Program Manager, Tom Barnes, was the primary management contact for this review. California Wildlife Foundation was the grant manager for this project.

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Recommended citation: Final report of the scientific review committee, scientific review of the reference point thresholds prescribed in the draft Fishery Management Plan for California Spiny Lobster (*Panulirus interruptus*). California Ocean Science Trust, Oakland, CA. May, 2015.

Cover image: Ken Curtis

Background

Spiny lobster (*Panulirus interruptus*) populations support important commercial and recreational fisheries, and play a key role in the southern California kelp forest ecosystem. Over the last three years, the California Department of Fish and Wildlife (the Department) has developed a draft spiny lobster fishery management plan (FMP) to guide management of these fisheries in accordance with the Marine Life Management Act. An FMP assembles information, analyses, and management options, and serves as the vehicle for the Department to present a coherent package of information, and proposed regulatory and management measures to the California Fish and Game Commission (the Commission). The FMP becomes effective upon adoption by the Commission, following their public process for review and revision. Thus, it is important for the scientific underpinnings of the draft FMP to have undergone independent review prior to submission to the Commission.

The Department is committed to incorporating the best scientific information into management decisions. To this end, the Department approached the Ocean Science Trust to convene experts to conduct an assessment of key scientific and technical components within the FMP and supporting spawning potential ratio (SPR) cable model. Ocean Science Trust, an independent organization that works to advance independent science in management decisions, tailored this review to meet the science needs of the Department, and served as the appointed entity to design and coordinate all aspects of this review.

REVIEW SCOPE

Ocean Science Trust, in consideration of the management request, worked with the Department to develop a scope of review focusing on the scientific and technical underpinnings of the FMP and supporting materials. Thus, this was not a comprehensive review of the FMP, or the proposed approach to management contained therein. Rather, the central question of this review was:

Given the Department of Fish and Wildlife's available data streams and analysis techniques, are the technical components, models, and supporting documents that underpin the FMP scientifically sound and reasonable?

The review focused on the following components:

1. The three proposed reference point thresholds (i.e., catch, catch per unit effort (CPUE), and spawning potential ratio) that will serve as signals for when changes within the fishery may warrant management responses;
2. The underlying science that informed the decision to manage the fishery as a single stock;
3. The comprehensiveness of the data supporting the estimate of spiny lobster habitat contained within marine protected areas;
4. Estimates of stock productivity and its ability to support fishing (i.e., calculations for the lobster growth curves adopted in the Parrish Model for setting the spawning potential ratio threshold); and
5. The spawning potential ratio (SPR) model as presented in “DRAFT Report on the Cable-CDFW 1.0 Model and the Calculation of Spawning Potential Ratio” (cable model), including model assumptions, calculations, interpretation, and application of the model results in setting the SPR reference point threshold.

In addition to these specific sections of the FMP, reviewers were asked to identify priority research and monitoring gaps associated with the scientific and technical components of the FMP. Reviewers also provided recommendations for ways to work more closely with the academic community to collect and maintain the most up-to-date essential fishery information (EFI).

SUMMARY OF THE REVIEW PROCESS

This review took place from October 2014 – May 2015. Ocean Science Trust implemented a scientific review process[1] that sought to promote objectivity, transparency, candor, efficiency, and scientific rigor. A multidisciplinary, four-member review committee was assembled, representing international expertise in fisheries science and management, marine ecology, stock assessment, and modeling. Reviewer names remained anonymous until completion of this review to encourage candid feedback. Ocean Science Trust facilitated constructive interactions between reviewers and the Department through a series of remote meetings, where Department staff provided reviewers with the management context, presented an overview of the scientific and technical elements under review, and were available to answer reviewer's questions. In addition, Ocean Science Trust convened reviewers independently to allow the review committee to candidly discuss the review materials and conduct their assessment. Ocean Science Trust worked with the review committee to assemble and synthesize their written and verbal responses to guiding questions, as well as discussion from remote meetings into this final report. This report is publicly available on the Ocean Science Trust website[2].

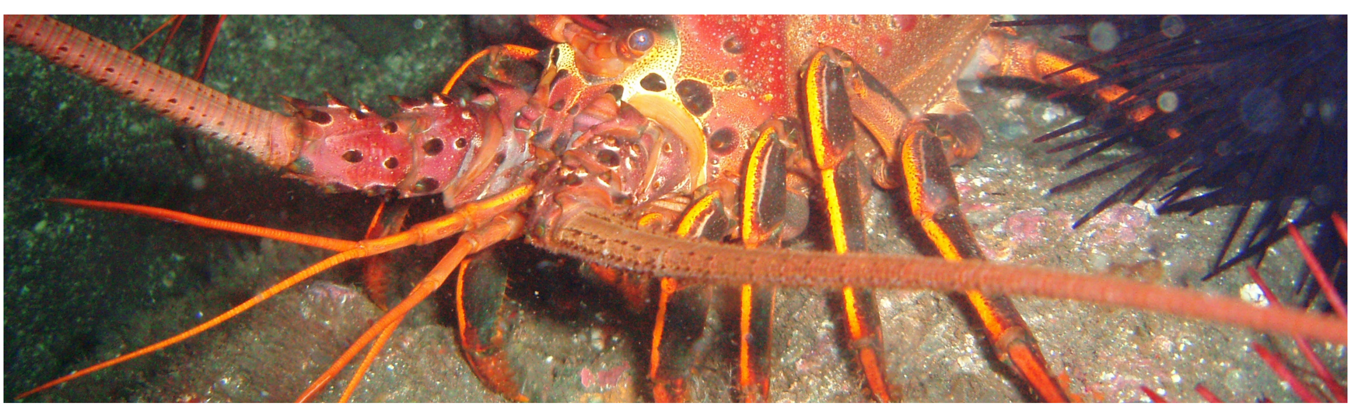
PROJECT MATERIALS UNDER REVIEW

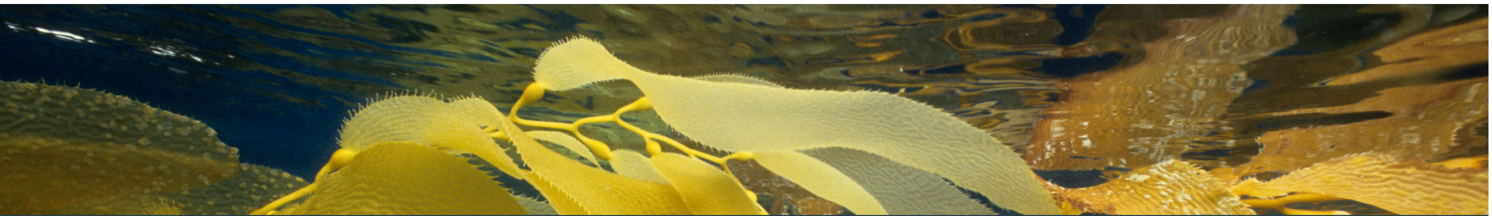
The following materials were provided by the Department to the review committee for scientific and technical review:

- Draft Spiny Lobster Fishery Management Plan, For Technical Review, 11/4/2014[3]
- Draft Report on the Cable-CDFW 1.0 Model and the Calculation of Spawning Potential Ratio
- Draft Spawning Potential Ratio Cable-CDFW 1.0 Model

Additional data and information were provided by the Department at the request of the review committee to assist with their assessment throughout the review process.

[1] Available at http://bit.ly/1Fd9A6X
[2] Available at http://bit.ly/1Fd9zA3
[3] Draft available on the Department of Fish and Wildlife website at http://bit.ly/1Fda254





Review and Recommendations

Foremost, the review committee valued the opportunity to provide independent scientific recommendations for consideration in management of the California spiny lobster fisheries. They acknowledged the extensive time and resources that went into the development of the FMP and supporting model by both the Department, the Lobster Advisory Committee, stakeholders, and outside experts, including modeler Dr. Richard Parrish. Reviewers appreciated the Department staff's constructive engagement throughout the course of the review, as well as their willingness to thoughtfully consider recommendations from this report. The Department produced an FMP that is user-friendly and readable by broad audiences, is well referenced, and incorporates the effects of no-take marine protected areas for the first time in a state-managed fishery. Reviewers noted that the FMP would complement the fairly robust management measures already in place.

This assessment is organized around the key focal points identified in the scope of review. These recommendations aim to improve the science supporting the proposed reference point thresholds prescribed in the draft FMP. Where possible, insight is provided on the implications of each recommendation.

The main recommendations concern the spawning potential ratio (SPR) cable model, several of which would need to be addressed before this model can provide a sound scientific basis for decision-making. Additional scientific guidance and considerations are included that would produce a more scientifically robust FMP, as well as longer-term recommendations, data and research needs that would strengthen the science contained within the model and FMP and its ability to inform management as new information and analyses become available.

This FMP is the first instance where state fisheries managers in California are employing a technical model (aside from a formal stock assessment) to inform the development of a harvest control rule. As such, reviewers thought it valuable to close the review with some insight into how scientific models are scoped, considered, and reviewed as FMPs are developed for other state fisheries in the future.

1. EVALUATION OF THE PROPOSED REFERENCE POINT THRESHOLDS

Three proposed quantitative reference points and associated thresholds – spawning potential ratio, catch, and catch per unit effort (CPUE) – are meant to serve as metrics to assess the state of the lobster fishery and stock. The FMP states that whenever a stock reaches a threshold reference point, resource managers must investigate the cause and potentially provide a response. The Department has to review the catch, catch per unit effort, and update the spawning potential ratio on an annual basis. This process is designed to monitor the fishery and its stock in order to prevent any of the metrics from reaching a threshold.

Below are the scientific review committee's recommendations for each reference point. For sections 1.1 (SPR) and 1.2 (catch, CPUE), recommendations are divided into those that reviewers suggest the Department address before adopting the FMP, and those that are longer-term considerations, which can be addressed after adoption of the FMP.

1.1 Spawning Potential Ratio (SPR) Cable Model and the SPR Reference Point

Much of the review focused on the SPR cable model, since it is the main measure of the spiny lobster spawning biomass structure and the only biological reference point in the FMP (i.e., it integrates information and assumptions about lobster growth, reproduction, and mortality). The model, starting with 1,000 recruits, calculates an equilibrium SPR value – a ratio of the number of eggs produced by the fished population over the number of eggs produced by the unfished population. Being an equilibrium model, it does not track cohorts or size trends over time, but does provide relative abundance estimates for the fixed number of recruits. Therefore, this SPR estimate is used to estimate an annual fishing mortality rate specific to a given year's observed mean size, with no temporal connection among the annual estimates. The FMP advises that when the $SPR_{CURRENT}$ falls below the "stable and productive" reference period between 2000-2010 ($SPR_{THRESHOLD}$, based on the average SPR value during this period), the Department is required to investigate the underlying cause and potentially provide a management response for the Commission to consider. The model also evaluates the effects that marine protected areas (MPAs) may have on the calculated SPR value of the lobster stock.

During the course of the review, reviewers were provided with three iterations of the SPR model. The model was originally developed by Dr. Richard Parrish, and underwent further development and revisions by the Department. The final version (referred to here as the cable model) is the version intended for use in the management of the fishery, and was the main focus of this assessment. The cable model includes the following revisions from the previous iterations:

1. a new growth model (i.e., changing the model from a von Bertalanffy growth model to a newly developed model)
2. changes to initial time step (i.e., size, age, season)

The draft FMP provided to reviewers for their work was developed based on the original model and did not reflect these revisions. The reviewers were instructed to assume that the draft FMP would be revised to reflect the most recent cable model. Additionally, following initial technical discussions between Department staff and the reviewers, the Department agreed to remove a prescribed value for the SPR threshold in order to allow for the ability to continually improve the model without amending the FMP.

1.1.1 Key Recommendations for Securing a Management-Ready SPR Model

Reviewers agreed that the cable model requires essential revisions before it can provide a scientific basis for management of the lobster fishery, but that these revisions are likely achievable before the FMP is adopted. In the longer term, more substantive data collection and research initiatives to better inform a model comparable to the current model, or an alternative modeling approach, are identified as priorities. Below are the key recommendations for securing a management-ready SPR model, organized around thematic areas.

Growth Model

- ***Rely on the von Bertalanffy growth modeling methods until the newly developed growth model can be robustly validated.***

  The primary revision to the SPR model by the Department was the replacement of a von Bertalanffy growth model, with a new set of Gaussian 4-parameter growth curves that were developed by Department staff. These were based on raw data from three tag-recapture studies in order to estimate male and female lobster growth rates. Growth curves are central to determining a stock's ability to replenish itself. Reviewers acknowledged the inherent difficulties in obtaining reliable growth rates for crustaceans, such as lobsters, that grow through molting. Though von Bertalanffy growth models are widely used and accepted, they represent a generic growth response; the Department examined multiple growth models in an attempt to employ an alternative that better represented the growth of *P. interruptus*.

