

Appendix A: Management Considerations

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Abalone

DFG's goals for abalone include the recovery of the abalone resource throughout its historic range to sustainable levels, pursuant to the mandates of legislation (Abalone Recovery and Management Plan and the Marine Life Management Act).

For reasons discussed above, many historic abalone fishery management practices were ineffective in protecting the resource south of San Francisco. The state recognizes the value and importance of abalone resources, and has made abalone recovery and management a high priority. Future abalone management might likely include the following:

1. Marine protected areas that provide refuge and protection for breeding populations of abalones, and other long lived, broadcast-spawning invertebrates. Such areas need to have active and adequate enforcement. These areas are necessary early in the recovery phase to enhance reproductive viability.
2. Individual species management. The life history, habitat needs, and population levels of each species should be recognized and considered within the framework of ecosystem management. Knowledge of the age class structure, frequency and rate of recruitment, natural mortality rate, and growth is needed to model the fishery for each species and area.
3. Rapid response to environmental and human induced stresses is needed to adjust or stop harvests when unforeseen problems such as disease or unusual climatic events arise.
4. Fishery-independent data to determine the health and sustainable harvest rate of the resource.
5. An evaluation to identify the potential size of the fishery using biological data and an economic analysis to evaluate resource rent, *i.e.*, the amount necessary to cover the cost of research, management, and pro-

tection of the resource, in order to apply these costs to the fishery.

6. A constituent involvement process that assists in evaluating the best uses of the resource. Such a process would also enable information-exchange between the DFG and interested parties.
7. An evaluation of the consequences of reoccupation of the sea otter into southern California waters.

Albacore

Currently, North Pacific albacore fisheries are not subject to formal management measures, such as limited entry or total catch restrictions for the commercial fisheries, or size or bag limits for the recreational fisheries. However, more structured management of the albacore population is being considered by an international convention (Multi-lateral High-Level Conference (MHLC) on the Conservation and Management of Highly Migratory Fish Stocks in the western and central Pacific Ocean) that includes nations that historically have supported fisheries for the highly migratory stocks of the Pacific Ocean. It is likely that initial management approaches will include some form of limited entry intended to minimize the detrimental effects to the stock that commonly arise due to intensive fishing over extended periods of time. One of the most difficult tasks that the MHLC must address will be to develop a strategic plan (research and management goals) for the North Pacific albacore stock that is applicable to the population's entire range. Such a plan must be supported by each nation's albacore management institution and industry if it is to be successful.

Angel Shark

Though the angel shark fishery is currently very minor in California (it is growing in Mexico), it can serve as a valuable case study of an emerging fishery that grew to be one of the most valuable elasmobranch fisheries on the Pacific coast in the past 25 years. A number of fishermen, both gill-netters and trawlers, who continue to harvest angel sharks, have expressed interest in working with DFG biologists to reassess the 1987 minimum size limit. They cite the fact that the main angel shark habitat and population centers have been protected by the Proposition 132 area closures for over six years and that the Marine Life Management Act (MLMA) encourages "adaptive management" to review and amend regulations if stocks improve. Participation of experienced fishermen proved valuable in the cooperative life history and population studies conducted on the research vessel *Squatina* in the 1980s and the MLMA identifies collaborative research as a priority

in obtaining cost-effective data for fisheries management. A future cooperative research study of the angel shark population could also shed light on the effectiveness of a large "no-take" marine reserve, at least on this single resident species.

Further studies on the genetic variability of geographically separated island and mainland stocks would provide resource managers with valuable information in developing a fisheries management plan. A review of the socio-economic impacts of the area closures on small scale fisheries, coastal communities, and local economies could also provide managers with tools to assess the pros and cons of incorporating marine reserves in future management strategies.

The fishing industry, university researchers, and resource managers might seek to initiate a cooperative program with Mexico to assure a sustainable angel shark fishery that can continue to supply both Mexican and U.S. markets.

Barred Sand Bass

This species seems to be a good candidate for the establishment of harvest refugia in some areas during peak spawning times.

Bay Shrimp

The current lack of catch limits, closed seasons or restricted areas is based upon the assumption that limited demand for bay shrimp maintains effort at levels far below the level that would threaten long-term sustainability of the fishery. Data is not available to test this assumption. Because of this, the following measures are suggested:

1. Continue the compilation of bay shrimp logbook data to get past and current catch per unit effort, as well as maintaining logbook requirements for commercial fishery participants.
2. Monitor species composition in bay shrimp landings. Currently, four species are known to be caught in the fishery with indications that a newly introduced fifth species may also be of importance. Long-term shifts in species landed by the fishery may be indicative of broader problems in the populations of each species.

Bocaccio

Bocaccio have been managed under the Groundfish Management Plan of the Pacific Fishery Management Council since 1982. The bocaccio population is now under a formal rebuilding program, requiring severe restrictions on fishing

opportunities. The length of time needed to rebuild the population depends on the frequency of rare large year classes, but may require 40 years under conditions similar to those seen in recent years.

Bull Kelp

In order to ensure a productive future for California's bull kelp resource and the species dependent on it, the following considerations are offered:

1. Continue the present management system for the 300-series beds, including the harvest prohibition for beds 303-307.
2. Modify the present 15 percent harvest-limit on the leasable 300-series beds to require distribution of the harvest throughout the bed to minimize local impacts.
3. Prohibit harvest of bull kelp in beds where the bull kelp resource has been shown to be chronically diminished during the past several decades.
4. Encourage the use of alternative feeds, some of which have already been developed for cultured species such as red abalone.
5. Fund more regular assessments and more research to examine the impacts of various harvest strategies.

