Chapter 4. Research to Support the Nearshore Fishery Management Plan

At the core of the Marine Life Management Act (MLMA) is the principle of basing decisions on the best available scientific information as well as other information that the Department and Commission possess [Fish and Game Code (FGC) §7050(b)6]. With this in mind, the MLMA includes, as a general objective, promotion of marine ecosystem research that will enable better management decisions [FGC §7050(b)5].

Within this general policy on science and marine living resources, the MLMA establishes more specific policies for the management of marine fisheries. Generally, fishery management decisions are to be based on the best available scientific and other relevant information, including what the MLMA calls Essential Fishery Information (EFI). The MLMA defines essential information as:

> "Essential fishery information," 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 to taking in the fishery that is necessary to permit fisheries to be managed according to the requirements of this code."

The MLMA calls upon the Department to collect EFI for all marine fisheries managed by the State in cooperation with participants in the fishery [FGC §7060(a and b)].

To foster improvements in the management of individual fisheries, the MLMA requires that fishery management plans include a research protocol that identifies critical information gaps and the steps that will be taken to close those gaps [7081]. This protocol is to describe the following:

- past and current monitoring of the fishery
- EFI, such as age structure of a population and spawning season, and other relevant information
- plans for additional monitoring and research needed to acquire EFI

In these ways, the MLMA provides an opportunity for fishermen, scientists, fishery managers, conservationists, and others to develop a model system for obtaining the information needed to manage our marine life resources. Many opportunities exist for the Department to better organize and exploit its own research, and to partner with other agencies, academic institutions, and the public to conduct investigations needed to support management decisions.

This chapter describes a research plan designed to implement the MLMA goals and objectives for the California nearshore fishery. The monitoring and assessment system outlined here, in addition to meeting the needs of nearshore fishery management, will provide necessary ecosystem information for the Department's other nearshore management responsibilities, such as for sea urchins, abalone, and kelp. More specifically, this plan is designed to develop information that will move

management through the three stages described in the Fishery Control Rule in Chapter 3 of the NFMP.

Relevance of Essential Fishery Information to Management Tools

The MLMA's requirement for collecting EFI has a practical value in evaluating and applying management tools to achieve the objectives of the NFMP. Brief descriptions of the application of EFI to specific management tools follow:

Sustainable Fishery Control Rules

Fishery control rules determine targets for take and other key management measures appropriate to the fishery. Information on stock size, reproductive potential and productivity, and age composition, as well as other biological, social, and economic parameters, is necessary to directly and accurately calculate allowable fishing mortality. The 19 species included in the NFMP are in a data-poor situation. Key EFI is not available for these species, with the exception of California sheephead and cabezon. These gaps make setting fishery control rules difficult. The NFMP Project management strategy requires significant increases in monitoring and assessment to acquire three critical EFI categories for each species:

- spatial and temporal estimates of abundance
- accurate accounts of total mortality (including information of species and location)
- age and growth information on a species-by-species basis

depletion - exploitation of a resource to unsustainable levels. *Serial depletion* is the progressive exploitation of a resource in discrete areas that eventually results in depletion throughout a region. This area-specific depletion often goes undetected as region-wide catch levels remain stable because fishing effort is continually re-focused on new, productive areas (or species) after old areas (or species) have been fished out. This occurs most frequently with species that are residential and/or long-lived (such as rockfish, giant sea bass, and abalone) since movement of individuals is unlikely and recovery time of stocks is lengthy.

larval transport - movement of larvae along or away from the coastline. This movement is usually directed by ocean

Regional Management

A regional management area is a geographic region within which regulations are uniform where practical. Area management may be based on many different factors such as biological, social and economic information, and regulatory mandates. Management regions rely on EFI categories such as the distribution of stocks and movement patterns and require fisheries information from discrete areas along the coast. In general, the 19 NFMP species appear to be residential, and the traditional statewide management and management measures for multiple species may allow **depletion** of stocks. Quantifying and adequately responding to this situation may require learning how much recruitment to the fishery is accounted for by long-range, pre-settlement **larval transport**, and what the home ranges are.