The reviewer's main concern with the current SPR cable model is with the application of the new Gaussian growth curves. While reviewers recognized that the Gaussian 4-parameter curves may better fit the data, they had concerns that these growth models have not been subject to rigorous scientific discussion. The results of the Gaussian curves are not consistent with the existing literature regarding the growth patterns of lobsters in similar ecosystems, and lead to potentially unrealistic SPR model behavior and results. In particular, they lead to growth rate estimates that are very slow such that mature individuals can reproduce many times prior to being vulnerable to full fishing mortality. Slow growth rates in this particular SPR model implementation translate into lower harvest rates and a reduced impact of fishing on population reproductive output; the slower you make growth, the lower the estimated relative exploitation rate is in the SPR model. This is contrary to what is typically understood about growth rates and stock productivity. The fact that this model estimates a "snapshot" of relative exploitation rate in a given year with assumed constant recruitment, rather than tracking exploitation and cohort strength (and potential feedback to recruitment) over time contributes to this somewhat counter-intuitive result, but the unusually slow growth is the primary driver. The net effect of the Gaussian growth model as applied in SPR cable model is that fishing mortality of most legal lobsters has a reduced impact on the estimated SPR, relative to SPR estimation based on the von Bertalanffy growth model.

These Gaussian growth curves are not necessarily incorrect – in fact, they may well be a more accurate representation of lobster growth – and should be improved with additional research. Reviewers commend the Department for making strides to move beyond the standard growth model. Further studies showing that the approach has some precedent with crustaceans and more investigation of the underlying data is necessary before the Gaussian growth model can be applied with confidence. If and when an alternative growth model is considered to be sufficiently developed to incorporate into the SPR model, the Department should consider whether that model is consistent with growth models of lobsters in other (similar) ecoystems, and ensure that sensitivity analyses are conducted to evaluate the effects of any new growth relationships on SPR model performance.

von Bertalanffy growth expands the resolution of the SPR model compared to the Gaussian growth curves

With current understanding, the von Bertalanffy growth model is more appropriate for a relative metric of exploitation as it is more responsive to changes in exploitation, produces results that are comparable to methods used elsewhere for similar fisheries, and expands the resolution of the SPR model (see Appendix A for further analyses conducted by reviewers). Thus, reviewers recommend that the Department rely on the more standard and widely used von Bertalanffy growth modeling methods, until the newer Gaussian curves can be robustly validated.

Longer-term considerations are included in section 1.1.2, including the need to routinely collect length or other size compositional data (length or weight distributions) and information on actual selectivity and maturity curves, which would provide the basis for a more robust SPR model (e.g., more accurate estimates of fishing mortality). Reviewers recognized that there is inherent variability in the growth data at small sizes using the available tag-recapture studies, and provide some recommendations that may increase comfort with new Gaussian growth curves based on these data.

- ***Use SPR with caution at high exploitation rates.***

It is also important to note that the SPR cable model (with either growth model applied, although the problem is exacerbated at slower growth rates) becomes uninformative at very high exploitation rates (Appendix A). This is partially a result of the confounding of the maturity and selectivity curves described below. This constraint should be recognized explicitly in the SPR model documentation and the FMP, and the Department should be cautious when interpreting results at high exploitation rates.

- ***Reconsider some of the tag-recapture data that were removed from the growth models.***

  The growth models are based on a limited data set, from which some outliers and negative values were removed (per Department presentation to review committee). Juveniles can often show high growth rates in short timeframes, thus some of the data identified and removed might actually be informative. In addition, the Department should consider making the “negative growth” data points zero instead of removing them from the analyses if they are believed to be measurement error. Reconsidering how these data points are treated may reduce variability at small lobster sizes and lead to more accurate estimates of growth.

Model Functionality

- ***Update the vulnerability relationship.***

  In the cable model, the vulnerability function has precisely the same coefficients as maturity. If this is a true coincidence, it should be explained. However, recent data on female lobsters from Hovel et al. (2015) and Kay (2011) indicate that female lobsters may be reproductive at smaller sizes than previously thought. The Department should verify, and if appropriate, update this function in the cable model. In addition, the current function in the cable model is for the commercial fishery that uses traps. Traps have an upper limit based on the throat size of the trap while there is no upper limit in the recreational fishery. Therefore, there should be a separate vulnerability relationship for the recreational fishery in any future model that can account for recreational catch.

- ***Revisit the natural mortality function.***

  The natural mortality function assumes that natural mortality decreases as lobsters grow; however within the current cable model, a minimum rate occurs at an age of 17.92 years and then the rate increases again. This pattern of senescence is unusual, and the Department should provide additional references or data to support the assumption that older, larger lobsters experience higher natural mortality. If the proportion of ‘plastered females’ (i.e., female lobsters that have mated) is lower at larger sizes, suggesting that large females are not contributing as much to SPR, those data should be presented.

- ***Explain the ramifications of SPR being independent year to year.***

  Each model run begins with exactly 1,000 larvae, and ignores variable and episodic recruitment, and the relationship between spawning biomass and recruitment. The model also assumes constant carrying capacity and a constant function for density dependence, among other considerations. These limitations should be made more explicit in the FMP and model report.

Sensitivity Analyses

- ***Make greater use of sensitivity analyses in explaining the model.***

  Sensitivity analyses are important for understanding the impacts of a model's input variables. They can help identify parameters that are likely to have no effect on the output (and could potentially be removed), as well as variables that have a large effect (where attention should be focused on ways to reduce uncertainty around these values/inputs). The Department should conduct explicit sensitivity analyses each time the SPR cable model is revised, and make this information available in the accompanying report to provide additional credibility to the reasoning behind such revisions. Standard practice is to double and halve the variable of interest and observe the impact to the outputs. The Department should consider assembling and formally communicating the error and uncertainty associated with the cable model results.

1.1.2 Longer-Term Considerations for the SPR Model

The review scope charged reviewers with conducting an assessment of the SPR model based on the Department's currently available data streams that would not require additional information or research. However, the model may benefit considerably from and be more robust as a result of addressing the following longer-term recommendations after adoption of the FMP.

Research Needs

- ***Explore alternative methods to estimate lobster growth.***

  Novel methods for age validation and improved growth estimation continue to emerge and should be explored, either by the Department or by academic and other independent research institutions. For example, direct methods of growth and age determination are now possible for crustaceans by measurements of annual molt-independent growth bands. Detection of growth bands in calcified regions of the eyestalk or gastric mill using the cold cure epoxy resin technique has been reported for cold-water shrimps (*Sclerocrangon boreas* and *Pandalus borealis*), snow crab (*Chionoecetes opilio*) and American lobster (*Homarus americanus*) (Kilada et al. 2012). A similar technique could be used to better estimate growth for the California spiny lobster (even on a spatially explicit basis), and perhaps elaborate or modify the 2011 stock assessment model to include an age-based parameter. Identifying these as key research priorities in the FMP may incentivize outside researchers and funders to pursue this research.

- ***Explore additional technical models that can account for variable recruitment.***

  Given that lobster recruitment is likely highly variable and episodic, a key longer-term research objective should be the development of a more sophisticated modeling approach that can track cohorts over time.

- ***Develop a sampling program to collect individual lobster length or weight composition data from both sectors of the fishery.***

  Estimates of fishing mortality used to obtain a corresponding SPR value each year are currently determined using average weight data from the commercial sector. The relevant parameters are derived using an extrapolation, linking logbook data to fish ticket data. These estimates would be greatly improved by a program in which actual length or weight measurements (by individual) could be collected. The sampling program needs to include the recreational sector as well because it accounts for approximately 30% of the landings and their vulnerable sizes may differ from commercial traps. Such data would be helpful in informing more sophisticated modeling approaches (e.g., that track cohorts over time) in the longer-term as well.

- ***Prioritize obtaining intermediate recapture data, which could be useful for better understanding the dynamics of lobster growth rates.***

  While alternative methods to estimate growth are ultimately necessary, reviewers provided a suggestion that may improve upon the existing estimates in the near term.

  The growth curves were developed from data sets with gaps at important size ranges. Tag-recapture data gaps exist between the Engle (1979) and Hovel et al. (2015) data sets, in the 30 mm and 55 mm size classes. Currently, juvenile data must be extrapolated out in any growth curve model. Additional data would be valuable in "filling in" the points between data sets for a more accurate estimate of California spiny lobster growth.

Model Functionality

- ***Develop a function or method to incorporate recreational catch into the model.***

  Recreational catch is a substantial portion of overall catch and is not accounted for in the SPR model. This sector is potentially harvesting larger lobsters, thus, the vulnerability to fishing differs between the recreational and commercial sectors. It is important to parse out the proportion of the spawning potential coming from larger individuals. If this is the case, the vulnerability curve applied in the SPR cable model for the recreational sector should not be dome-shaped, but rather should be asymptotic, and there may be other facets of the recreational fishery of significance in accurately assessing SPR.

- ***Revisit the SPR model as MPAs reach their full maturity.***

  The SPR cable model assumption that South Coast MPAs have reached full maturity (thus, are having a threshold impact on the fishery) is unlikely given the MPAs are newly established. A number of factors will differ as MPAs reach full maturity, including the possibility of increased density dependence which could affect movement and reproduction as well as that spawning stock (given growth curves) may not yet be optimized through size and density. In other words, the current SPR model inputs may be over- or underestimating the effects of MPAs.

- ***Formalize a process to review, revise, update, and evaluate the SPR model and its effectiveness in meeting management goals as new data, information, or analyses become available.***

  Models like SPR will require continual refinement as new information and data are obtained. Many such improvements can be accomplished within this FMP framework. The reviewers commend the Department for removing a prescribed SPR threshold from the language of the draft FMP. This allows the ability to recalculate an appropriate threshold as the model is improved rather than needing to delay implementing these changes by waiting for the FMP to be formally amended. It would be valuable to formalize a process for considering revisions to the model – which may have substantial implications for the SPR outputs – as changes and updates are made. Reviewers recommend convening fishery managers and biologists with independent experts to evaluate the input data, coding, and effectiveness of the model at regular intervals.

1.2 Catch- and CPUE-based Reference Points

As noted previously, the process of reviewing current seasonal catch and CPUE data should permit the Department to monitor the fishery and its stock, and prevent any of the measures from reaching a threshold. However, reviewer consensus is that the Catch and CPUE-based reference points are not very robust or sensitive to picking up trends or slow declines. There is concern that “sliding” calculations will rarely exceed the established thresholds. Even when a threshold is exceeded, no specific management responses are required, thus these measures act more as indicators than as reference points. Section 1.2.1 contains key recommendations that would allow for a more robust method to monitor the condition or trajectory of the fishery, and should be addressed before adopting the FMP. Section 1.2.2 includes recommendations that could be addressed in the longer-term.

1.2.1 Key Recommendations for Catch and CPUE-based Reference Points

- ***Describe the catch and CPUE thresholds as “fishery indicators” instead of reference points.***

  A more informative approach to identifying declines in the fishery may be to present the proposed catch and CPUE reference points as indicators of fishery condition, and set the thresholds to more conservative levels. This could provide a more sensitive measure (i.e., reference thresholds would be crossed more easily, making for earlier “warning signs”) and allow the Department to elicit useful scientific information for interpreting any changes observed in SPR.

  Reviewers conducted some additional analyses to explore the sensitivity of the threshold to detecting changes in the fishery (see Appendix B for a description of the full method). They compared California’s proposed approach to a method currently under development for the American lobster (*Homarus americanus*) in Canada. In 2014, Canada established a reference point for the American lobster using commercial catch based on the Precautionary Approach (PA) for the southern Gulf of St. Lawrence fisheries. Employing the PA on a 123-year long data series, American lobster landings were below an upper stock reference point 85 times (Appendix B, Figure 1). However, applying the California spiny lobster approach to the same American lobster data revealed that California’s proposed 0.8 catch-based reference point would only be exceeded two times (Appendix B, Figure 2), indicating it may not be a very sensitive measure for detecting fishery declines.

  Reviewers then applied Canada’s Precautionary Approach to the California spiny lobster commercial landings data (Appendix B, Figure 3). Based on the PA and using a three year running average for landings, California spiny lobster commercial landings would have dropped below an upper stock reference point 31 times between 1935 and 2013, compared to 11 times as indicated in the draft FMP using the current 0.8 catch-based reference point (FMP Figure 4-6).

Based on these preliminary analyses, the 0.8 thresholds are not very sensitive to picking up trends in the fishery. If catch and CPUE data were used as contextual information for interpreting SPR, the thresholds could be set to more conservative levels to allow for greater sensitivity to detect fishery declines.

Another approach for detecting trends would be to report both a static number for $CATCH_{threshold}$ and $CPUE_{threshold}$ in addition to the moving averages, along with a discussion of the pros and cons of each method and what information they can provide.

- ***Clarify rationale for the use of 0.8 thresholds prescribed in the FMP.***

  The FMP should provide more clarity about how the thresholds were derived. They appear to be derived from the Hilborn 2010 citation referenced in the FMP. That study made the point that a broad range of relative abundance levels are typically associated with a more narrow range of relative yield (e.g., most give 80% or more of theoretical maximum), such that declines below 80% of the theoretical maximum could indicate substantial stock declines (if not driven by declines in effort or markets). This is an important aspect of the Catch and CPUE component, and should be better explained in the text.

- ***Report the CPUE statistic in mass per unit effort.***

  The current approach to calculating the CPUE statistic in the FMP is in numbers of individual lobster, not total weight of catch. Using weight (linked to fish tickets) may be more appropriate and is a more typical metric used in such fisheries.

- ***Include greater discussion of the reliability of recreational catch estimates.***

  Recreational catches are a substantial portion of the total catch for spiny lobsters, but seem to have a different trajectory, and one might expect trends to vary from commercial trends in the future as well. The Department should discuss the uncertainty around these recreational catch estimates in greater detail, and clarify whether they were adjusted or tuned to account for non- or under-reporting. Understanding the magnitude and significance of recreational catch is key in considering control rules.