Cabezon

In recent years, federal groundfish management policy has resulted in drastic reductions in allowable take of many groundfish species due to the overfished status of some species such as lingcod, bocaccio, and canary rockfish. These reductions in turn have shifted effort to more lucrative markets, such as the live-fish fishery. For bocaccio and canary rockfish, the efforts required to rebuild stocks will restrict harvest levels for all associated species for several years, so fishing pressure on cabezon and other nearshore groundfish species is not likely to decrease, and may increase further, without some intervention. DFG developed interim management measures to further address increasing demands on these nearshore fish populations. Measures for cabezon include:

1. An increase in the minimum size limit.
2. A closed commercial and recreational fishery during spawning and nest guarding seasons.

In addition, the department is mandated to develop a Nearshore Fishery Management Plan, which will include cabezon and may be adopted by the Fish and Game Commission in January 2002.

Calico Rockfish

Calico rockfish are a minor component of commercial rockfish landings in California, but they may comprise a significant portion of the undocumented bycatch of the nearshore commercial fisheries that target other finfish or invertebrate species. The extent to which these nearshore fishing operations increase calico rockfish mortality is not known and requires further study, including onboard observation and sampling of the bycatch of nearshore commercial hook and line, trap, and trawl fishing vessels in southern and central California.

There is currently some onboard sampling of CPFVs in California as part of the ongoing coastwide Marine Recreational Fisheries Statistical Survey, but additional onboard sampling of CPFVs will be required to adequately assess the mortality that is caused by sport anglers to calico rockfish stocks. Angler education and enforcement efforts to reduce the sport angler practice of high-grading would also help conserve the stocks of calico rockfish.

California Barracuda

1. Establish equilateral regulations with Mexico based on collaborative research.
2. Maintain current commercial and recreational regulations.

California Corbina

1. Maintain the current sport fish regulations and the ban on commercial take of corbina.
2. Ascertain size and age structure of populations.

California Halibut

1. Maintain the current commercial and recreational regulations.
2. Protect nursery grounds in southern California's embayments and estuaries.
3. Prohibit dredging operations in embayments and estuaries during periods of peak abundance (March-May) of larval and newly settled halibut in southern California.

California Sheephead

Implementation of the minimal size (12 inches) for the sheephead may allow smaller females to reproduce prior to their entry to the fishery. However, larger, more fertile females are still at risk. Careful monitoring of catch and effort data, if possible, is needed to allow early detection of a problem. A better understanding of reproduction would help set a more realistic minimum size limit.

Coonstripe Shrimp

Information on biological parameters of coonstripe shrimp off California is limited. A precautionary approach to management should be employed until more is known about the impacts of commercial harvest on this resource. Given this lack of knowledge, the following management measures should be considered:

1. Restrictions on access.
2. Limit the number of traps used by each fisherman.
3. A season closure from November through April, during the predominant egg-bearing period.
4. A mandatory logbook.
5. Development of a fishery dependent and independent monitoring program to gather data on life history and population characteristics.
6. Since sport harvest of this resource may increase in the future, the issue of equitable allocation should be seriously considered.

Coastal Cutthroat Trout

Sportfishing regulations in many waters have been changed to catch-and-release, enabling sport fishing to continue, at reduced harvest levels.

1. Catch and release regulations should be continued.
2. Data on abundance and distribution of coastal cutthroat trout should be collected in the context of habitat conditions so that the relationship between the fish and ecological processes can be understood.
3. Programs should implement conservation measures and restoration of habitat to permit dispersal among populations and different strains of coastal cutthroat.

Dolphin

Continue to monitor the commercial and sport fisheries for catch and effort data. Work with the Pacific Fishery Management Council to implement the Highly Migratory Species Fishery Management Plan, which includes dolphin.

Eel Grass

1. Carry out and maintain a comprehensive eelgrass inventory for the state.
2. Revise the Southern California Eelgrass Mitigation Policy or develop and implement a new statewide eelgrass disturbance, avoidance, and mitigation policy that recognizes eelgrass as a vital living marine resource whose presence is critical in nearshore food web.
3. Evaluate the potential impacts of anticipated sea level rise and coastal erosion on remnant and re-established eelgrass bed communities. Because the natural, often gently sloping shorelines around many of California's bays have been replaced by revetments, a study of the potential loss of eelgrass habitat due to the lack of intertidal refuge from increased water depth and reduced light penetration should be undertaken. The results of such a study would then be added to the analyses of potential impacts and preparations for the anticipated rise in sea level.
4. Include maintaining plant stock genetic diversity as an important parameter within mitigation-based eelgrass re-establishment requirements.

Flatfish

The author of the 1992 arrowtooth flounder assessment recommended a conservative management approach, especially until new data and models could estimate absolute biomass and exploitation rates. Management of this species falls under the jurisdiction of the Pacific Fishery Management Council (PFMC). The Pacific halibut fishery is regulated by the International Pacific Halibut Commission, made up of members from the United States and Canada. For the other minor flatfishes, the most recent recommendations of the Groundfish Management Team of the PFMC suggest no change in the coastwide acceptable biological catch.