Marine Protected Areas

Marine Protected Areas (MPAs) are "discrete geographic marine or estuarine areas" [FGC §2852(3)(c)] that are set aside to protect or conserve marine life. Their benefits include basic levels of ecosystem conservation, full protection for some part of target and bycatch populations, and buffering against the inherent uncertainty in marine fisheries management. One objective of MPAs for fisheries management is achieved when "reserves are large enough to export sufficient larvae and adults, and small enough to minimize the initial economic impact to fisheries" (Marine Resource Working Group Science Advisory Panel 2001). To achieve this, it is crucial to obtain information on reproduction, larval transport, recruitment, and the effects of periodic fluctuations in oceanographic conditions. Research methods will need to be developed to assess the effectiveness of MPAs on enhancing stocks and protecting habitats. MPAs can also serve as reference areas in a study design to assess the impacts of fishing, or the efficacy of management (Appendix K).

Restricted Access

Restricted access refers to setting upper limits on the number of participants in a fishery and otherwise limiting fishing effort. Information such as ex-vessel product prices, vessel operating costs, consumer product prices, historical participation in the fishery, and landings are all essential to developing a restricted access program. Biological EFI, such as abundance estimates, are then applied to set fishery control rules for the vessels included in the fishery.

Size Limits

Size limits establish allowable sizes of catch that can be retained for each species, and are used to prevent the capture, and/or retention of small and/or large fish. Small fish are often immature and have not reached their full reproductive capacity, and large fish often have a higher reproductive output than smaller fish, and are therefore, valuable to the population. Information on reproductive characteristics for a species including location-specific information is important for applying size limits to a fishery. It is also important to establish the ability of a species to survive capture and release.

Gear Restrictions

By increasing or decreasing the size and amount of gear used, it is possible to increase or decrease the size of the fish retained as well as the fishing power (i.e., the efficiency of catching fish). Information on the efficiency of gear types and bycatch mortality is necessary in order to evaluate gear restrictions.

Bag Limits

Bag limits are restrictions on the number of a species that an individual can retain. The intended effect of bag limits is to restrict the overall catch. Information gained by estimates of abundance and catch-per-unit-of-effort can improve managers' ability to use bag limits to control effort.

Time and Area Closures

The prohibition of fishing in certain areas or during certain times is used to reduce overall fishing effort, to protect vulnerable populations, and for other purposes. Evaluating the proposed use of these tools benefits from such EFI as distribution of stocks, age and growth, and movement patterns.

Past and Current Fishery-Dependent Monitoring

The Department has conducted various programs for collecting information from commercial and from recreational fisheries. The flow of EFI through the management process is shown in Figure 1.4-1.

Fishery-dependent data are collected directly from the fishery, such as sampling catch at landing sites and information from commercial landing receipts and logbooks. Fishery-dependent monitoring can provide information on the number of participants in the fishery; types of gear used; the kinds, sizes, and amounts of fish landed at each port; the value of the fishery; recruitment of young into the fishery; age composition; fishing mortality; and catch-per-unit-effort (CPUE). Fishery-dependent data collection efforts are often long-term, and are usually less costly to conduct since the fishery is used as a means to obtain information. Monitoring fisheries in this way provides EFI on fishing mortality, distribution of stocks, and some life history characteristics.

This kind of information has its limits, however. For instance, fishery-dependent data provide information only on certain life stages of those species that are taken by specific fishing gear. Fishery-dependent data also provide limited information about ecosystem interactions. In addition, the accuracy and reliability of fishery-dependent data can vary for a variety of reasons, including misidentification of species, under-reporting, or misreporting.

market categories - general groupings of fish that are not species-specific. One or many species may be landed and weighed as a group and recorded in a general category. Price per pound of fish often determines what species are included in a market category.