1.2.2 Longer-Term Considerations for Catch and CPUE Data

Again, the review scope charged reviewers with conducting an assessment of the existing reference points and associated thresholds. However, the model may benefit considerably from, and be more robust as a result of addressing the following longer-term recommendations.

- ***Explore other technical models to obtain additional or alternative biological reference points that account for inter-annual variability in recruitment and other variables.***

  The Department could consider estimating the annual fishing mortality rates with a modified Delury depletion model (González-Yáñez et al. 2006, Puga et al. 2013) rather than the moving average approaches for catch and CPUE from average size used in the FMP. A Delury model includes the total numerical catch, the effort and the index of abundance in number (CPUE) as input data, which also takes into account inter-annual variability in recruitment. This approach would allow for both the commercial and recreational sectors to be modeled and there are extensions of the model that include a stock-recruit relationship for obtaining biological reference points. If size composition data become available in the future, the Department may also want to consider a more robust population dynamics analysis similar to one used for Australian southern rock lobsters (*Jasus edwardsii*) (Punt and Kennedy 1997). Additional age-structured analyses (Muller et al. 1997) or yield or egg production models that account for individual variability in growth (Fogarty and Idoine, 1988) may also be informative and should be explored further.

- ***Standardize commercial and recreational catch data to the same spatial reference points.***

  Commercial and recreational fishermen report location at different spatial scales. In comparing Figures 2-3 and 2-10 in the FMP, it appears that commercial fishermen report by Department of Fish and Wildlife block, while recreational fishermen may report by various specific locations (e.g., each of the Channel Islands has a single location code). This discrepancy will confound comparisons in evaluating questions such as the extent of spatial overlap in the commercial and recreational fisheries (e.g., line 825-26 in the FMP).

2. SCIENCE SUPPORTING THE DECISION TO MANAGE AS A SINGLE-STOCK

The FMP provides evidence to suggest that California spiny lobster larvae are well mixed throughout the Southern California Bight ("…complete population mixing due to the species' protracted larval phase"). Accordingly, the Department proposes considering the entire lobster stock within the U.S. border with one spawning potential ratio (SPR) value and threshold. However, Department data show that individuals in the northern Channel Islands are notably larger than the minimum legal size, while lobsters in the south are generally caught very close to the legal size, suggesting northern lobsters participate in more spawning seasons than southern lobsters before capture.

Reviewer's evaluation of the literature and existing research on the population structure of California spiny lobster suggests there is some potential for localized recruitment, and that the species does not maintain a single homogenous population despite the extended pelagic larval duration (Iacchei et al. 2013). However, reviewers recognize that the decision on single-stock management must take into account social, economic, and other factors in addition to the science. It is ultimately up to the Fish and Game Commission to determine the most appropriate method to manage the stock.

- ***Assess and report any spatially explicit differences between regions of the fishery.***

  Available data suggests there are clear regional differences in size distribution, catch, timing of catch, and effort – several of which are meaningful to the calculation of SPR and to determining how it varies in space and time. There is also evidence that growth and reproduction differ spatially, which could lead to spatially structured source-sink dynamics that may interact with fishing in a way inconsistent with single stock predictions. While lobsters have an extended larval period with extreme dispersal potential (which could lead to assumptions of complete larval mixing), studies in other lobster species suggest substantial localized recruitment (Iacchei et al. 2013).

Reviewers recommend reporting any spatial differences among regions of the fishery to assist decision-makers with parsing out trends in catch and life history traits across the region, and assess whether current harvest control rules are adequately meeting management goals.

Reporting spatial differences among regions of the fishery can help decision-makers parse out trends in catch and life history traits

- ***Interactions with the Mexican spiny lobster stock should be considered and discussed in greater detail throughout the FMP.***

The reviewers expressed concern about the decision to neglect potential interactions between California and Mexico lobster populations. Given how the biology and management of Mexico's portion of the stock has implications for the entire range of the species, the FMP should include discussion of the potential uncertainty in SPR calculations associated with neglecting potential contributions from the south.

For example, regardless of the genetic structure of California spiny lobster, if the larval pool for California's population includes a large contribution from the Mexican portion of the stock, the actual SPR may be insensitive to management actions in California. The Department should discuss uncertainty around larval transport and reproductive interactions between California and Mexico's lobster populations. This should include a more comprehensive review of the literature (e.g., bolstering literature citations supporting the idea that stock is, or is not, well mixed).

- ***Prioritize longer-term research needs relating to regional differences in the species' biological parameters.***

The Department should prioritize collection of data aimed at better understanding lobster population genetics, plankton connectivity modeling, and the benthic stage. This could provide greater insight into source and sink populations, interactions with Mexican spiny lobster populations, and how management in California will affect the population.

Evidence from multiple lobster fisheries suggests local recruitment processes are possible. A recent microsatellite and mitochondrial DNA study in California spiny lobster suggests that the genetic structure of the *P. interruptus* exhibits genetic patchiness (Iacchei et al. 2013). The species does not maintain a single homogenous population, despite the species' 240-to 330-day pelagic larval duration. Instead, these lobsters appear to either have substantial localized recruitment or maintain planktonic larval cohesiveness whereby siblings more likely settle together than disperse across sites. However, DNA analysis in the Caribbean lobster (*P. argus*) suggest that populations of this spiny lobster are highly interconnected throughout its range, with a single genetic stock structure (Truelove et al. 2014, Lipcius and Cobb 1994; Silberman and Walsh 1994), except for a few sites where self-recruitment is enhanced by persistent offshore gyres. Lastly, a genetic study in the American lobster *(Homarus americanus*) indicated a genetic homogeneity of the northern region of the lobster population (suggesting a single genetic stock) within the Gulf of St. Lawrence (Kenchington et al. 2009). However, a larval transport model for this species also showed an extensive pelagic connectivity with some level of local recruitment (Chassé and Miller 2010) and no physical features that restrict benthic stage exchanges (Comeau and Savoie 2002).

Research suggests California spiny lobster populations exhibit localized recruitment

3. ESTIMATE OF LOBSTER HABITAT CONTAINED WITHIN MARINE PROTECTED AREAS

The FMP factors in the effects of California's network of MPAs by including them as a component of the fishing mortality calculation in the SPR cable model. The model includes an estimate that 14.6% of all available lobster habitat is protected by MPAs. This is based on available hard-bottom habitat data, augmented by proxy information where suitable bottom-type data are not available, for all the areas that comprise lobster habitat. Only areas that prohibit both recreational and commercial take were used for this calculation. In the near term, reviewers would like to see additional discussion in the FMP of the data sources used, and going forward, refinements to these estimates as the model is improved. Given other uncertainties in the spatial analyses, reviewers suggested that an estimate of 15% is likely adequate.

- ***Provide greater discussion of the data sources used to estimate suitable lobster habitat.***

  Reviewers acknowledge the rigor of the hard bottom data set used to generate the estimate, however the Department should provide more clarity on the locations where information was not available from this data set. It would also be informative to report a rough percent of unmapped habitat and percent of the estimate that was calculated using kelp canopy.

- ***Continue to refine the MPA estimate as new information becomes available.***

  The data used to estimate lobster habitat contain critical data gaps within the shallow nearshore regions (typically 10-15 meter depths) where remote sensing techniques are generally infeasible (known as the "white zone"). New research is providing better information to bridge these data gaps.

  Ongoing research through UC Santa Cruz, the California Department of Fish and Wildlife (staff contact: Paulo Serpa), and Ocean Science Trust is making progress on estimating sand versus rocky habitats across the State within this white zone. The first stage has been completed in the North Central coast and may be expanded statewide over the coming years, and could potentially provide an additional data source to incorporate into the Department's MPA estimate. The Seafloor Mapping Lab at California State University, Monterey Bay developed a shallow water mapping vessel, the R/V Kelp Fly, uniquely able to map the white zone. As these new data sources become available, the Department should include them as refinements to the cable model. The Department should also explore the contribution of habitat from breakwaters and artificial jetties.

- ***Consider developing a function or method to consider actual marine protected area sizes in the SPR cable model.***

  The SPR cable model makes coarse assumptions about the size and spacing of MPAs within the lobster range. The actual values of these parameters are well known, and accounting for California's actual MPA sizes and spacing – which differ regionally – could have implications for regional estimates of vulnerability because of the assumptions of movement that interact with the size and location of MPAs.

4. RESEARCH AND MONITORING

- ***Continue to update and prioritize research and data needs in the FMP.***

  The FMP includes Table 5-1, a prioritized list of research and data needs. Throughout this report, reviewers have identified additional research and data needs that would support more robust management of the fishery (some of which parallel those noted in the FMP). Additional recommendations from this review should be incorporated in the table as well. These science needs could provide further impetus for collecting the information identified and prioritized. A resource with up-to-date research and monitoring needs provides independent researchers (and potential funders), with the basis for assessing the applicability of given research or other proposals to spiny lobster management and/or state information needs. The Department should continue to update this prioritization and guidance.

5. ADDITIONAL RECOMMENDATIONS

This section contains additional recommendations reviewers considered important, but were not clearly outlined in the formal scope of review.

- ***The harvest control rule matrix should include predetermined management options.***

While reviewers recognized that this recommendation might be outside of the review scope, they agreed that scientific recommendations are most successful when they are accompanied by predetermined management actions. The lack of pre-determined management response options when one or more of the management thresholds are exceeded has the potential for inaction if the indices or data suggest there are troubling in the fishery. Table 4-2 in the draft FMP lists the suggested management response sequence, including four scenarios in which “No response is required,” and another four in which a response is required. However, the required response in these scenarios is an investigation of underlying causes and confirmation with multiple models and approaches; if management action is required, the FMP guidance is to “tailor management response to prevailing conditions.” The reviewers found these requirements vague.

One of the key benefits of pre-specified harvest control rules is a higher certainty of the actions that will be taken when reference points are exceeded. This allows models to be used to evaluate the effectiveness of these actions to restore the fishery to the desired condition.

Other fisheries that have used SPR for developing harvest control rules may provide good resources for identifying appropriate management responses to thresholds that have been exceeded. Consider supplementing FMP Table 4-1 (summary of SPR thresholds for other lobster fisheries) with a discussion of the management response are in those various management scenarios, as well as whether any of those fisheries also include target SPR rates.

- ***Clarify the information required for setting total allowable catch (TAC).***

Lines 1964-1965 state that “Creating a TAC for the CA lobster fishery would likely require the Department to estimate the total biomass of the stock…”. This is not necessarily true. For example the Market Squid fisheries established a TAC based on historical high catch levels in the absolute absence of total biomass estimates or idealized CPUEs. For many groundfish and other exploited fishes, a common practice in the absence of a quantitative guidance for stocks or stock complexes is to set a TAC at some fraction (e.g., 0.5, 0.75) of the peak historical catch. Any TAC that might be implemented should have a rationale, but it does not mean it requires a sophisticated model.

Looking Forward: Considerations for developing scientific models for state fishery management plans

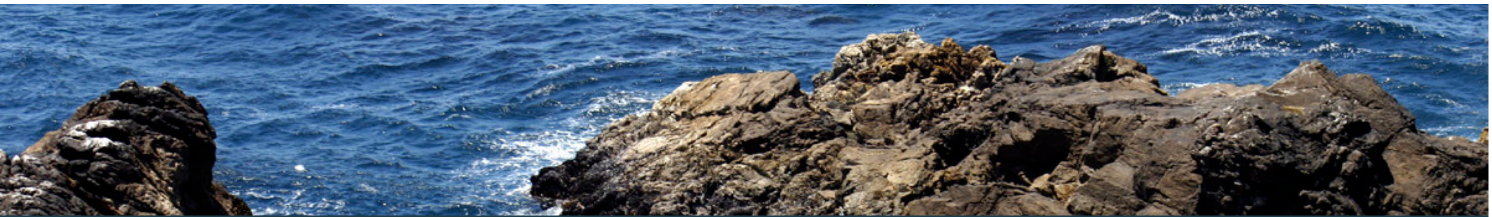
The California spiny lobster FMP represents one of the first examples of a state fishery management plan including the use of a technical model to obtain harvest control rules. The experts who participated in this review have experience developing and using fisheries models at the federal and international levels, and thought it valuable to provide insight into processes employed elsewhere.

When considering the development and use of other technical models going forward, the Department should ensure that the plan for producing the science is decoupled from any management concerns. This will include scoping the objectives, approaches, reporting requirements, and responsibilities of various participants in advance. Model development should take place from a position of academic freedom focused on developing the best model, given the resources and data. The Department should ensure the process is inclusive and transparent from the outset.

Reviewers also suggest decoupling the review of technical models from review of the FMP that such models inform. Future model reviewers should have the responsibility of ensuring that the models represent the best available science and the most robust methods. This review committee acknowledges that ideally an in-person, multi-day review workshop with the model development team would allow more detailed technical discussion and model improvement. It is advantageous to have several days to review, so that modelers can be given “homework” on sensitivity tests or alternative analyses that come up during the review and report back. Any future review team should include scientists from outside the region and fishery, and if possible, international expertise. A goal should be to ensure that the model is clearly understandable to those with no background in the particular fishery under consideration. Only models that have been accepted by reviewers as the best available science are advanced to managers. This way, managers can make recommendations and develop harvest control rules based on a model that has been independently recognized as scientifically rigorous.