Because of tighter restrictions on the primary federally-managed groundfish species (notably members of the *Sebastes* complex and lingcod), it is reasonable to assume that more fishing effort may be placed on other species of fish in the immediate future as fishermen seek alternate fisheries, including the minor flatfishes. If so, it is imperative that this group of fish be included in fishery management plan development.

Gaper Clam

Present sport bag limits for locations with large sport clam fisheries seem adequate to protect the gaper clam populations in those areas and also in areas where declines in populations have occurred. Population declines in other areas are most likely not caused by over-harvest since there remains a subtidal portion of the population that acts as a spawning reserve. There are a number of reasons for reduced clammer success in formerly productive bay and estuarine areas, including decreased tidal flushing and increased sedimentation reducing gaper clam habitat; increased foraging on gaper clams within the range of southern sea otters; and environmental effects, both long-term and those associated with shorter-term El Niño events. Poor clammer success and take of small-sized clams tend to limit effort in areas where this occurs and should preclude the necessity of having a large number of differing bag limits for gaper clams throughout the state.

Geoduck Clam

The present sport bag limit is adequate to protect the resource from overharvest. In areas where foraging by sea otters has reduced populations, the extremely low sport take presents no threat to the populations, since reduced clam density usually leads to reduced clammer effort.

Giant Kelp

For the purpose of management, the kelp beds off California represent more than just a single species of interest. They represent an important nearshore ecosystem. Giant kelp forests provide essential habitat for a diverse assemblage of marine fishes and invertebrates and their loss would reduce the populations of many marine species. Kelp forests are also important to sport and commercial fishermen, kelp harvesters, recreational divers, photographers, and sightseers, and for their general aesthetic value. During the latter half of the 20th century, throughout California and in southern California in particular, kelp forests have been subjected to increasing environmental stresses. Some are natural, such as the warm water El Niños. Other stresses are clearly the result of human activity. These include sources of pollution and sedimentation resulting from coastal development and the increasing influences of human population growth. While the causes of decline are complex and are masked by seasonal fluctuations, there is general agreement that there is much less kelp along the southern California coast than there was when we first began conducting surveys, shortly after the turn of the century.

At least three areas of management offer some hope for reversing this trend of decline:

1. Reduce harvest rates of urchin predators. These include California sheephead and spiny lobster. The Southern sea otter may eventually return to southern California areas which would result in less dense populations of urchins.
2. Coastwide kelp photographic flights should be increased. The causes for the apparent declines in kelp beds, particularly in southern California cannot be thoroughly analyzed or understood without a better time series of data. Once gathered, the data should be incorporated into a statewide Geographic Information System (GIS). A similar database should be gathered on coastal development. Once established the GIS should be frequently reviewed for evidence of kelp bed damage tied to onshore activities.
3. Provide additional substrate (constructed reefs) over widespread areas for establishment of new kelp beds. These may also serve as spore sources for re-establishment of former natural kelp communities.

Giant Sea Bass

Although there has been recent interest in re-opening the recreational giant sea bass fishery, this does not seem prudent at this time given the lack of data and new evidence that suggest high body burdens of DDE and PCB in California giant sea bass. Research projects underway at this time are collecting detailed information on the movement, habitat use and behavior of this species. In a few years, we may have enough data to make informed management decisions regarding giant sea bass. Current management measures should remain in place.

Gracilaria

Baseline data on the extent and density for *Gracilaria* and *Gracilariopsis* in areas favorable for its growth are lacking. Little is known about its ability to capture and recycle nutrients, its invertebrate associates, and its value as a food source for macrofauna, especially the various avian species that over-winter in California's bays and estuaries. The California Fish and Game Code gives the commission authority to make regulations to insure the proper harvesting of kelp or other aquatic plants. If the worldwide market for *Gracilaria* and *Gracilariopsis* increases, the pressure on the commission to open up more of California's nearshore waters to wild stock harvesting of these and other agar-bearing marine plants will likely increase. However, until essential information is obtained on the role these seaweeds play in the ecology of California's

bays and estuaries, a proactive management recommendation would continue to prohibit harvest of wild stocks of *Gracilaria* and *Gracilariopsis* species at this time.

Grunion

Proactive investigations to enhance knowledge of this species for future management should include estimates of relative abundance of spawning fish and human take along the sandy beaches of the Southern California Bight. This would reveal trends in abundance, distribution, beach preference, and fishing mortality. On-site observations at several locations, over several nights of each run, could add quantitative data on abundance and human take. This information would be valuable for resource damage assessment in the event of widespread petroleum spills during the spawning season.

The only current aspect of grunion management that should be a candidate for revision is the lack of a bag limit. The case for establishing a bag limit is not based on current harvest rates but on the potential impact of a constantly growing human population in California. A nominal bag limit of, perhaps, 50 fish would not restrict current legitimate recreational harvesting but could serve to prevent over harvest if grunion gathering became more popular. A bag limit also is valuable to insure that fish caught under the authority of a sport fishing license are not being harvested in large quantities for illegal sale.

Jack Mackerel

The jack mackerel population can probably continue to support the current level of fishing exploitation, but it is difficult to predict the effects of increased exploitation, due to the limited knowledge of the composition and behavior of the older segment of the population and to the limited knowledge of reproduction and recruitment in jack mackerel. Under the CPS FMP, jack mackerel are a monitored species unless landings exceed the ABC for two years. Should jack mackerel become actively managed, it will be important to know the contribution of older fish to the population and fishery.