Commercial Monitoring

The Department has compiled commercial landing records since 1916. The principal source of this information has been landing receipts, or "fish tickets," which provide information on the total weight landed by species or **market categories**, price per pound, and the condition of the catch. Fish buyers must complete these landing receipts at the time of delivery from a fishermen and must submit them to the Department on a semi-monthly basis. However, a single receipt may not represent a fisherman's entire daily catch, and a single day's catch can be sold to two or more buyers resulting in several landing receipts.

In many cases, at their discretion, buyers may sort fish into market categories, which often include several different species. Commonly, buyers group fish by price per pound or other criteria rather than by species. Before 1994, nearly all nearshore rockfish market categories were not listed on these landing receipts. Listing a market category on the landing receipt tends to increase the amount of fish reported to that category. In 1994, some of the nearshore rockfish market categories plus two new categories, the quillback rockfish and group black/blue, were added to the landing receipts.

Before 1977, this basic information was enhanced for some ports through on-site monitoring and sampling of landings for such biological data as species composition, length frequency, and age composition. Then, in 1977, in cooperation with the National Marine Fisheries Service (NMFS), the California Cooperative Rockfish Survey (CCRS) was established to extend monitoring of commercial rockfish landings to major ports coast-wide. In 1992, with facilitation from the Pacific States Marine Fisheries Commission (PSMFC), the CCRS was developed into the California Cooperative

Groundfish Survey (CCGS). In 1997, it became the California Cooperative Survey (CCS). The focus of this sampling program was the groundfish trawl fleet, not the hook-and-line nearshore fishery (Sampson and Crone 1997). In ports where there were few trawl landings, some nearshore landings were incidentally sampled.

As the nearshore commercial finfish fishery began to expand in the late 1980s and early 1990s, the Department started to monitor the nearshore finfish catches, beginning in 1991 in San Diego and Los Angeles. In 1993, the Department began coordinating its sampling from Morro Bay to Eureka with the CCGS, using a modified groundfish sampling protocol. In some areas, particularly those north of Bodega Bay, this monitoring started only after the fishery expanded into those areas. In 2000, the Department ended its participation in this program and CCS samplers were given the sole responsibility of sampling the nearshore fishery.

Nearshore sampling information is used to assess regional and state-wide changes in species composition and size composition of the catch. Landings are sampled by market category, which may include more than one species. Samplers collect biological information including weight of each market category sampled, number and weight of each species in the sample, and fork lengths, as well as general information such as boat name and number, landing date, port, gear, and catch location. For the nearshore fishery, it is necessary for samplers to obtain samples as fish are unloaded from their respective vessels because many buyers keep the landings of several vessels in one large tank of live fish.

In addition to the above sampling program, Department staff conducted an onboard observation program of gill and trammel nets in the 1980s. Also, in a program started in 1997, landings by central California commercial skiff fishermen who fished near an ecological reserve along the Big Sur coast, were monitored at sites where they launched their skiffs. Additionally, in 1999, a bycatch study was conducted on trap boats and shrimp and spot prawn trawlers.

Effort information is also available from logbooks that are submitted to the Department by commercial fishermen who use gill and trammel nets, traps, and trawl gear.

Shortcomings in Current Commercial Fishery-Dependent Monitoring

The Department's effort to collect fishery-dependent information is hampered by several factors:

- lack of coordination: There is no designated nearshore fisheries coordinator who would ensure that uniform and consistent methods are used in sampling the catch of nearshore finfish.
- staff turnover: Low pay, the high cost of living in some port areas, and the need for extensive training in species identification contribute to high turnover of port samplers. In addition, port sampler positions often are seasonal.
- market categories: Species-specific reporting of landings of nearshore fishes is hampered in several ways. First, buyers are responsible for recording their purchases from fishermen in one of several market categories on landing receipts. Second, market categories, even species-specific categories, can

contain a number of different species of fish because buyers typically sort the fish by price or other criteria rather than type of fish. Also, until relatively recently, the landing receipts listed general rockfish market categories such as "group, red" or "group, unspecified rockfish."