As noted in this report, models like SPR will require continual refinement and review to ensure they are effectively meeting management goals. Formalizing a process to periodically review the model coding and configuration, and incorporate recent information is recommended. Groups like SouthEast Data, Assessment and Review[1] (SEDAR) and NOAA PFMC Stock Assessment Review (STAR) Panels may provide informative examples of successful approaches that vary in detail and level of time and analyses required.

[1] More information at http://sedarweb.org/



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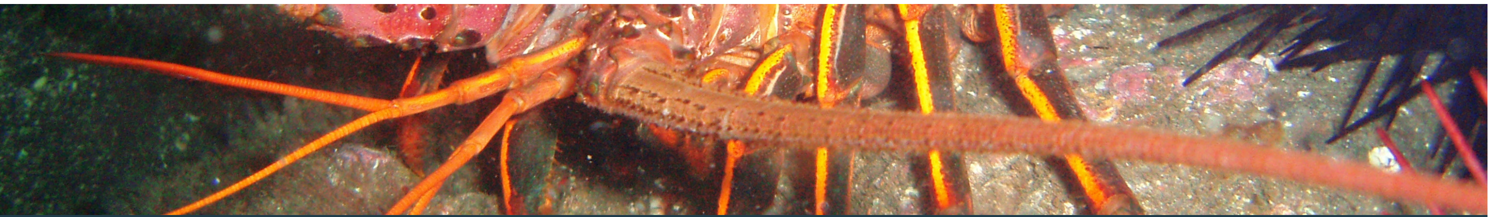


Appendices

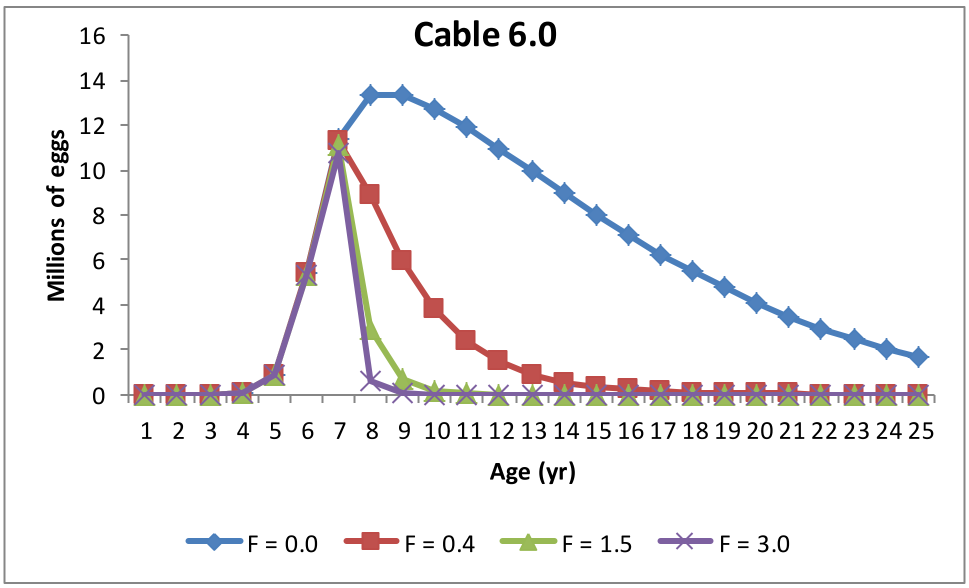
Appendix A: von Bertalanffy and Gaussian Growth Curve Comparison, and *Appendix B: Applying the Canadian Precautionary Approach to California Department of Fish and Wildlife Commercial Landings* contain additional analyses that were conducted by the review committee as part of their assessment in support of the recommendations contained within this report.

Appendix C: Scientific and Technical Review Process details the process Ocean Science Trust developed and implemented for this review.

APPENDIX A: VON BERTALANFFY AND GAUSSIAN GROWTH CURVE COMPARISON

We (the review committee) compared the von Bertalanffy and Gaussian growth models to determine which would be most appropriately applied in the SPR model. The first step was to examine the cumulative fecundities, in millions of eggs, over the projected 25-year lifetime. The age-specific fecundities from the Cable 6.0 model, which uses a von Bertalanffy growth curve, and those from the CDFW 1.0 model, that uses their new growth model, are shown in Figure 1 plotted at the same scale. The main difference is the levels of fecundity. In the Cable model, the cumulative fecundity at F = 0 is 147.2 million eggs while the fecundity at F = 0 in the CDFW model is 46.4 million. At high fishing mortality rates, the fecundities are similar (17.7 vs. 15.8 million eggs at F = 3.0) which means that the SPR ratio will be much higher in the CDFW model; the higher SPR is just the result of the much lower unfished cumulative fecundity (Figure 2).

A.



B.

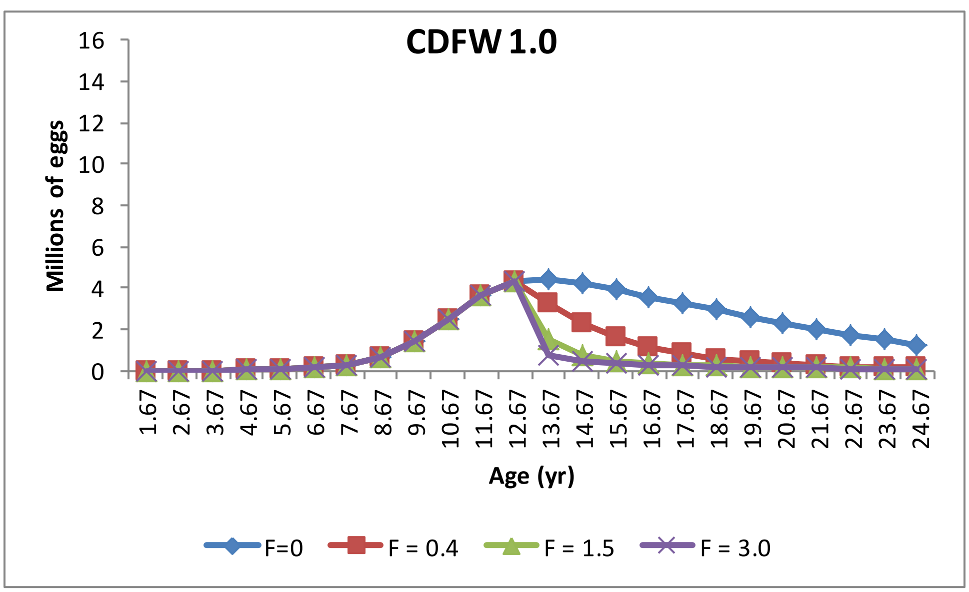


Figure 1. Fecundity by age for the two SPR models: a) the Cable 6.0 and b) CDFW 1.0 for a range of fishing mortality rates.

Even for a high fishing mortality rate of 3.0 per year, the CDFW model still has a SPR value of 34%. However, when we plotted the corresponding average lobster weight against fishing mortality (Figure 3), which is the basis of the control rule, we found that neither model would be a very sensitive way of determining fishing mortality and the corresponding fishing mortality rate that would be used to obtain the SPR value each year. Note that the axes in Fig. 3 are plotted to reflect that the average weight is what is measured so as to estimate the fishing mortality rate. With the current SPR model, fishing mortality would be undefined at average weights less than 1.40 lb. For comparison, the average weight at legal size (82.5 mm CL is 1.25 lb for males and 1.38 lb for females).

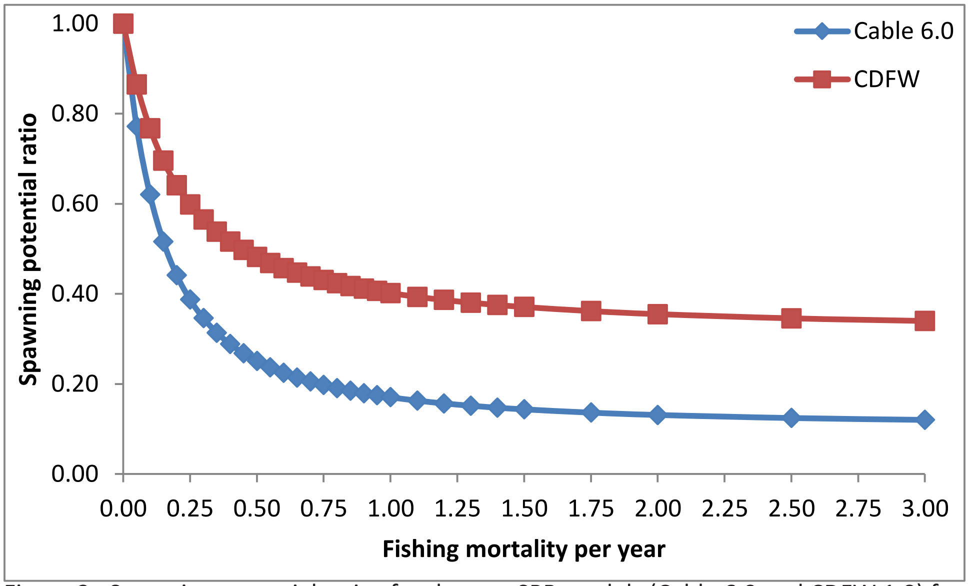


Figure 2. Spawning potential ratios for the two SPR models (Cable 6.0 and CDFW 1.0) for a range of fishing mortality rates.

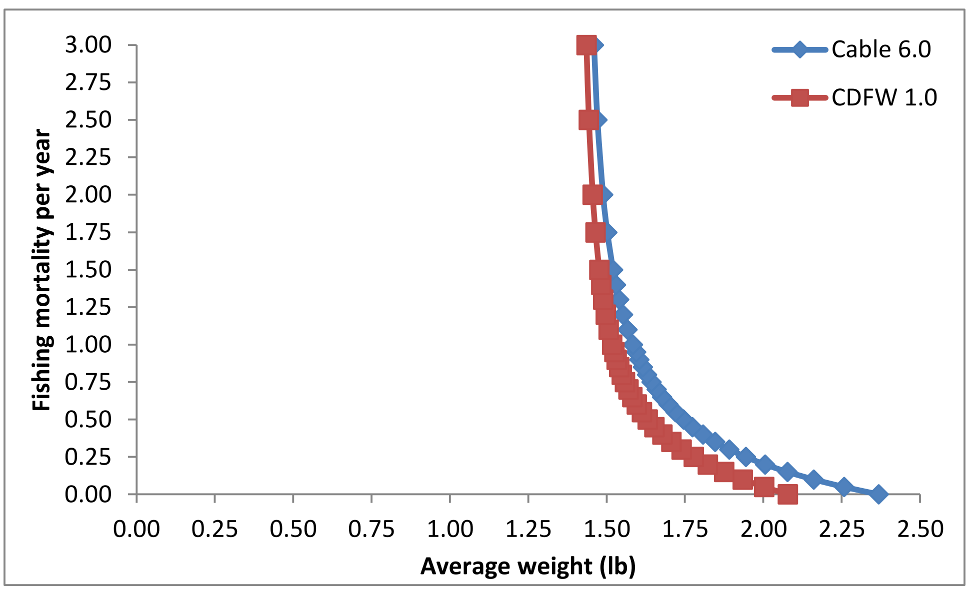


Figure 3. Average spiny lobster weights and the corresponding fishing mortality rates from the two SPR models (Cable 6.0 and CDFW 1.0).

APPENDIX B: APPLYING THE CANADIAN PRECAUTIONARY APPROACH TO CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE COMMERCIAL LANDINGS

We compared the sensitivity of the Department's proposed catch-based threshold approach with another strategy in use for the American lobster in Canada. In 2014, Canada established a reference point for their southern Gulf of Saint Lawrence lobster fisheries using commercial catch based on the Precautionary Approach. Based on this approach, if landings are between an upper stock reference (USR) and the limit reference point (LRP, i.e., the caution zone) it automatically triggers management considerations. These harvest control rules are pre-set management actions aimed at exiting the caution zone and re-entering the healthy zone (i.e., above the upper stock reference point). Based on a 123-year data series for the southern Gulf of Saint Lawrence, management considerations would have been triggered for the American lobster 85 times, and 12 times in a recovery mode (i.e., drastic reduction of effort to a no fishing situation) (Figure 1). However, applying the California spiny lobster approach to the same American lobster data revealed that California's proposed 0.8 reference point would only be exceeded two times (Figure 2).