Kelp Bass

It may be time to explore new conservation measures such as increasing the size limit, imposing minimum and maximum size limits (slot fishing), and/or promoting catch-and-release fishing.

Louvar

Biological requirements and worldwide distribution limit the ability of local fisheries to severely impact the louvar population. If a breeding or subpopulation is determined to exist off the California coast, a level of awareness through proactive management could be utilized to prevent over fishing and maintain optimum yield.

Monkeyface Prickleback

Due to the relative low utilization of monkeyface prickleback, specific management recommendations are not considered at this time. However, in view of the unique and limited habitat which this species occupies, a reduction in number (from the existing 10-fish recreational bag limit) and a minimum legal size (such as 14 inches) might be appropriate in the future. Most individuals are taken in the intertidal zone or in very shallow water, and the survival rate for those returned to the water would be expected to be high. However, based on their mode of feeding, hooking mortality might be a limiting factor and would preclude a size limitation.

Mussels

Improving and maintaining the water quality of California's coastal and estuarine waters is the most critical management issue affecting the continued survival of the mussel industry. Both sport and commercial utilization of all of the state's shellfish fisheries is impacted by increasing quantities of ocean-bound effluents produced by point and non-point sources in many areas of the state. Community-based education programs beginning in elementary school and emphasizing the linkages between our coastal watersheds, urban and ocean environments, and human health are a positive step in developing an informed public. DFG, the California Sea Grant Extension Program, California Water Quality Control Board, National Marine Sanctuary Programs and several other public and private groups have made progress in this effort, but persistence and determination are needed to slow and reverse the loss of our clean coastal waters.

Opah

Although commercial landings of opah are recorded by the department, opah is not presently a target species and their take is not managed. The impact of California landings on the species as a whole may be minimal, as the population is worldwide in temperate and tropical seas. However, since very little is known about the

opah, it is difficult to determine the impacts of various fisheries worldwide.

Other Nearshore Rockfish

Concerns are increasing due to increasing demand on a limited resource; commercial size limits, commercial permits, and gear limitations have been implemented to address these concerns. Recent changes in federal management of nearshore species have resulted in very low allowable take, increasing the demand and thus the prices. DFG is currently mandated to develop a Nearshore Fishery Management Plan (NFMP), which uses the best available data, provides for significant public involvement in the process, and is peer-reviewed. The NFMP may be adopted by the Commission in January 2002. DFG has developed interim management measures to further protect this emerging fishery. Interim measures included control date for limited entry, reduced bag limits, season closures, gear limitations (rod and reel only), and adjustment of size limits. Increased sampling of landings, education of buyers to use proper market categories, and more fishery-independent sampling to assess stocks adequately are needed to effectively protect these resources.

Pacific Bonito

An assessed decline in bonito abundance coupled with a drastic reduction in the size of the fish harvested commercially, brought about a reduced bag limit and minimum size regulation in 1982. The status of the population has not been re-assessed since then. Also, this species is not covered under any current or proposed federal fishery management plan. Declines in both recreational and commercial landings in the 1990s indicate that this species should be re-assessed and appropriate management actions be taken. Such actions might include the initiation of discussions between the U.S. and Mexican governments on coordinating management of this trans-boundary stock.

Pacific Hake

Since implementation of the Fisheries Conservation and Management Act in the U.S. and the declaration of a 200-mile fishery conservation zone in Canada in the late 1970s, annual quotas have been the primary management tool used to limit the catch of Pacific hake in both zones by foreign and domestic fisheries. The scientists from both countries have collaborated through the Technical Subcommittee of the U.S.-Canada Groundfish Committee, and there has been informal agreement on the adoption

of an annual fishing policy. However, overall management performance has been hampered by a long-standing disagreement between the U.S. and Canada on the division of the acceptable biological catch (ABC) between U.S. and Canadian fisheries. In 1991-1992, U.S. and Canadian managers set quotas that summed to 128 percent of the ABC, while in 1993-1998, the combined quotas were 112 percent of the ABC on average. Under the current management impasse there is a potential for overfishing of Pacific hake.

The current management of hake and the composition of the fishery may be affected by growth of tribal fisheries. At present, only the Makah Tribe of western Washington has initiated a fishery. However, two other Washington tribes have stated an interest in entering the hake fishery and NMFS has established preliminary quotas for these tribes. Other coastal tribes may also qualify for entry into the hake fishery. Non-Indian fishers are challenging allocation of hake to treaty tribes, but definitive court rulings on this matter have not yet been reached.

Hake remains the largest fishery on the West Coast. With the recent declines in salmon and the low abundance of rockfish, fishermen engaged in these fisheries are concerned about the bycatch of these species in the hake fishery. The hake fishery is one of the lowest bycatch fisheries in the U.S., but even the relatively low bycatch of salmon and rockfish is a large portion of the current low quotas for depleted salmon and rockfish. The hake fishery is currently faced with the challenge of developing fishing practices to minimize bycatch to the lowest level possible.

Pacific Herring

In general, the current management strategy used for California's herring fisheries has proven to be effective because it allows the department and commission to integrate new and comprehensive information. This strategy has several key components that have contributed to its effectiveness over the years:

1. Conservative harvest levels. Since the inception of the roe fishery, harvest quotas have been conservative and adjusted annually based on spawning population assessments for Tomales and San Francisco bays.
2. Annual population assessments. Each year, DFG assesses the status of the state's two largest spawning populations (San Francisco Bay and Tomales Bay) by collecting information on spawning biomass, age structure, and other biological data.
3. Limited entry. The expansion of the fishery was carefully controlled and has not increased since 1983.
4. Commission management authority. Unlike other commercial fisheries, which have been regulated by

the legislature, the commission was given management authority for the herring fishery during the roe fishery's second year. This allows the regulations to be changed on an annual basis and new issues to be addressed as they arise.