Landing Information from the Commercial Fishery

Between 1929 and 1986, the Department summarized its records of commercial landings in issues of the Fish Bulletin. Landing statistics have not been included in the Fish Bulletin since 1990, but they have been summarized and distributed annually. For the most part, nearshore finfishes were not reported by species. A brief summary of the available information, by species, follows:

California sheephead: California sheephead is the only nearshore species whose records date back to the first Fish Bulletin reporting on commercial catch.

California scorpionfish: This species and the unrelated cabezon were combined under the name Sculpin in reports for 1926-1928. For the 1929 report, sculpin represented only California scorpionfish, and cabezon was not listed. After 1930, the two species were reported separately, although scorpionfish may also have been reported under the category "rockfish" (see below).

Cabezon: Cabezon, the largest of the true sculpins, was first reported as a separate species in 1930.

Kelp greenling: This species was first reported as "California sea-trout" in the 1935 catch. In the 1947 bulletin, the species was reported as "greenling seatrout" and beginning in 1961, was reported as kelp greenling. Because kelp greenling is a minor component of the overall commercial catch, it was not included in the catch summaries for some years.

Rock greenling: This species, which is uncommon in California and is often confused with kelp greenling, is not reported in the Fish Bulletins.

Monkeyface prickleback: Generally, monkeyface prickleback has been reported in the "eel" category, which includes a number of eels and eel-like fishes. As a result, specific information on landings of monkeyface prickleback is unavailable for most years.

Rockfishes: Commercial landings were last reported in Fish Bulletin #173 (1990) and covered the period 1977-1986. In previous bulletins, rockfish were lumped together and with other related fishes such as thornyheads and scorpionfish. In Fish Bulletin #173, rockfish were divided into six categories: blackgill, group bocaccio/chilipepper, group red, group rosefish, miscellaneous, and widow. The rockfishes included in the NFMP would have generally been placed in the categories for group red or miscellaneous. Reporting of rockfishes has become increasingly specific, particularly in the last decade, but statistics based on landing receipts do not provide species-specific data for the nearshore rockfish before the early1990s.

Commercial landings have been published most recently in California's Living Marine

- sampling: To estimate the species composition of landings recorded in market categories, the Department has sampled commercial landings at ports. This effort is compromised in several ways. Samplers require extensive training in the identification of the large number of relatively similar-looking species in nearshore catches. Frequently, especially in larger port complexes, several

boats make landings at approximately the same time, thus preventing the single sampler from sampling adequately. As a result, the number of samples collected in many port areas is too small, and the sample variance is generally too high for meaningful analysis, reducing the Department's ability to estimate trends in relative abundance.

- catch location: Currently, landings receipts require noting the location of the catch by Fish and Game blocks, which measure 10' latitude by 10' longitude. This geographic scale prevents meaningful fine scale assessment of the distribution of stocks.
- mobile dealers: The current system for monitoring commercial landings was based on monitoring landings at permanent facilities. However, a significant number of buyers for nearshore species operate from vans that are capable of traveling long distances to marinas and launch ramps. The difficulty of monitoring these mobile buyers reduces sampling of the commercial catch.
- no logbook requirement: One major component of the nearshore fishery, the hook-and-line fishery, has no logbook requirement. Without the ability to document effort in all sectors (all gears) of the fishery, the Department is prevented from estimating CPUE. See Appendix K for revised protocols for fishery-dependent monitoring.