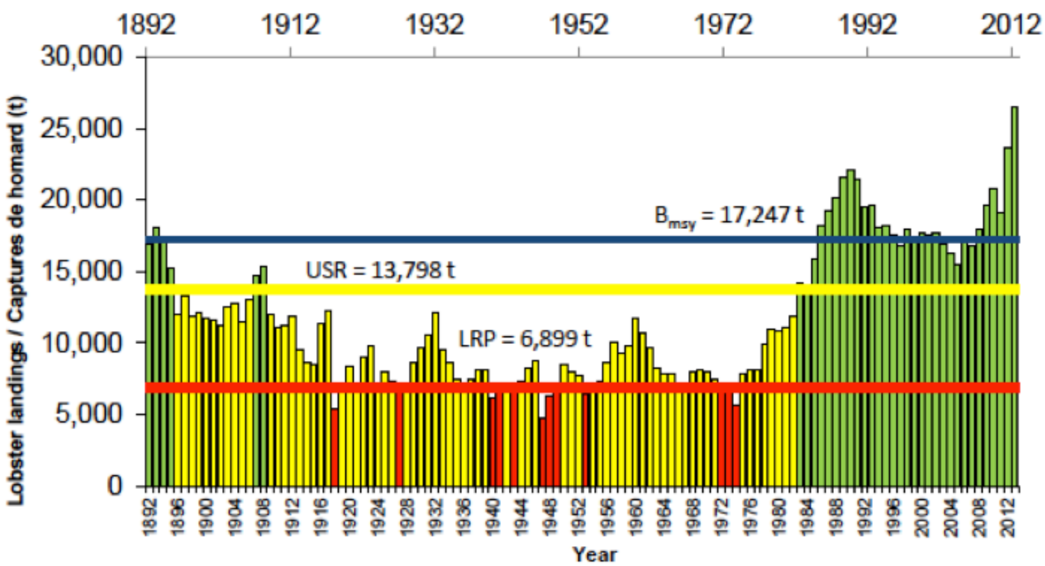


Figure 1. American lobster landings (1893-2013) in the southern Gulf of St. Lawrence; years in the healthy zone (i.e., above the upper stock reference [USR]) in green, caution zone (i.e., between the USR and the limit reference point [LRP]) in yellow, and below LRB in red. The biomass for the maximum sustainable yield (B_{msy}) is estimated at 17,247 t.

We then applied Canada's Precautionary Approach to the Department's California spiny lobster commercial landings data. To do this, we calculated a hypothetical biomass at maximum sustainable yield (B_{msy}) based on a time period from low landings followed by a "recovery" to higher and more sustained landings. Based on the information in the draft spiny lobster FMP, the lowest landings (with information available on effort) were observed in 1974 followed by increasing landings (with fluctuations) until 2013. Based on the trap pull haul (webinar presentation fig. 2.6), it seems that the effort level (traps hauled) increased 4 times: 200,000-400,000 between 1973-1979; 400,000-600,000 (with a drop in 1991-2) between 1980-94; ±800,000 between 1995-2011; and above 1 million in 2012-3. A reasonable assumption is that the stock could sustain the 800,000 trap haul level (16 years) since the landings did not drop during the time. Hence, the time period could be established between 1974 and 2011. However, please note that based on the CPUE reference values (see fig. 4.7 in FMP document), one could reasonably argue that the stock does not seem to react well to the level of effort in the last 7 years and that the time period should/could be 1974-2007. Nevertheless, using the 1974-2011 period

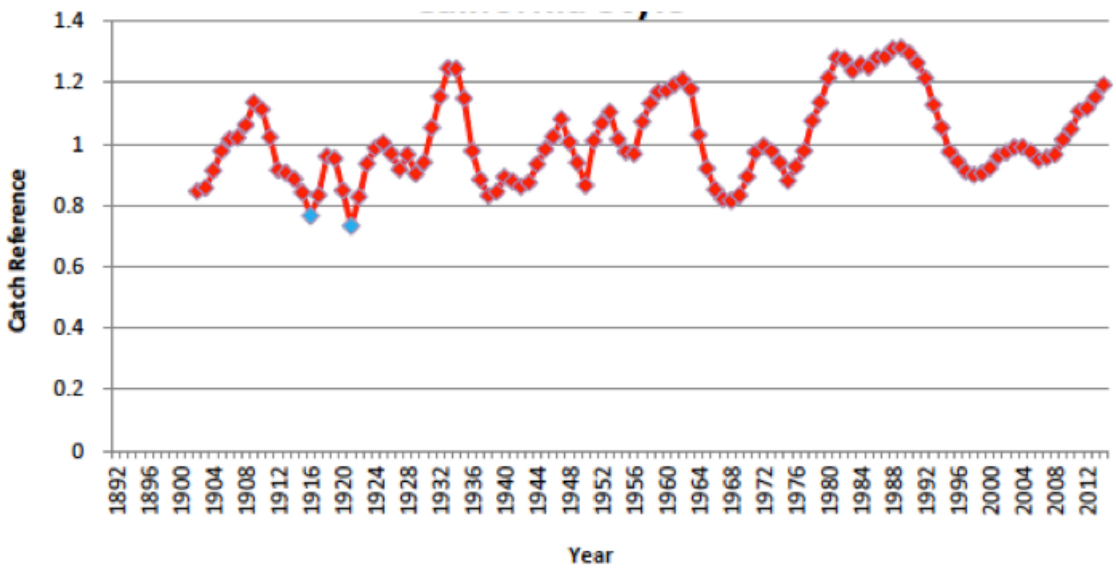


Figure 2. Catch reference for the American lobster landings (1892-2013) in the southern Gulf of St. Lawrence using the California spiny lobster catch-based threshold approach.

the B_{msy} is estimated at 587,409, given an upper stock reference (80% of B_{msy}; USR) of 469,927, and the limit reference point (40% of B_{msy}; LRP) of 234,963 (Figure 3). The draft FMP (Figure 4.6) indicates that between 1935 and 2013 management considerations would have been trigged 11 times, mostly between 1960-74. Based on the precautionary approach and using a 3-year running average for landings, the spiny lobster fishery was below LPR in 1975-6 (critical zone; normal because the time period stated at low values), which would trigger a recovery period (i.e., drastic reduction of effort to a no fishery situation). Since 1935, landings were between LRP and USR (caution zone) 31 times (latest 1977-87) that would have triggered immediate management actions from pre-established harvest control rules (mainly effort reductions) to, hopefully, exit the caution zone and re-enter the healthy zone. Landings between USR and Bmsy was observed 9 times (latest 1993-5) but does not trigger urgent management considerations, but could be used by managers to start a dialogue with the industry (e.g., to be cautious).

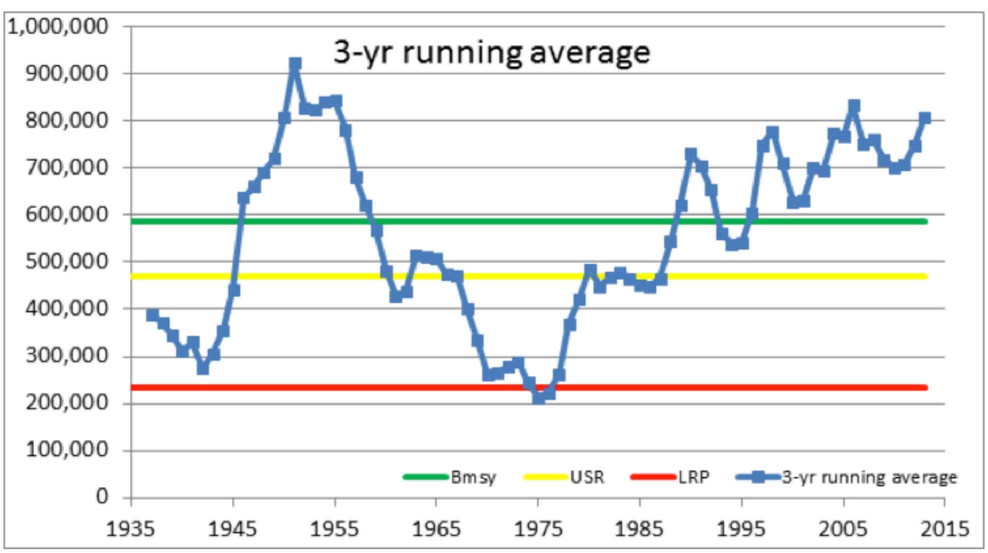


Figure 3. Application of Canada's Precautionary Approach to California spiny lobster commercial landings data; years in the healthy zone (i.e., above the upper stock reference [USR; yellow line]), caution zone (i.e., between the USR [yellow line] and the limit reference point [LRP; red line]), and below LRP. The biomass for the maximum sustainable yield (B_{msy}) is estimated at 587,409 lbs.

APPENDIX C: SCIENTIFIC AND TECHNICAL REVIEW PROCESS

The California Department of Fish and Wildlife (the Department) asked California Ocean Science Trust to coordinate an external scientific and technical review of the reference point thresholds prescribed in the California Spiny Lobster Fishery Management Plan (FMP) and supporting materials. Specifically, the Department sought an independent assessment of whether the technical components, spawning potential ratio model, and supporting documents that underpin the proposed reference point thresholds prescribed in the FMP are scientifically sound and reasonable given the Department's currently available data streams and analysis techniques. See the "Scope of Review" for details on the charge to reviewers.

Ocean Science Trust designed and implemented all aspects of the review process, including compiling appropriate background materials, drafting instructions to guide reviewers throughout the process, scheduling and hosting remote meetings as appropriate, and working with reviewers to produce a written final summary report, among other activities. Upon completion of the review, the final report was delivered to the Department and made publicly available on the Ocean Science Trust website. Throughout, Ocean Science Trust facilitated constructive interactions between the Department and reviewers as needed in order to ensure reviewers provide recommendations that are valuable and actionable, while maintaining the independence of the review process and outputs

Scientific Review Principles

In any review, it is our intent to provide an assessment of the work product that is balanced, fairly represents all reviewer evaluations, and provides feedback that is actionable. When building a scientific and technical review process, we seek to balance and adhere to six core review principles. These principles help guide the design and implementation of each review, and shape the final outputs:

- **Scientific rigor:** the process must yield an evaluation of whether scientific and technical components contained within products are valid, accurate and thorough.
- **Transparency:** given the context for the review, the process must include the appropriate level of information disclosure and openness in order to facilitate social recognition and accountability.
- **Legitimacy:** the process must yield an output that is viewed as authoritative in the eyes of scientific community, the requesting agency, and other constituents.
- **Credibility:** the process will seek to be unbiased and incorporate the best available science.
- **Salience:** the process will consider the most relevant scientific information while balancing management needs and timelines.
- **Efficiency:** the process will be as cost-effective as possible, and utilize time, resources, and effort in a proficient manner to create the most robust output possible.

Review Process

The review took place from October 2014 through May 2015. A timeline of each task is provided below.

	2014			2015				
Milestone	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
Task 1 - Review Preparation								
Scope and process development; budget and administrative preparation; reviewer solicitation and selection process; collateral material development	X							
CDFW delivery of draft FMP to Ocean Science Trust		X						
Task 2 – Conduct Review								
Webinar 1: Initiation of Review (Attendees: CDFW, Review Committee, Ocean Science Trust)			X					
Webinars 2: FMP Assessment (Attendees: Review Committee, Ocean Science Trust)				X				
CDFW delivery of draft SPR model and report to Ocean Science Trust						X		
Webinar 3: SPR Model Assessment *(Attendees: CDFW, Review Committee, Ocean Science Trust)*						X		
Webinar 4: Cont. SPR Model Assessment, Develop Review Recommendations *(Attendees: Review Committee, Ocean Science Trust)*							X	
Task 3 – Finalize Summary Report								
Deliver final report to CDFW and make available online; publish membership of review committee; present findings to the Fish and Game Commission								X

Assembling the Review Committee

Ocean Science Trust implemented a reviewer selection process to assemble a review committee composed of four external scientific experts. Ocean Science Trust consulted with and accepted reviewer recommendations from the Ocean Protection Council Science Advisory Team (OPC-SAT), as well as Ocean Science Trust's own professional network among the academic and research community. Membership included experts from academia, research institutions, and government entities in order to deliver balanced feedback and multiple perspectives. Reviewers were considered based on three key criteria:

- **Expertise:** The reviewer should have demonstrated knowledge, experience, and skills in one or more of the following areas:
    - Fisheries biology, stock assessments and modeling, including spawning potential ratio analyses and application
    - Invertebrate ecology and/or population biology, with an understanding of California's coastal ecosystems, and how invertebrate stocks respond to fishing pressure, climate change and marine protected areas
- **Objectivity:** The reviewer should be independent from the generation of the product under review, free from institutional or ideological bias regarding the issues under review, and able to provide an objective, open minded, and thoughtful review in the best interest of the review outcome(s). In addition, the reviewer should be comfortable sharing his or her knowledge and perspectives and openly identifying his or her knowledge gaps.
- **Conflict of Interest:** Reviewers will be asked to disclose any potential conflicts of interest to determine if they stand to financially gain from the outcome of the process (i.e. employment and funding). Conflicts will be considered and may exclude a potential reviewer's participation.

Final selections for the review committee were made by the Ocean Protection Council Science Advisor (Ocean Science Trust Executive Director). Ocean Science Trust selected one member of the review committee to serve as chair to provide leadership among reviewers, help ensure that all members act in accordance with review principles and policies, and promote a set of review outputs that adequately fulfill the charge and accurately reflect the views of all members.

Series of Review Webinars

All meetings took place via a series of remote online meetings (webinars) and phone calls. At the outset of the review, Ocean Science Trust worked with the Department to develop detailed reviewer instructions that encouraged focused scientific feedback throughout the process. Instructions included directed evaluation questions and delegated tasks for reviewers based on their individual areas of expertise. The instructions were used to guide the development of meeting agendas, and track progress throughout the course of the review. For each meeting, advanced work was required of participants (e.g., conducting analyses, drafting responses to guiding questions, preparing presentations) in order for all parties to come prepared for meaningful discussions. Ocean Science Trust notified CDFW of additional requested materials and data prior to the first "Initiation of Review" webinar in mid-November.