5. Director's Herring Advisory Committee. This committee was established to seek valuable industry input on fishery-related matters.

The department is striving to incorporate an ecosystem approach to management of its marine resources. The harvest level used for Pacific herring to some extent takes into consideration this species' role in the marine food web and its connection to environmental factors, but these relationships are not well understood. Most aspects of herring biology and ecology are in need of further scientific research to improve existing herring management and further incorporate an ecosystem approach. The Humboldt Bay and Crescent City spawning populations need re-assessment and more frequent assessments in the future to improve harvest levels. Herring spawning habitat requirements need to be better understood so that they can be adequately protected.

One of the weakest aspects of current management is the inability to predict the number of two-year-old herring that will recruit to the spawning population each year because this age group has the largest impact on spawning population size. Research is needed to understand how environmental factors affect herring survival, particularly during early life history stages, so that we may better predict year-class strength.

Stock assessments and quota management will also improve with better understanding of the distribution and abundance of herring in the open ocean, and whether or not spawning populations are genetically distinct from each other.

Pacific Razor Clam

Current estimates for total catch and effort are needed for the Crescent City beaches and especially Clam and Moonstone beaches in the Eureka area. Little is known about the extent and importance of subtidal populations acting as brood stock for intertidal populations; dependence on these alone to repopulate the Eureka area beaches may be unwarranted. Closure of Clam and Moonstone beaches to intertidal take or reduction of the present bag limit may increase the rate of recovery for these fisheries. In other parts of the state, the present sport bag limit appears to be adequate to protect the resource since minimal digger effort is seen for razor clams.

Pismo Clam

Since 1948, DFG has managed the recreational Pismo clam fishery by the use of bag limits, size limits, closed seasons and closed areas. In 1976, an invertebrate reserve (closed to the commercial and recreational take of any invertebrates) was established in the Pismo Beach area to study the separate effects of recreational clamming and sea otter foraging on the Pismo clam population. In 1979, sea otters were first observed foraging on Pismo clams. By 1982, beach surveys found few clams either inside or outside of the invertebrate reserve.

1. There is no further need for the closed seasons or the five-inch size limit in San Mateo, Santa Cruz or Monterey counties since there is no recreational clamming.
2. It is suggested that a 4.5-inch statewide size limit be adopted to simplify regulations.
3. There is no further need for the invertebrate reserve established in California Code of Regulations or the various Pismo clam closed areas (known as clam preserves) because long term management of a recreational fishery in these areas is not likely to be needed.

Purple Sea Urchin

There are several gaps in basic knowledge concerning purple sea urchins. Although there are scattered studies of growth and survival in the literature, data have not been gathered together and synthesized in a manner suitable for setting harvest size limits. Studies of early growth and survival up to an age of one year are few and are needed to link settlement information with recruitment to the reproductive population. Linking sources of larvae with sites of settlement has not been done and is crucial to developing management plans that involve marine reserves. Because of ocean current patterns, not every region of coastline can be considered to be a suitable source of larvae for all marine species. Both fishery-dependent and -independent monitoring should continue in order to assess changes in stock condition. Fishery dependent monitoring of commercial landing levels and patterns should detect any trend toward large-scale harvests that might require more specific management measures. At present, the most comprehensive fishery independent data consists of the long-term monitoring of settlement patterns in northern and southern California. Continuing this monitoring should provide a measure of settlement supply, and an early warning of possible adverse effects of harvesting on recruitment.

Red Rock Shrimp

Information on the size and condition of the red rock shrimp population in California is mostly anecdotal. For this reason, the resource should be managed cautiously until its status is better understood. Fortunately, fishing pressure has historically been light, with only a few fishermen involved, mostly along rock jetties and breakwaters. In addition, these shrimp may have a low susceptibility to trapping. Large numbers of shrimp have been observed outside of traps while few, if any, were inside. In 1975, a small number of experimental traps were set in deeper water (20 to 70 feet) at locations including reefs and rocky shorelines. Red rock shrimp were known to be present at these locations, based on diver observation, but for unknown reasons, no shrimp entered the traps. Traps have also been observed with many shrimp climbing on the outside, but none entering the trap. These characteristics make it unlikely that the shrimp could be widely, or excessively, harvested with current gear. Regardless, it would be advisable to take the following precautions in managing this fishery:

1. Apply a closure during the egg-rearing period, most likely from May through July.
2. Regulate the size of openings in traps to allow small shrimp (< one inch) to escape.
3. Collect data from fishermen including bycatch and occurrence of females carrying eggs.