Recreational Monitoring

Monitoring of nearshore recreational fishing has focused on collecting information on four modes of fishing: party/charter or Commercial Passenger Fishing Vessels (CPFVs), private/rental boats, beach/bank, and man-made structures such as piers. Landings are made by anglers and divers. The three principal monitoring programs that the Department has used for the recreational fishery are the Marine Recreational Fisheries Statistics Survey (MRFSS), CPFV logbooks, and on-board CPFV surveys. The Department also has monitored some skiff fisheries in various parts of the State and recreational dive meets along the central coast.

MRFSS

Since 1979, the NMFS has provided funding for the MRFSS program, which is designed to collect economic, ecological and catch information on sport fishing for four modes. The MRFSS program, which has been conducted continuously with the exception of 1990-1992, consists of an angler field survey paired with a randomized telephone survey of households in California counties that lie within 50 miles of the coast. For the field survey, a fishery technician conducts on-site interviews of recreational anglers at the conclusion of angling for the day. This survey collects such information as the stated dedication of fishermen to fishing, demographic and economic information, species caught, length, discards, and since 1999, catch location. The distribution of sampling to reach the sampling goal within each stratum (2-month period, fishing mode, and subregion) is based on the expected fishing effort in each month, at each fishing site, and weekend/weekday day type. The data from the field survey and the telephone survey are mathematically expanded by strata to generate estimates of such things as catch and effort. Separate estimates are generated for

northern California (from the Oregon border through San Luis Obispo County) and southern California (from Santa Barbara County to the Mexican border).

CPFV Logbooks

Since 1936, CPFV operators have been required to submit records (logbooks) to the Department for each day of fishing. For each log entry, the vessel operator must list the number of anglers and number of hours fished, fishing location by Department fishing block (which measures 10' latitude by 10' longitude), port of departure, type and number of fish caught, and number of discards. These logs are required for both hook-and-line fishing trips and diving trips; they must be submitted whether or not fish and invertebrates are retained. Monthly catch and effort data by Fish and Game block has been summarized for the years 1936-1999.

Commercial Passenger Fishing Vessel Onboard Surveys

Between 1984 and 1998, the Department conducted two onboard survey programs of CPFVs. The first was conducted in 1984-1989 and covered CPFV fishing trips in southern California. The second survey covered 1987-1998 and surveyed CPFV rockfish and lingcod trips from Point Conception (Santa Barbara County) to Crescent City. Each survey collected information on catch composition, amount, size, and bycatch for selected passengers at each location fished. While the southern California survey collected catch information by general fishing area, the central/northern California survey collected more specific location information and therefore more site-specific catch information. Some of the results from the second survey have been used for in-season fisheries management and to supplement MRFSS data.

Launch Ramp Surveys

Landings of recreational skiff fishermen were sampled from 1975-1978 and 1980-1982 in southern California, and more recently on an intermittent basis at Bodega Bay, Monterey Bay, and Morro Bay and Eureka. Since 1999, the Department's Ocean Salmon Project and the Bodega Bay office have been monitoring the private skiff groundfish fishery in the Bodega Bay area. The goal of this activity has been to sample landings from at least 20% of allowed fishing days and to collect information on CPUE and species composition by location.

Dive reports

Since 1950, the Department has collected information (such as size frequency) on nearshore species from spearfish meets held on the central coast. Although data from individual events have been summarized, the entire data set has not been analyzed.

Information from the Recreational Fishery

In general, data from these programs are used for management of California's fishery resources via statewide, or federal (Pacific Fishery Management Council) regulation, and in stock assessments. In recent years, the overfished status of several

species of rockfishes and lingcod has required a closer accounting of the level of recreational catch of these and associated species. As a result, catch estimates and the data used to generate estimates have been subject to greater scrutiny because they are used in management decisions. Information provided from these data falls into several main categories including:

- fishing mortality estimates
- number of anglers
- indices of abundance (size/age distribution of catch, catch rates, evidence of recruitment to fishery)
- which species are caught together
- changes through time in specific areas
- bycatch
- evaluation of overlap in resource uses between user groups (both recreational and commercial)
- development and evaluation of proposed and existing regulations

Total catch estimates provide information used to estimate fishing mortality and are calculated using average size of fish, catch rates and total effort. Also, information from one or several programs can be combined to provide an independent check of the other methods. Table 1.4-1 provides a summary of the data uses for three of these programs.