- **Webinar 1: Initiation of Review (*December 2014*)**

Ocean Science Trust hosted an initial remote meeting (webinar) to provide the review committee and Department staff an overview of the scope and process, and clarify the roles and responsibilities of each participant. The Department provided a summary of the relevant management context to ensure reviewers understood the role of the review in the FMP development process, and how the outputs would be considered. The bulk of the webinar focused on a presentation by the Department of the scientific and technical components of the draft FMP. The webinar was an opportunity to develop a shared understanding of the tasks and allow reviewers to ask the Department any clarifying questions about the review materials before they convened independently to conduct their technical assessment.

- **Webinars 2-4: Reviewers convened with Ocean Science Trust to conduct review (*January through April 2015*)**

Ocean Science Trust convened three remote one- to two-hour webinars with the review committee to conduct an in-depth evaluation of the components identified in the Scope of Review. In advance of each webinar, reviewers were asked to prepare responses to guiding evaluation criteria questions from the review instructions. During each webinar, reviewers discussed their findings and developed conclusions and recommendations. Outputs from each webinar, as well as reviewer responses to the questions, guided the development of the final report.

Final Summary Report

Ocean Science Trust worked with the review committee to synthesize reviewer assessments (responses to the review instructions and input during webinars) into a cohesive, concise final report. The final report was delivered to the Department in May 2015, and made publicly available on Ocean Science Trust's website along with the identities of the review committee members. Ocean Science Trust presented the review results on behalf of the review committee at the June 10, 2015 California Fish and Game Commission public meeting in Mammoth, California.

Contact Information

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Appendix VIII – CA Lobster FMP Edits in Response to Scientific Peer Review Comments

The scientific foundation for the California Spiny Lobster Fishery Management Plan (CA lobster FMP) underwent an independent, external peer review by a panel of academic and government scientists, expert in lobster fisheries and marine invertebrates. Reviewers focused on the reference points used within the harvest control rule (HCR), the model used to calculate spawning potential ratio (SPR), methods for incorporation of the effects of marine protected areas on the stock and fishery, and the decision to manage CA lobster as a single stock. The primary changes to the previous draft of this FMP in response to peer review include:

- A von Bertalanffy growth model was used to describe lobster age at a given size within the model used to calculate SPR.
- Catch and catch per unit effort (CPUE) reference points were made more sensitive by setting the threshold levels at 0.9 rather than 0.8.
- Expanded discussion of possible reference points and associated models was added to the FMP along with increased explanation of the selected approach.
- Information on regional differences within the stock was added and better understanding of these differences was highlighted as an information need.

The responses below address each specific recommendation made by the panel and highlight what changes, if any, were made to the draft FMP in response. California Department of Fish and Wildlife (CDFW) responses to comments follow the same outline structure within the panel's final report (Appendix VIII to the CA lobster FMP). The Cable model was originally developed by Dr. Richard Parrish under contract with the South Bay Cable Liaison Committee (Parrish 2013), and ongoing revision of it has been necessary to address some panel recommendations. References to the CDFW-Cable model in this document are for the most recent version that was developed through collaboration among CDFW staff and CDFW contractors, including assistance from Dr. Parrish.

1 Evaluation of the proposed reference point thresholds

1.1 Spawning Potential Ratio (SPR) Cable Model and the SPR Reference Point

1.1.1 Key Recommendations for Securing a Management-Ready SPR Model

Growth Model

Comment: Rely on the von Bertalanffy growth modeling methods until the newly developed growth model can be robustly validated.
Response: CDFW fit a von Bertalanffy model to existing growth data from tag-recapture studies generating a new equation to relate size and age within the CDFW-Cable model. Separate male and female equations resulted in greatly underestimated maximum size, which lead to unrealistic model results. Given this, von Bertalanffy parameters derived for the Mexican CA spiny lobster stock were taken from Vega (2003). Equations with separate parameters for males and females were input to the CDFW-Cable model (see Appendix VII to the CA lobster FMP).

Comment: Use SPR with caution at high exploitation rates.
Response: Discussion of the limitations to the CDFW-Cable model at high exploitation rates were added to the FMP within section 4.3.1 and the corresponding Figure 4-9.

Comment: Reconsider some of the tag-recapture data that were removed from the growth models.
Response: Growth increments of 0 mm were retained as recommended. The occurrence of negative growth increments as well as outliers was re-examined. After accommodating the data filtering requirements designed to ensure a molt had occurred between lobster measurements (>150 days at liberty and measurements before and after the molting season) negative values fell out of the data set. Two extreme outliers remained and were removed. As stated above, the resulting von Bertalanffy model was unrealistic and was not used.

Model Functionality

Comment: Update the vulnerability relationship.
Response: Lobster vulnerability to traps is described by a size-dependent equation within the CDFW-Cable model. This equation simulates low vulnerability for small lobsters that are able to escape through escape ports, grows to high vulnerability for legal-size lobsters, then low vulnerability again for very large lobsters that are too large to enter trap funnels. Parameters determine the rate at which vulnerability increases then decreases again. Equations for vulnerability and female sexual maturity are of a similar form because maturity also increases quickly as females increase in size. The parameter guiding this increase was the same in an earlier model version by coincidence. The parameter for female maturity was set based on published observations of sizes of berried females. The parameter for vulnerability was set based on sizes of lobsters typical in traps. That parameter was then "tuned" within the model to produce a simulated percentage of shorts in the catch that matched this percentage from commercial log data. This tuning procedure was repeated on the most recent model version, which utilizes a different growth model, resulting in slightly different vulnerability parameters.

Comment: Revisit the natural mortality function.
Response: The CDFW-Cable model natural mortality function is size-based and results in high natural mortality for young lobsters which decreases to a value of 0.17 for most size classes before increasing again for large lobsters. CDFW performed a sensitivity analysis to examine differences in model output using natural mortality equations with and without increasing natural mortality for old, large lobsters (senescence). Senescence had little impact on model results because few lobsters live to achieve the size at which senescence is relevant. Therefore simulated senescence was removed from the natural mortality function. Additional references were added to the FMP within section 5.2, subsection on total mortality. The referenced studies also used natural mortality rates of approximately 0.17 although typically used a constant rate rather than size-based. Temperature and von Bertalanffy parameters were also used to calculate an estimate for natural mortality following methods described in Hearn (2008) and again achieved a result of approximately 0.17.

Comment: Explain the ramifications of SPR being independent year to year.
Response: Additional discussion of the drawbacks to equilibrium modeling was added to section 4.3.1.3. The constant recruitment used within the CDFW-Cable model, and therefore lack of a stock-recruitment relationship, is described as the reason for using an SPR threshold based on a set of reference years rather than knowledge of a sustainable spawning stock biomass based in MSY. Additional discussion of this issue has been added to CDFW's report on the Cable-CDFW Model.

Sensitivity Analyses

Comment: Make greater use of sensitivity analyses in explaining the model.
Response: In response to requests by the review panel for additional sensitivity analyses during the review process, CDFW analyzed model sensitivity to natural mortality equations of multiple forms, MPA and movement related parameters, vulnerability parameters, and ghost fishing. Results from these analyses have been added to CDFW's report on the model. Results of further sensitivity analyses on changes in model output resulting from growth model changes requested by the review panel were also added. CDFW will continue to use these analysis techniques when future model changes are considered.

1.1.2 Longer-Term Considerations for the SPR Model

Research Needs

Comment: Explore alternative methods to estimate lobster growth.
Response: This was identified as a research priority in section 5.2 on Essential Fisheries Information (EFI) and subsection on age and growth. Emerging techniques for direct identification of crustacean age were described and referenced. Available tag-recapture data and modeling efforts of CDFW to date were also described. The CDFW-Cable model report provides more detail. A statement that CDFW will look to collect more growth data and develop new models was added to the natural history section (3.2) subsection on growth. The importance of regionally specific growth information, if the CDFW-Cable model is to be used in a regionally specific way, was added to section 4.3.1.3.

Comment: Explore additional technical models that can account for variable recruitment.
Response: There are currently no adequate data on lobster recruitment that can be used to develop a stock-recruitment relationship for CA lobster. This is one of the reasons for the choice to use equilibrium modeling to estimate SPR. However, CDFW recognizes the drawbacks of equilibrium modeling and will seek to improve understanding of CA lobster recruitment in the future. CDFW has demonstrated a relationship between CA lobster landings and the abundance of phyllosoma larvae in CalCOFI samples (Koslow et al. 2012) but this may not translate into a relationship between landings and recruitment. The MSE model has options for the use of either a Beverton-Holt or Ricker recruitment curve and CDFW hopes to further improve the MSE model and use it to provide context for future management decisions. Models for calculating reference points that incorporate stock-recruitment relationships are noted in section 4.2.4.

Comment: Develop a sampling program to collect individual lobster length or weight composition data from both sectors of the fishery.
Response: This is noted as a research priority in section 5.2 covering EFI, subsection on stock composition. Improvements that these data could provide to models are noted in section 4.3.1.3.

Comment: Prioritize obtaining intermediate recapture data, which could be useful for better understanding the dynamics of lobster growth rates.
Response: This was noted as a priority in section 5.2 on EFI, subsection on age and growth.

Model Functionality

Comment: Develop a function or method to incorporate recreational catch into the model.
Response: The CDFW-Cable model calculates SPR based on input data on average weight of individuals in the commercial catch. Currently, there are not adequate data on average weight of lobsters taken in the recreational fishery. Other aspects of the model, such as vulnerability, are based on data describing the vulnerability of lobsters to traps and not to hand take. An intensive research program and annual monitoring would be required to generate appropriate equations, parameters, and input data for recreational take. Additionally, improvement in recreational catch estimates as report card return rates improve would be necessary for confident inclusion of recreational dynamics in models. Additional data sources, such as as annual telephone surveys of fishermen who did not return their report card would help, but require additional capacity and resources to undertake.

Comment: Revisit the SPR model as MPAs reach their full maturity.
Response: Additional discussion of the "credit" given to the simulated lobster stock from MPAs was added to section 4.3.1.3. CDFW agrees that MPAs are unlikely to have achieved their full potential and may not for some time and now state within the FMP "… it is unlikely that the MPAs, implemented in 2012 as a result of the south coast MLPA process, have actually achieved equilibrium and their full potential. Given that the average weight during the 2014-15 fishing season was above the average of the reference years, $SPR_{CURRENT}$ for 2014-15 was also above $SPR_{THRESHOLD}$ with or without the model benefit from MPAs. CDFW will monitor average weight and SPR closely until further research illustrates substantial benefit of MPAs to CA lobster and that the model-simulated enhancement to reproductive potential is warranted."

Comment: Formalize a process to review, revise, update, and evaluate the SPR model and its effectiveness in meeting management goals as new data, information, or analyses become available.
Response: Section 4.3.1.3 notes that equations and parameters in the model will be revised as information becomes available. Section 6.2.2 on the amendment process states that revising calculations within the Cable-CDFW model to include new EFI would not require an amendment but removal or addition of a different reference point would.

1.2 Catch and CPUE-based Reference Points

1.2.1 Key Recommendations for Catch and CPUE-based Reference Points

Comment: Describe catch and CPUE thresholds as "fishery indicators" instead of reference points.
Response: The Canadian precautionary approach described in the peer-review report as well as other reference point approaches were explored. Discussion of these approaches relative to the approach used in the CA Lobster FMP was added to sections 4.2.4, 4.2.5, and 4.3.1.3. CDFW asserts the catch and CPUE reference points play a valuable role in the HCR and therefore were not removed from the HCR or reclassified as "indicators." However, as recommended by the review panel, the effects of making the catch and CPUE reference points more sensitive were explored and threshold levels were increased from 0.8 to 0.9. Descriptions of stock history relative to those thresholds are given in sections 4.3.1.1 and 4.3.1.2. Previously the FMP stated that investigations would be initiated if the catch or CPUE declined for seven consecutive seasons. This was intended to bring additional attention to declining catch or CPUE even if they remain above the reference point threshold. In recognition that consistent declines have not been seen previously, investigations will instead be initiated if the catch or CPUE reference points decline for six consecutive seasons. This adds additional sensitivity to the reference points and is better aligned with stock history.

Comment: Clarify rationale for the use of 0.8 thresholds prescribed in the FMP.
Response: Additional explanation of the rationale for using moving averages and the revised threshold values of 0.9 for the catch and CPUE reference points was added to sections 4.3.1.1 and 4.3.1.2.

Comment: Report the CPUE statistic in mass per unit effort.
Response: CPUE is calculated as number of lobsters caught per trap pull because both of these data are collected on the commercial log. Reporting mass per unit effort would require linking logs to landing receipts which requires a variety of assumptions and results in removal of a large amount of data. Therefore no change was made in response to this comment.

Comment: Include greater discussion of the reliability of recreational catch estimates.
Response: Additional discussion of the reliability of these data was added to section 2.2. Table 2-1 was updated with new estimates of the total weight of recreational landings and 95% confidence intervals, as well as the percent of total landings represented by recreational landings. However, these confidence intervals cannot reflect uncertainty "due to poaching or the potential that catch on returned report cards is not representative of catch on un-returned report cards."

1.2.2 Longer-Term Considerations for Catch and CPUE Data

Comment: Explore other technical models to obtain additional or alternative biological reference points that account for inter-annual variability in recruitment and other variables.
Response: Discussion of, and references to, other types of models for generating reference points was added to sections 4.2.4, 4.2.5 and 4.3.1.3. CDFW is open to further exploration of these model options. These options, particularly a Delury depletion model which may not require new data streams, could be useful if prompted to investigate stock status by the HCR.