Red Sea Urchin

The red sea urchin fishery is fully exploited in California, and evidence from a variety of sources points to an overfished condition in northern and portions of southern California. Management measures developed and implemented collaboratively with the industry (minimum size limits, restricted access, temporal closures) have not been effective in reversing long-term declines in harvestable stocks. The following management-related actions may be needed to reverse this condition:

1. Expand existing fishery-dependent and -independent monitoring programs. Logbook data needs to be collected at a higher spatial resolution using GPS technology. Fishery-independent needs to be expanded to allow managers to assess density and size distributions. Fishery-dependent monitoring will detect trends in harvest, but is confounded by harvest levels, which are strongly affected by quality of urchin gonads and market conditions. Fishery-independent monitoring will allow managers to assess abundance of size classes and poor quality urchins not sampled within the fishery. Continuation and expansion

sion of long-term monitoring of settlement patterns is crucial to providing a relative measure of settlement supply and should be continued and expanded. Re-establishment of an industry-based revenue system would assist in funding these programs.

2. Develop a science-based red sea urchin fishery management plan for the Fish and Game Commission.
3. Conduct a capacity goal analysis. Consider reducing the permit goal to below the present level of 300 divers and explore methods for accelerating the attrition rate.
4. Continue to examine and consider the use of spatial management techniques (*i.e.*, marine protected areas, rotating harvest zones) in urchin management.
5. Expand collaborative monitoring and research with industry participation.

The following management measures could be implemented on an interim basis before a fishery management plan is in place:

1. Establish and monitor a maximum size limit to accelerate recovery of fished areas. A maximum size limit would be expected to protect animals with the greatest spawning potential and enhance the survival of juvenile urchins under the spine canopy.
2. Establish regional management zones for northern and southern California.
3. Establish annual harvest quotas based on the five-year average annual catch. This measure could ensure that a sudden increase in demand, as occurred in the mid-1980s, does not drive stock levels below their ability to recover.

Ridgeback Prawn

Recommendations for the management of ridgeback prawns closely follow that of spot prawns. Current regulations need to be evaluated for effectiveness. As mentioned above, no population estimates are available for ridgeback prawns in California; periodic assessments are necessary to determine whether the resource is robust and able to support a continuing fishery.

Rock Crabs

The rock crab fishery is currently one of the few remaining significant nearshore fisheries not subject to some form of restricted access limitation. Present open access and relatively low capital requirements for entry could result in large increases in effort for rock crabs as fishermen

seek opportunities to diversify their fishing activities. The multi-species nature of the rock crab fishery also presents a number of challenges to implementing biologically meaningful management measures. Future management activities, which should be considered to help insure the future health of this resource and fishery include:

1. Establish a system for obtaining periodic fishery-independent data on rock crab abundance, species and size composition, recruitment patterns, and bycatch characteristics.
2. Begin to monitor the commercial fishery for species and size composition, geographic and temporal patterns in catch and effort, and bycatch characteristics.
3. Investigate the need to establish a restricted access program for this fishery.
4. Explore gear modifications to reduce bycatch.

Rock Scallop

The rock scallop is a valuable marine resource to the sport diver as well as a highly promising candidate for extensive cultivation in the sea by new methods of aquaculture. There will be an increasing demand for hatcheries to provide seed stock for population enhancement and for the developing aquaculture industry.

Salmon

The major threat to California's salmon resource is further degradation and elimination of its freshwater and estuarine habitats. Restoration of inland spawning and rearing habitats and renegotiation of inland water management policies, particularly in the Central Valley, must be pursued if salmon production levels from naturally spawning areas are ever to return to their former levels. Prudent regulation of the fisheries will be required to equitably distribute the available fish between the various ocean and in-river users and to meet spawning escapement needs. To these ends, the California Department of Fish and Game should:

1. Continue its efforts to improve, restore, and enhance freshwater and estuarine habitats for salmon, focusing on:
 - a. Screening of water diversions
 - b. Abatement of pollution sources, chemical and thermal
 - c. Reductions in siltation and gravel compaction levels
 - d. Elimination of gravel removal operations in important spawning and rearing areas

- e. Reduction of vegetation encroachment into major spawning areas
 - f. Maintenance of suitable stream flows and temperatures
 - g. Control of diseases, particularly bacterial kidney disease in hatcheries.
2. Support studies to differentiate races of salmon, particularly in the Central Valley, where winter chinook and spring chinook are severely depressed.
 3. Develop and implement plans addressing habitat and fishery management to reverse the status of depleted salmon stocks, winter-run and spring-run in particular.
 4. Investigate the feasibility of constructing a salmon (and steelhead) hatchery within the San Joaquin basin to produce study fish needed to evaluate delta water management strategies.
 5. Continue to work with the Klamath Fishery Management Council in negotiating harvest sharing agreements between ocean and river user groups, developing methods of adjusting fisheries on an a real time basis, and refining stock projection and fishery models.
 6. Support studies to compare hooking mortality rates following release for sublegal and out-of-season salmon caught by trolling and mooching.
 7. Operate hatcheries and rearing facilities and conduct fish stocking practices responsibly to minimize effects on natural production.

Sand Crab

Not all beaches are suitable for sand crab survival through the winter and must be colonized annually. For this reason, regulation of the fishery should focus on smaller management areas such as the Santa Monica Bay in southern California, where most of the historic catch has been taken.

Scorpionfish

Because there has been no assessment of California scorpionfish numbers, it may be prudent to set conservative quotas on both the recreational and commercial catches, in order to forestall the collapses seen in many other California fisheries.