Table 1.4-1. Recreational data sources (X = data set does provide information)

	MRFSS	CPFV logbooks	northern/central California CPFV onboard sampling[1]
Bycatch	X	X[2]	X
Catch per angler	X	X	X
Catch per angler hour	X	X	X
Compliance estimates	X	in conjunction with column 3	in conjunction with column 2
Developing and evaluating sport regulations	X	X	X
Economic information	X		
In-season monitoring	(limited)	(very limited)	
Marine bird interactions		limited	X
Marine mammal interactions	X	limited	X
Mean length	X		X
Seasonal catch	X	in conjunction with column 3	in conjunction with column 2
Species composition of catch	X	X (Rockfish grouped)	X
Total catch estimates	X		
Total catch estimates (no. fish)	X	X (Rockfish grouped)	in conjunction with column 2
Total effort estimates (no. anglers)	X	X	in conjunction with column 2

Trends by fishing location			X
Trends by port area	X		X

1. primarily rockfishes and lingcod
2. not for individual rockfish species until 2001 then only for some spp.

Recreational Catch

Publication of recreational catches of nearshore and other species has been sporadic. Fish Bulletin 121 (1961) reported on CPFV catches between 1936 and 1961 (with a hiatus for the war years of 1941-1946). Of the nearshore species, only catches for rockfish as a group, California scorpionfish, cabezon, and California sheephead were listed. Between 1961 and 1985, two 10-year synopses of CPFV catches were published in the fish bulletins.

CPFV catches for 1947-1999 also were published in the most current issue of California's Living Marine Resources: A Status Report (2001). Catches in this volume list catch separately for all NFMP species except rock greenling (included under other greenlings).

The MRFSS results from 1979-1989 are available in published form. Also, sample and total catch estimate data are available from the Recreational Fishery Information website (www.recfin.org) for 1980-1989 and 1993 to the present.

Shortcomings in Current Recreational Fishery-Dependent Monitoring

Recreational fishery sampling faces the same personnel and species-identification issues as commercial sampling as well as problems unique to the recreational fishery (see Appendix K for further information).

- field and telephone surveys: Several problems have been identified in the field and telephone surveys conducted by MRFSS. First, the random telephone survey of households in coastal counties may not provide a representative sample of recreational anglers participating in the four different modes. Second, the field surveys sample in proportion to the number of trips, thus geographic areas with large numbers of trips are better represented than areas with fewer trips. It is costly to survey and make estimates for areas with little fishing effort. Third, the difficulty of correctly identifying rockfish species reduces the reliability of species identifications made by samplers. Fourth, sampling of CPFVs is limited to cooperating vessels. Finally, the number of sampled angler trips is low, with the overall sampling rate at less than 1% of all angler trips.

- CPFV logbooks: CPFV logbooks historically have had limited use in managing nearshore species. The reporting rate for CPFVs and the accuracy of the logbook information is highly variable. Location information is not precise, being recorded as 10 by 10 nautical mile Fish and Game blocks. Also, until 2001 many of the nearshore rockfish were recorded as unspecified rockfish.