Comment: Standardize commercial and recreational catch data to the same spatial reference points.
Response: CDFW commercial fishing blocks, which are 10 x 10 nm, are a long-standing reporting requirement on commercial logs. This level of detail is not tractable on a recreational report card. Existing report card catch locations can be overlaid with and attributed to commercial blocks. However a variety of assumptions are required where boundaries are not well aligned. In the future, CDFW will seek to better define recreational take locations so that they align well with commercial blocks, where possible.

2. Science Supporting the Decision to Manage as a Single-Stock

Comment: Assess and report any spatially explicit differences between regions of the fishery.
Response: A new section (3.10) was added to the natural history chapter to describe what is known about regional differences within the stock. The spatial limitations of the CDFW-Cable model and the concerns of using the model to produce regionally specific results are discussed in section 4.3.1.3. Some analyses of differences in effort and catch were performed as part of an effort to refine our analyses of average weight. This helped inform the discussion of regional differences in section 3.10. Another new section (3.4) was added to describe existing literature on genetic population structure. This literature suggests that management as a single stock is appropriate and that while mixing across the border with Mexico occurs, it likely doesn't dominate CA dynamics.

Comment: Interactions with Mexico's spiny lobster stock should be considered and discussed in greater detail throughout the FMP.
Response: A new section (4.4.1) was added to describe Mexico's stock status and management. Additional discussion of how recruitment from Mexico would affect our use of SPR as a reference point was added to section 4.3.1.3.

Comment: Prioritize longer-term research needs relating to regional differences in the species' biological parameters.
Response: Additional description and references for larval recruitment data were added to section 5.1.2 in the larval collectors subsection. The potential use of these data to understand regional differences and population sources and sinks is noted in section 5.2 on recruitment. The importance of understanding regional differences in age at maturity and fecundity is noted in section 5.2, subsection on reproduction. Regionally-specific estimates of fishing mortality were already given the highest research priority in section 5.2, subsection on Mortality. The importance of information in all these categories if the CDFW-Cable model is to be used for regionally-specific results is noted in section 4.3.1.3. Genetic population structure/larval mixing was added as a data type in Table 5-1.

3. Estimate of Lobster Habitat Contained within Marine Protected Areas

Comment: Provide greater discussion of the data sources used to estimate suitable lobster habitat.
Response: Sources for different lobster habitat categories were foot noted in section 3.1. Table 4-2 was added to provide the relative areas of hard and soft habitat types and unknown regions, as well as their mapping resolution within regions of the Southern California Bight (SCB). The amount of hard bottom area estimated using kelp canopy as a proxy was also noted.

Comment: Continue to refine the MPA estimate as new information becomes available.
Response: Improvement of habitat information is given the highest priority in section 5.2 and Table 5-1. Its importance to calculation of SPR within the CDFW-Cable model is noted.

Comment: Consider developing a function or method to consider actual marine protected area sizes in the SPR cable model.
Response: The CDFW-Cable model was designed as an equilibrium model. It is run only a single time under each scenario with no stochasticity or variability in parameters. MPA size and spacing represents an average of the actual variation along the entire SCB coast. One method for incorporating a range of MPA parameters could be to average outputs from multiple runs using different MPA parameter settings. However, using the CDFW-Cable model to produce regionally-specific results based on MPA parameters without including regionally specific biological parameters for many of the functions may not be appropriate. A much more complex model would be more appropriate for inclusion of realistic MPA size and spacing and could concurrently include variable recruitment and other regional differences. An individual-based model like the MSE model is better structured for these functions and CDFW hopes to continue improvement of that model in the future.

4. Research and Monitoring

Comment: Continue to update and prioritize research and data needs in the FMP.
Response: The data needs and research priorities outlined in Chapter 5 of the FMP were closely reviewed. CDFW is undergoing a systematic review of data needs and existing data streams for the lobster fishery as well as all other fisheries. CDFW is also working towards developing a public-facing repository for our research and data needs.

5. Additional Recommendations

Comment: The harvest control rule matrix should include predetermined management options.
Response: The HCR was designed to be discretionary as predetermined management options were not supported by the LAC. Inclusion of multiple reference points was intended to help provide a more complete picture of stock status and influences. Based on these relatively nuanced reference points, management responses can be flexible because of multiple toolbox options and also because investigations prompted by the HCR should provide further guidance on stock influences. Edits were made to both Table 4-3: Harvest Control Rule Matrix and Table 4-4: Control Rule Toolbox to clarify potential reasons for reference point positions and suggested responses.

Comment: Clarify the information required for setting total allowable catch (TAC).
Response: Additional description of TACs, methods for their determination, and references were added to section 4.3.3.

Appendix IX: LAC Regulatory Recommendations and CDFW Memorandum to the Commission on LAC Recommendations

The following appendix provides historical documents related to the lobster advisory committee (LAC), which was a constituent body tasked with developing management recommendations to be associated with the fishery management plan. The documents are 1) a description of regulatory proposals for the commercial fishery, 2) a description of regulatory proposals for the recreational fishery, and 3) a memorandum from the Department of Fish and Wildlife (CDFW) to the Fish and Game Commission requesting direction on preparation of a regulatory package based on LAC recommendations. Only those proposals achieving full consensus from LAC members were presented to the Commission. Two proposals achieved near consensus but did not receive agreement from members representing the recreational fishery. Those were 1) a recreational seasonal limit of 70 lobsters per person and 2) a ban on the use of conical hoop nets in the recreational fishery. At the direction of the Fish and Game Commission, two proposals that did achieve consensus from the LAC were not carried forward. Those would have restricted the use of mechanized pullers to only disabled recreational fishermen and would have provided a three-year phase in period to commercial fishermen to reduce their trap use to the trap limit.

In addition to regulatory proposals, the LAC also came to consensus on a broad policy statement regarding allocation between the commercial and recreational fisheries and generated the following objectives:

- Identify current effort levels for each sector, and establish controls to prevent unrestricted growth.
- Identify the proportion of overall catch and or effort from each sector, and, if necessary, take corrective action to maintain those proportions if the percent of total catch and or effort by sector deviates significantly from a pre-determined base period.
- Recognize the current differences between sectors in traditional fishing grounds and time of day fished, and seek to maintain those differences.
- If increases or decreases to the fishery are required due to application of the control rule, those changes should seek to maintain equitability and not give an advantage to either sector unless biological triggers require a change to allocation.
- End illegal commercialization.

California Department of Fish and Wildlife

CDFW Feedback on Implementation Details of the Lobster Advisory Committee Commercial Recommendations:

The California Department of Fish and Wildlife (CDFW) recently met with the Lobster Advisory Committee (LAC) Commercial Representatives to discuss details regarding implementation of the proposed regulatory changes to the commercial lobster fishery recommended by the LAC. Input from CDFW Marine Region and Law Enforcement Division (LED) is provided in Blue Font below. This information is being disseminated to refine the details prior to the formal regulatory process which takes place after the Fisheries Management Plan (FMP) has been adopted in 2015. The LAC recommendations will part of the Lobster FMP implementing regulations that will be formally introduced to the Fish and Game Commission in mid-2015. Any new regulations that are adopted would not be implemented until the 2016-2017 lobster season.

LAC Commercial Proposal

Table 1. COMMERCIAL TRAP LIMIT

CATEGORY	NUMBER OF TRAPS	PROVISIONS
"300" Transferable Permit (T) "300" Non-transferable permit (NT)	300	• May stack another permit for a maximum of 2 permits (2 x 300 traps = 600 trap maximum) • The second permit remains transferable • Death provision applies only to transferable permits (NT permits are not transferable – even due to death)
CDFW supports the proposed LAC trap limit of 300 traps with the ability to stack another permit for a maximum of 2 permits (2 permits X 300 traps = 600 trap maximum). The second permit remains transferable, and the death provision only applies to transferable permits.		
Phase-In Stacking Permit	300	• Available to either transferable or non-transferable permittees • Non-transferable permit • Only available for three years (must be renewed annually) • Permit funds would go for commercial lobster research & monitoring – ($5,000 - $10,000 annual permit fee) • Would become effective when trap limits go into effect
CDFW recognizes that a "Phase-In Stacking Permit" may no longer be necessary given the projected timeline for the proposed implementing regulations. New regulations would become effective for the 2016/2017 season.		

Table 2. GENERAL PROVISIONS

- Death provision applies only to transferable permits

  CDFW Proposed Details:
- non-transferable permits can never be transferred - even upon death

- All traps must be tagged (on trap or buoy or both)(must be purchased annually); details to be worked out with LED

  CDFW Proposed Details:
- Traps shall be tagged w/ Dept. issued trap tags
- 300 trap tags shall be issued once a year to each permittee before the start of the season
- Program costs to be incorporated into permit fees, and tags will not be purchased separately

- Catastrophic gear loss provision; details to be worked out with LED (application would include requirement to report details of loss)(Information could be shared with permitted recovery projects)

  CDFW Proposed Details:
- The Department is considering defining catastrophic loss as the loss of 75 or more tags per permit. Catastrophic loss claims will be formally submitted to the Department for approval. LED will determine whether to approve or deny catastrophic loss claims. Claim information must include a detailed description of the circumstance that caused the loss, date of loss, number of traps lost along with their tag numbers, and location of lost traps (Latitude and Longitude coordinates).
- Catastrophic loss tags would be uniquely identifiable.

- Allow scuba equipment on board commercial vessels to retrieve lost traps or remove line from prop (not allowed to "fish" when on scuba)

  CDFW Proposed Details:
- Scuba gear already allowed per T14 122. Cannot be used for "take"
- Provide clarification that no lobsters can be taken or possessed w/scuba gear, or any other underwater breathing apparatus (including hookah). However, this equipment can be used to locate and secure (retrieve) traps
- Provide clarification that lobsters contained in a trap that has been secured using scuba gear, or any other underwater breathing apparatus equipment (including hookah), can be possessed after the trap has been serviced aboard the vessel

- More than one permittee may operate from a single vessel; each permittee whose traps are being pulled must be aboard

  CDFW Proposed Details:
- Dual Permittee on board – both permittees will be responsible for any violation found on vessel

- 7 day soak time using "Federal Rules" regarding weather

  CDFW Proposed Details:
- Adopt similar language to CFR Title 50 §660.230(3)
- Traps must be attended at least once every 7 days. No specific weather exemption. If traps cannot be pulled due to weather, fishermen will be responsible for burden of proof (e.g. NOAA weather advisory, or other formal documentation from a government weather agency)

- Limit use of “note” to fish traps by other than permit holder. May open (and retain the lobsters within) or retrieve traps belonging to another lobster fisherman with a note and notification to DFW LED (details to be worked out with LED); may not bait or fish traps for another permittee

  CDFW Proposed Details:
- Formalize the “note” process by requiring permittees to submit a waiver request to the Department. Waiver should be similar to the Dungeness Crab Waiver to Pull Traps
- Specific protocol and procedures for the Lobster Waiver to be established by LED
- CDFW will determine each waiver request on individual case basis. The information submitted in the waiver request will be used to determine the conditions. Lobsters may not be retained unless specified by CDFW as a condition on the waiver
- Department to be notified in advance
- Responsibility for violations is transferred to the individual permittee that has permission to pull
- Traps need to be either removed from water or wired open as specified by CDFW as a condition on the waiver.
- Establish provision to allow other fishermen targeting other species to recover lost or derelict gear (if found more than 9 days after the close of lobster season). This would be modeled after the existing provision for the recovery of up to 6 Dungeness crab traps.

- Allow commercial fishermen to start hauling their traps to sea before the season starts on the Monday before opening week (9 days before the commercial opener) and allow traps with doors open to remain in the water not more than 9 days after the close of the season

  CDFW Proposed Details:
- Allow traps to be deployed (unbaited and doors wired open) 9 days before the commercial opener, and allow traps to remain in the water (unbaited and doors wired open) not more than 9 days after the close of the season. Traps must be out of the water no later than 9 day after the close of the season.
- “Bait day” remains the same

- Branding of floats allowed (details to be worked out with LED)

  CDFW Proposed Details:
- This is already allowed under current regulations and so a regulatory change is not necessary to implement it. Therefore, the following clarification is provided as guidance to encourage effective compliance. Each buoy identifying a lobster trap would display the commercial fishing license identification number of the lobster operator permit holder followed by the letter P. The commercial fishing license number and the letter P would be at least one (1) inch in height and at least one-eight (1/8) inch in width, and either branded on the buoy in a way that is clearly readable or painted in a color that contrasts with that of the buoy. All lobster permit holders would maintain lobster trap buoys in such a condition that buoy identifying numbers are clearly readable.

- **Additional Issue (Not addressed by the LAC):** Traps that are wired open and unbaited still need to be serviced every 96 hours per FG9004

  CDFW Proposed Details:
- Traps that are wired open and unbaited would be exempt from the trap service requirement for a period up to 14 days. Traps that have not been serviced after 14 days will be considered

abandoned.