Sea Cucumber

The dive and trawl fisheries target different species. In order to manage these fisheries, it is important to know the quantities of each species taken. Presently, both the dive and trawl landings of sea cucumber are lumped on commercial landing receipts under a single code for "sea cucumbers, unspecified." It is recommended that:

1. Individual species codes be assigned to both the California and warty sea cucumber. The logbook data also should be coded to species. This is especially important for dive logbooks, because it is possible for divers to target either species depending on where in the state they are fishing.
2. Limited entry regulations for the two fisheries be maintained.
3. Effort is needed to collect the field data necessary to perform stock assessments and generate biomass estimates for both the warty and California sea cucumber. The biological, catch, effort and catch per unit effort parameters derived from logbook data would be used to model the impact of different levels of fishing intensity.
4. Fishery-independent, as well as the fishery-dependent, information is needed to properly manage this fishery. Video surveys of fished areas, to compare with unfished areas, should be conducted.
5. Closed areas may need to be established to serve as controls in order to evaluate the impact of harvests on abundance in open areas.
6. Finally, if the limited entry restrictions do not adequately limit the take of sea cucumbers to sustainable levels, additional management options, such as individual or area quotas, may need to be considered.

Sheep Crab

The sheep crab fishery is presently unregulated. Additional biological information, including a better understanding of physiological and behavioral reproduction, is needed for the development of sound management policies. Nevertheless, limited recommendations can be made based on certain biological characteristics of the sheep crab.

1. The sheep crab undergoes a terminal molt upon reaching adulthood. Thus, the adult claws will not regenerate once removed indicating the claw fishery utilizes a non-renewable resource.
2. The terminal molt, as well as other characteristics, also has implications for management of the live, whole body fishery. For example, size limits would

likely need to include both an upper and lower limit, leaving the largest and smallest crabs to mate so as to maintain recruitment and intermediate sizes, as well as to protect large juvenile males which overlap in size with the adults.

3. Protection of seasonal spawning aggregations may need to be incorporated into a management plan for this species.
4. Use of abrasion stages may also provide a good tool for management. However, duration of the various abrasion stages and their association with gonadal development and reproductive success needs to be determined before considering this management strategy.

Shortfin Mako

The shortfin mako's uncertain status calls for increased investment in fishery-dependent and -independent research. Population assessments are needed, which require more research on fishing mortality, demographics, stock structure, and abundance. The state might consider reinstatement of its volunteer pelagic shark-tagging program. This program has provided information on the migration paths, biology, and ecology of mako sharks. Satellite pop-up tags may also prove useful in determining the distribution and biology of adult mako sharks.

Silversides

The only current aspect of topsmelt and jacksmelt management that might be a candidate for revision is the lack of a bag limit. The case for establishing a bag limit is not based on current harvest rates, but on the potential impact of a constantly growing human population in California. A nominal bag limit of, perhaps, 30 topsmelt (which are commonly used for game fish bait), including jacksmelt in a general provision such as "20 fish, no more than 10 of any one species," would not restrict current legitimate recreational harvesting but would serve to prevent over-harvest if fishing for these species became more popular. A bag limit also is valuable to insure that fish caught under the authority of a sport fishing license are not being harvested in large quantities for illegal sale.

Skates and Rays

The continued removal of large numbers of skates and rays without additional management would be ill advised. More data are needed to produce an effective management plan for the species involved. The information needed includes:

1. Landing data on size, sex, and species composition of the sport and commercial catch.
2. Survival rates for released catch.
3. Life history parameters for many of the species involved.
4. Population dynamics including species movements. All of this information will help determine if increased landings of previously discarded catch are altering the impact to the species involved.
5. With skate landings increasing in California, Oregon, and Washington, it would be advisable to coordinate management among the three states.

Skipjack Tuna

Since skipjack tuna in the Pacific are considered underfished, management is not being considered. However, because skipjack tuna in the eastern Pacific are caught with yellowfin tuna, many of the recommended management measures applied to yellowfin tuna may impact skipjack tuna. Some of these include reduction of effort levels and reducing fishing on schools associated with drifting objects to minimize bycatch and the catches of small tunas.

Spiny Lobster

The limited entry program has had some beneficial results. An active fishermen's organization, the California Lobster and Trap Fishermen's Association, worked with the department to develop the current management program. In addition to formalizing a trap retrieval program for traps washed into the surf or onto the beach, the trappers regularly participate in the commission process to resolve industry problems or improve the current regulations.

The current logbook system needs to be maintained, and a program needs to be initiated to determine the recreational take of spiny lobster. A formal review of the current limited access program should be scheduled to address issues such as permit transferability until a fishery management plan is produced.

Spot Prawn

The spot prawn fishery has undergone significant growth in the last 10 years in terms of the total pounds landed, numbers of participants and vessels. This pressure is not likely to ease given the worldwide demand for shrimp and prawn as well as the displacement of fishermen from other fisheries such as the groundfish fishery along the Pacific Coast and from the spot prawn fishery in Washington. Given these issues, the following management measures should be considered:

1. Limited entry for both the trap and trawl fleet.
2. Development of a coastwide spot prawn geographic information system (GIS) database, which would identify historic and current fishing areas as well as preferred habitats.
3. Coastwide fisheries-independent population survey of the spot prawn resource.
4. Evaluation of the effectiveness of the current management scheme.
5. Evaluation and establishment of a minimum and/or maximum roller gear size-limit.

Spotfin Croaker

1. Maintain the current sport fish regulations and the ban on commercial take of spotfin croaker.
2. Protect and enhance available bay and nearshore habitats.
3. Collect more complete data on age, growth and maturity.
4. Ascertain size and age structure of populations.