- sample size: One of the major features of any sampling program is the variance of the estimate, or the range of high and low values around the point estimate. Usually, a variance of ± 20% with 95% confidence is desirable. This means that if the catch is estimated at 100 fish, the true value will be between 80 and 120 fish 95% of the time. Generally, the variance can be reduced by larger sample sizes. In cases where effort and catch are determined independently, and then multiplied together to produce an estimate, the variance can often be significantly reduced by only increasing the sample size in one element. Practically, reducing the variance in the effort estimate better achieves a more accurate total catch estimate than only reducing the variance in the catch component.
- effort estimate: Past and current experience with Department sampling programs on CPFVs and private/rental boats over a large geographical area (southern or northern California) have shown that sampling 20% of angler or boat trips provides a good estimate of catch. However, to achieve an acceptable total catch estimate, an accurate effort estimate is necessary. Preliminary efforts indicate that this can be achieved by a census of CPFV vessels to determine number of anglers and trips, or exit counts of private/rental boats which survey 20% of anglers or trips. Producing total catch estimates for smaller geographical areas requires higher levels of sampling to achieve the same variance.

Past and Current Fishery-Independent Assessment

Fishery-independent sources of information include surveys conducted with standardized fishing gear, scuba gear, or remotely operated vehicles (ROVs). The last two types of surveys in particular are not constrained by the selectivity of fishing gear and practices, and can serve as unique sources of critical information about key aspects of marine fish populations and ecosystems.

Like fishery-dependent monitoring, fishery-independent assessment activities should be conducted in a standardized manner, and survey information should be maintained in databases with consistent formats in order to facilitate comparison and analysis. Knowledge sought from fishery-independent activities should not be limited to the 19 species, but must also encompass key factors that represent the health and integrity of the nearshore ecosystem as a whole.

Key aspects of marine fish populations and ecosystems include:

1. measures of the relative abundance, trends, size estimates, recruitment, and age structure of fished and unfished populations

2. calibration of trends in estimates derived from fishery-dependent surveys, and fine-tuning assessment models

3. long term consistency in sampling, which is essential for the management of long-live fishes

4. information on the biological community, the physical environment, and the ecosystem as a whole, which cannot be obtained directly from fishery-dependent methods

5. socio-economic issues that affect fishery dynamics and non-extractive uses of the resource

Such data facilitate the development of alternatives to conventional modeling of fish populations and of the impact of fishing. More powerful and sophisticated models can, in turn, enhance the accuracy of stock estimates and the ability to estimate sustainable level of fishing.

If scuba, ROV, and Department hook-and-line surveys are to provide reliable information, data must be analyzed in a timely manner and published in peer-reviewed journals. Methods for comparing assessments on temporal and spatial scales need to be developed to incorporate results from all Department and cooperative agency projects into management efforts. Furthermore, geographical variation in the abundance, life history, and other parameters of nearshore fish argue for expanding assessment surveys spatially, in order to provide meaningful sampling of all regional management areas.

Essential Fishery Information on Biological and Ecological Dimensions of the Fishery

Besides requiring a description of current and past monitoring of the fishery, the MLMA also requires that research protocols in FMPs include a description of EFI for the fishery. All EFI categories are important or essential; however, resources required to obtain this information will always be finite. If all types of EFI are not immediately available, the EFI most critical to reducing uncertainty about the sustainability of a fishery must be identified. Together with collaborating scientists from other agencies and academia, the Department set priorities among eight types of EFI. The prioritization identified the most immediate needs for biological information and did not consider methods for collecting it. In practice, many methods are flexible enough to accommodate collection of more than one type of EFI. For example, while recording species composition and length data, a dockside sampler could also collect samples for age, growth, and reproductive information. During subsurface abundance surveys, observers can also collect recruitment, habitat, and oceanographic information (Table 1.4-2). The types of EFI are listed below in order of priority, with the first three of roughly equal importance:

1. spatial and temporal estimates of abundance
2. total mortality by species, as well as temporally and spatially
3. age and growth characteristics
4. recruitment
5. ecological interactions
6. reproductive characteristics
7. distribution of stocks
8. movement patterns

Table 1.4-2. Potential of fishery-dependent monitoring and fishery-independent assessment studies to provide essential fishery information (X = Can be obtained, P = Possibly can be obtained)