CDFW Staff

Bob Puccinelli – Captain, Law Enforcements Division

Craig Shuman – Regional Manager

Tom Barnes – Manager of State Managed Species

Kai Lampson – Lobster FMP Coordinator

Representatives on the LAC

Rodger Healy – Commercial Fishing Representative

Shad Catarius – Commercial Fishing Representative

Jim Colomy – Commercial Fishing Representative

Josh Fisher – Alternate Commercial Fishing Representative

Spiny Lobster Fishery Management Plan
Lobster Advisory Committee
Recreational Lobster Fishery Management Recommendations

The California Department of Fish and Wildlife (CDFW) recently met with the Lobster Advisory Committee (LAC) Recreational Representatives to discuss details regarding implementation of the proposed regulatory changes to the recreation lobster fishery recommended by the LAC. Input from CDFW Marine Region and Law Enforcement Division (LED) is provided in Blue Font below. This information is being disseminated to refine the details prior to the formal regulatory process which takes place after the Fisheries Management Plan (FMP) has been adopted in 2015. The LAC recommendations will be part of the Lobster FMP implementing regulations that will be formally introduced to the Fish and Game Commission (Commission) in mid-2015. It is expected that any new regulations adopted by the Commission would be implemented at the start of 2016-2017 lobster season.

Please Note: Proposals to prohibit or "ban" the use of conical hoop nets or to establish a seasonal limit were not part of the LAC's consensus recommendations for the recreational fishery. CDFW will not be forwarding these proposals to the Commission as part of the LAC recommendations.

Full consensus was achieved by the Lobster Advisory Committee for the following:

Issue: Lobster caught by recreational fishermen is being illegally sold in the commercial market place. Requiring sport fishermen to clip or punch the center tail flap makes it possible for law enforcement to identify lobsters caught in a recreational fishery that end up in the market and take appropriate legal action. This proposal will give law enforcement a tool to address buyers and markets that purchase lobster from recreational fishermen.

Proposal: Recreationally caught lobsters are to be tail-clipped (removing the bottom half of the central tail flap) or tail-punched in the central tail flap (Australia requires a 10 mm minimum hole). Additional details will be worked out with LED (e.g. clipped when landed?).

LAC Action: The LAC achieved consensus on the tail-clipping proposal above.

CDFW Proposed Details:

- Allow both tail clipping and tail punching as an option: remove at least the bottom half of central tail fin or single hole punch the center tail fin with a hole no less than ¼ inch in diameter

- The tail must be clipped or punched at the same time the catch information is reported on the report card (T14 29.91(C): When the cardholder moves to another location code, or finishes fishing for the day, he or she must immediately record on the card the number of lobster kept from that location

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Issue: Use of mechanized pullers has made it easier to rob from commercial traps.

Proposal: Restrict the use of mechanized pullers only to persons in possession of proof of disability/medical (Disabled Mechanized Hoop Net Puller Permit). This restriction would only pertain to power driven mechanized pullers and not hand operated davits with single pulley systems.

> Clarification: This restriction only applies to individuals targeting or in possession of lobster, not persons solely targeting crab.
>
> Proposed CDFW Disabled Mechanized Hoop Net Puller Permit Form:
> The following conditions must be met to qualify for issuance of a Disabled Mechanized Hoop Net Puller Permit: "For the purposes of this permit a disability means a permanent loss, significant limitation, or diagnosed disease or disorder, which substantially impairs an individual's ability to physically pull by hand and retrieve a hoop net for the purpose of targeting lobster." A medical physician must sign the permit application form.

LAC Action: The LAC achieved consensus on the mechanical puller restriction proposal above.

Some members noted that the broad wording of the disability option could render the management measure ineffective and suggested that the LAC work with LED to ensure the new rule has "teeth" when it is applied.

CDFW Recommendation:

- Mechanized pullers should not be restricted beyond current legal use
- The potential for illegal use given the circumstance is not viewed as a reasonable justification for restriction
- Illegal use of mechanized pullers is not a commonly observed problem. LED reported one case over ten years ago, with four lobsters taken from a commercial trap using a mechanized puller
- The creation of disabled hoop net puller permit creates an unnecessary burden on disabled persons through the potential added expense and time to obtain the necessary note from a physician in order to obtain a permit

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Issue: The midnight opener creates a "rush" mentality that fuels conflicts between recreational users and poses a safety risk. The current lobster opener date and time can be difficult to understand (confusion regarding when the season actual "starts") and constituents are having trouble following the law. CDFW has been asked to consider an alternate start time.

Proposal: Make the lobster opener 6:00 a.m. on Saturday instead of 12:01 a.m. on Saturday.

Key discussion points:

- New time is workable for LED
- Proposal improves safety conditions
- Regulatory change has no impact on the resource
- Commercial season dates would not change

LAC Action: The LAC achieved consensus on the lobster opener proposal above. The group acknowledged concerns regarding the economic impact this proposal may have on some dive charters.
LAC recommendation is for a 6:00 a.m. Saturday start time (lobster opener)

CDFW Recommendation:

- Proposed 6:00 am Saturday start time is easier to facilitate enforcement patrols
- Promotes a safer environment for both boaters and divers on opening day
- Reduces the "rush" mentality which fuels negative diver/hoop netter interactions at harbors and jetties

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Issue: Marking hoop net floats will improve accountability and safety among recreational fishermen, and may help reduce illegal commercialization.

Proposal: Hoop net floats should be marked with unique ID (DL, Go ID, etc. — details to be worked out with LED).

LAC Action: The LAC achieved consensus on the marked hoop net proposal above.

CDFW Proposed Details:

- Buoy identification should be required with GO ID number. This number shall be legible, but there will be no size or color specification. Go ID number helps maintain fishermen's confidentiality, and minimizes the risk of identity theft
- LED can easily verify this number in the field as it can be cross referenced with the fishing license

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Issue: Spear fisherman have been harassed or cited for carrying a spear gun while in the pursuit of lobster. Constituents have asked for clarity on the definition of a "hooked" device.

Proposal: Keep change simple. Ensure regulatory language focuses on how lobster can be taken (i.e. "skin and scuba divers may take lobsters by hand only") and not how it cannot be taken; remove "hooked device" term from current regulations. The proposal allows for possession of a spear gun or pole spear underwater while hunting lobsters. Misuse of this equipment to take lobster (lobster can only be taken by hand) would remain illegal.

LAC Action: The LAC achieved consensus on the hooked device proposal above.

CDFW Recommendation:

- Remove "hooked device" for clarification

MEETING PARTICIPANTS

CDFW Staff

Bob Puccinelli – Captain, Law Enforcements Division

Craig Shuman – Regional Manager

Tom Barnes – Manager of State Managed Species

Kai Lampson – Lobster FMP Coordinator

Representatives on the LAC

Jim Salazar – Recreational Fishing Representative

Michael Gould – Recreational Fishing Representative

Al Stasukevich – Recreational Fishing Representative

Paul Romanowski – Recreational Fishing Representative

State of California
Department of Fish and Wildlife

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2015 MAY 29 PM 2:55

Memorandum

Date: May 22, 2015

To: Sonke Mastrup
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: Briefing Binder Submission for the June 10-11 Fish and Game Commission Meeting Regarding the Spiny Lobster Fishery Management Plan

Background

An extensive public scoping process was used by the Department of Fish and Wildlife (Department) to develop implementing regulations for a Spiny Lobster Fishery Management Plan (FMP). The Department established the Lobster Advisory Committee (LAC) as a formal stakeholder group who met over a period of two years to make management recommendations, including regulation changes. The LAC consisted of seated representatives from a broad spectrum of constituencies. Through consensus, the LAC approved a management framework that established proposed mechanisms to promote an orderly fishery while assuring sustainability and also taking into account the economic implications of that same framework. The Department supports the efforts of the LAC, and has made every effort to recommend FMP regulations that are consistent with the LAC consensus-based proposals. The Department and LAC regulatory recommendations were transmitted to the Commission for consideration at its April 8th, 2015 meeting.

The Department is requesting direction from the Commission on options to include in a regulatory package that is associated with the FMP. The enclosed table summarizes the LAC and Department commercial and recreation spiny lobster regulatory recommendations. This table provides a summary of the recommendations transmitted to the Commission at its April 8th, 2015 meeting. The Department will also be requesting direction from the Commission on four additional Department recommendations for the commercial spiny lobster fishery that are included in the table.

The additional recommendations include:

1. Require each lobster operator permit holder to report the number and location of traps lost at the end of each season. This will allow the Department to estimate gear loss for the fishery and help facilitate recovery efforts.

2. Extend the lobster operator permit death provision transfer period from one to two years. This is recommended by the Department's License and Revenue Branch (LRB) to provide families or estates an extra year to transfer a permit.
3. Add a prohibition on the transfer of lobster operator permits to include pending violation(s). Current regulations allow permits to be transferred when a permit holder has pending violations. This recommendation was added at the request of LRB and Law Enforcement Division to prevent transfers from occurring before results of the pending violation(s) are known.
4. Require a Department application for the transfer of lobster operator permits.

If you have any questions or need additional information, please contact Dr. Craig Shuman, Regional Manager of the Marine Region, by telephone at (805) 568-0216 or by email at craig.shuman@wildlife.ca.gov.

Attachment

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Summary Table of the Lobster Advisory Committee and Department of Fish and Wildlife spiny lobster regulatory recommendations

Background: The Department of Fish and Wildlife (Department) is requesting direction from the Fish and Game Commission (Commission) on options to include in the regulatory package that is associated with the Spiny Lobster Fishery Management Plan. This table provides a summary of the Lobster Advisory Committee (LAC) and Department commercial and recreation spiny lobster regulatory recommendations transmitted to the Commission at its April 8th, 2015 meeting. The table also includes additional Department recommendations not addressed by the LAC.

	LAC Consensus and Department Recommended Lobster Regulatory Changes	
1	Regulations to implement the lobster Fishery Management Plan (FMP).	Identifies the purpose and scope, harvest control rules, management responses, and lists definitions specific to the FMP.
	Recreational Recommendations	
	Change Summary	**Purpose**
2	Require the hole-punching or fin-clipping of all retained lobsters.	To reduce illegal commercialization of sport caught lobsters.
3	Change recreational season opener from 12:01 am to 6 a.m. on Saturday.	To increase safety during the season opener.
4	Require hoop net operators to mark hoop net floats with GO-ID numbers.	Allows Enforcement to easily identify the owner of a hoop net.
5	Clarify methods of take for crustaceans.	Clarifies that spear gear can be possessed by divers while targeting or in possession of lobsters so long as the gear is not used in the taking of lobster.
	Commercial Recommendations	
	Change Summary	**Purpose**
6	Trap limit of 300 traps per permit with the ability to purchase a second permit for a maximum 600 traps.	To improve the commercial fishery and create a more orderly fishery.
7	Add fees and forms associated with trap tag program.	Required to add new fees and other administrative requirements for the trap tag program.
8	Catastrophic trap tag loss provision. Catastrophic loss defined as the loss of 75 or more tags per permit.	To allow for the replacement of tags lost over a season.
9	Clarify use and possession of SCUBA equipment from commercial lobster vessels.	Amended for clarification purposes.
10	More than one permittee may operate from single vessel.	Added for clarification purposes. Each permittee whose traps are being pulled must be aboard and both permittees will be responsible for any violation found on vessel.
11	Require traps to be serviced at least every 7 days (currently 4 days).	Proposed as part of the trap limit proposal.
12	Waiver requirement for allowing lobster operator permit holders to service another fishermen's traps.	To formalize the process to meet enforcement and fishermen's needs.
13	Add a provision to allow fishermen to recover up to 6 lost traps.	To allow for the retrieval of lost gear.
14	Extend the period (from 6 to 9 days) for deploying and retrieving traps before and after the season.	Proposed as part of the trap limit proposal.
15	Allow branding of trap buoys.	**No regulatory change needed**: Already covered by existing regulations and will be clarified.

Summary Table of the Lobster Advisory Committee and Department of Fish and Wildlife spiny lobster regulatory recommendations

Additional Department Recommendations Not Addressed by the LAC		
	Change Summary	**Purpose**
16	Define abandoned traps. Traps considered abandoned if not retrieved 14 days after the season ends.	To define when a trap is considered abandoned.
17	Improving fishery dependent data collection.	Department recommends modifying lobster logbooks and landing receipts to gather essential fishery information to better manage the fisheries.
18	Prohibit the transfer of a lobster operator permit when there are pending violation(s).	Added as an enforcement need.
19	Extend the lobster operator permit death provision transfer period from 1 to 2 years.	Added at the request of the Departments Licenses and Revenue Branch to allow more time to transfer a permit.
20	Require an application for the transfer of lobster operator permits.	Require an application to transfer a permit. Add appeal requirements when a transfer is denied. Add criteria for transfer of permit under a tag system.
21	Reporting of commercial trap loss.	At the end of each season, require commercial fishermen to report the number and location of traps lost over the season.
LAC Consensus Recommendations Not Supported by the Department		
	Change Summary	**Rationale for not Supporting**
22	Restrict the recreational use of mechanized pullers to only disabled fishermen.	Proposed by the LAC due to concerns of the illegal use of mechanized pullers to poach commercial traps. Law Enforcement Division indicates that illegal use of mechanized pullers is not a commonly observed problem. Proposed regulation would penalize the lawful anglers using mechanical pullers due to the very few anglers that may abuse the use of mechanized pullers.
23	Three-year phase-in trap limit approach.	The Department does not support this recommendation as the projected timeline for the proposed implementing regulations is later than anticipated by the LAC. This gives industry more time to prepare for the proposed new trap limit. In addition, it will be difficult for the Department to implement and administer the program as proposed by the LAC.

Appendix X: Cable-CDFW Model Report

The Cable-CDFW Model Report is available at https://www.wildlife.ca.gov/Conservation/Marine/Lobster-FMP. Report revisions may be made to present updated model results based on future fishing seasons or to present model modifications resulting from improved information on lobster biology. Updated versions will be available at the same web address.