Spotted Sand Bass

Since they are not specifically targeted as a food fish and are mostly caught by recreational anglers adopting a catch and release policy might prove beneficial to this species.

Steelhead

Steelhead are rarely caught in the ocean and state laws and regulations require they be released. The management challenges for this species are almost exclusively in inland waters. In 1996, the Steelhead Restoration and Management Plan for California was published which identified the goals and objectives for management and research needs. The primary management focus for the department recovery of imperiled populations is through the restoration of freshwater habitat, particularly restora-

tion of access to historical habitats that are still suitable but blocked by dams.

In 1999, the department implemented the north coast steelhead research and monitoring project to obtain information on status and life history of north coast steelhead stocks. A similar effort is needed for the Central Valley and south coast. More steelhead focused research and monitoring is needed to provide the necessary information to facilitate the recovery these stocks.

Striped Marlin

All Pacific billfish resources will soon be covered under new international conventions and a federal management plan for highly migratory species is currently being drafted for the Pacific Fishery Management Council. These management groups provide a great opportunity for effective long-term management and conservation of striped marlin and other highly migratory species. However, stock assessments for striped marlin are badly out of date and in need of re-examination. New assessments should include current fishery statistics, a clear definition of geographical limits, better understanding of age, growth and reproductive status, better indices of abundance and evaluation of the effectiveness of catch and release in the recreational fisheries.

Swordfish

Current assessments are based on old, incomplete and sometimes inaccurate data. New assessments using updated and standardized fishery statistics are necessary to determine stock condition and to validate existing levels for MSY. International and domestic conventions are currently being developed to improve reporting of fishery statistics from all fishing nations. These international management authorities need to establish comprehensive assessments to ensure precautionary exploitation, allocation, and conservation of the Pacific swordfish resource.

Smelts

Delta Smelt

Since the delta smelt was listed as a threatened species, modifications to provide better habitat conditions as well as restrictions on the timing and amounts of diversions from the estuary have been instituted. Large-scale habitat restoration projects to improve spawning and rearing habitat have also been planned. Monitoring of the population as well as research designed to determine mechanisms affecting abundance are needed to evaluate the success or failure of these modifications.

Eulachon

The eulachon populations in California need investigation in order to evaluate the status of these populations. It is unknown whether a fishery for this fascinating fish can be restored.

Longfin Smelt

Abundance trends of longfin smelt should be closely monitored since freshwater outflows out of San Francisco Bay estuary are highly regulated and other coastal estuaries are highly modified.

Night Smelt

The fishery for night smelt appears to be stable or increasing; however the fishery is in fact poorly regulated and monitored. Fisheries independent sampling, as suggested earlier, can verify whether apparent increases in fishing effort are over-exploiting the resource. An evaluation of the recreational impacts on spawning beaches should be done.

Surf Smelt

The apparent shift from surf smelt to night smelt as the most common smelt in the commercial fishery may reflect changes in effort or methods; however, the fishery should be monitored much more closely. Fisheries-independent sampling would also verify changes in abundance irrespective of changes in fishing effort. Any additional information, especially on life stages where little or no information is known, would greatly add to our understanding of surf smelt biology.

Wakasagi

Additional research is recommended in order to monitor the potential expansion of wakasagi distribution. The impacts of wakasagi expanding its range into southern California are unknown.

Whitebait Smelt

Since very little is known about the life history of this species, any research or information would add greatly to our understanding. Smelt catches should be constantly examined for the presence of this species.

Washington Clam

The greatest take of Washington clams occurs in Humboldt Bay and with the present level of effort unlikely to increase greatly. The current combination of Washington and gaper clam bag limits appears to be adequate. The present sport bag limits for the rest of the state also appear to be adequate at this time to protect Washington and butter clams from over-harvest.

Wavy Turban Snails

Further development of the fishery should follow procedures for emerging fisheries under the Marine Life Management Act. Thus, the department should identify and monitor new emerging fisheries and notify the commission of such fisheries. The commission can then adopt regulations that limit taking in the fishery until a fishery management plan is adopted and/or direct the department to prepare a fishery management plan for the fishery and regulations necessary to implement the plan.

Recommended interim regulations, based on current best scientific knowledge and slow growth rates, include:

1. A minimum legal size of four inches in shell diameter.
2. A fall and winter fishing season.
3. A temporary cap on the number of fishery participants.
4. Closed areas for study where snails can not be fished.

These interim regulations could be implemented while the department is developing and evaluating a fishery management plan and conducting population monitoring.

White Croaker

There are currently no limitations on catches of white croaker off California, with the exception of a small no-take zone off Palos Verdes. Future management considerations should include continual monitoring of the population size and the status of contaminant levels in areas of concern.

Yellowfin Tuna

The current IATTC management objective for yellowfin tuna in the eastern Pacific is to maintain the stock at levels capable of producing the average MSY. To attain this objective, the IATTC continues to recommend an annual catch quota. Future management issues for yellowfin tuna in the eastern Pacific will also include capacity reductions to maintain or reduce effort levels and reduced fishing on drifting objects to minimize the catches of small tunas and bycatch.

Yellowfin croaker

1. Retain current status as a recreational resource only and existing bag limit of 10 fish.
2. Collect basic life history information such as age and growth, size at first maturity, and fecundity.

Yellowtail

Given the current status of the yellowtail population, and recent enactment of a minimum size limit for sport caught fish, no further management measures are needed to protect the stock.