	Fishery-dependent information			Fishery-independent information		
Essential fishery information	Market or dockside sampling	Onboard vessel sampling	Landing receipt information	In-situ surveys (scuba, ROV)	Investigatory fishing surveys- all life stages	Socio-economic surveys
Age and growth	P	P			X	
Distribution of stocks	X	X	P	P	X	
Ecological interactions	P	P		X	X	
Estimates of abundance	P	P	P	X	X	
Movement patterns	P	X	P	X	X	
Recruitment:						
population				X	X	
fishery	X	X	P			
Reproductive characteristics	P	P		P	X	
Total mortality	P	P	P	P	P	
Socio-economic information	X	X	X			X

Department scientists then evaluated the adequacy of EFI for each of the 19 NFMP species. The sections below describe each type of EFI, and the adequacy of current knowledge.

Estimates of Abundance

Estimates of abundance are essential elements for predictive modeling of nearshore populations and for evaluating the effect of management measures. Rather than seeking an absolute number of fish in the sea, abundance may also be monitored by estimating the number of fish per unit of appropriate habitat. The following specific types of EFI are considered under estimates of abundance: relative densities of species from commercial catch records and standardized fishing surveys; habitat-specific densities of target and non-target species from underwater surveys; **length-frequency distributions**; estimates of the relative density of target species at different life stages, such as eggs, larva, young-of-the-year, juveniles, or adults; and CPUE. Long-term sampling to determine abundance helps identify not only the effects of

fishing on stocks but also the occurrence of critical strong year-classes, which can support the fishery for many years.

Habitat-specific estimates of abundance (or fish density estimates) can be obtained using scuba, ROV, submersibles, or tagging studies (Adams et al. 1995, Bodkin 1986, Carr 1991, Gingras 1998, Karpov et al. 2000, Krieger 1993, Matthews and Richards 1991, O'Connell and Carlile 1994, VenTresca et al. 1996, Yoklavich et al. 2000). With a lesser degree of resolution and reliability, this information can also be obtained by using landings data, fishing surveys, and CPUE. To be useful, estimates must be specific regarding location, species, and life stage, and must be examined over time. Although complete integration of various sampling methodologies is possible, the biases of each protocol must be well understood, and their selective efforts must be corroborated (Adams et al. 1995; Krieger 1993; O'Connell and Carlile 1994).

length-frequency distributions - a graphical representation of the number of organisms by length.

Adequacy of Current Information

No statewide estimates of abundance information exist for the 19 NFMP species. However, several scuba, ROV, and submersible studies (covering less than 10 mi or 16 km of coastline), as well as hook-and-line CPUE studies have well-documented sampling methods and collected valuable regional time-series of relevant information. Methods, data recording, and analysis have not been standardized among surveys. While few of the studies have been reported in peer-reviewed literature, about half have been reported in Department in-house reports.

Although existing data sets are incomplete, they do provide a valuable time-series of data on abundance. Both fishery-independent and fishery-dependent surveys have documented years of significantly higher recruitment success for several of the 19 NFMP species. In one central California survey, for example, an increase in densities of nearshore, kelp-forest species (black-and-yellow, blue, copper, gopher, kelp, and olive rockfishes, and California sheephead) was correlated with **cohort** recruitment into the CPFV fishery (Adams 1995, Adams et al. 1995, Reilly et al. 1993, VenTresca et al. 1996). Also, scuba surveys of sub-adult and adult black-and-yellow, blue, copper, gopher, kelp, and olive rockfishes, California sheephead, and kelp greenling have demonstrated significant differences in densities within and adjacent to reserves (VenTresca et al. 2001).

cohort - a group of individuals of a species that resulted from a discrete spawning event, period or season.

Total Mortality

Total mortality includes landings, discard mortality, and natural mortality. Catch mortality can be estimated using landings data and CPUE, whereas discard mortality requires observer programs and experimental studies of the discard process and discard survival. It is particularly important to quantify discard mortality in a fishery managed, in part, with size limits. Natural mortality can be estimated using mass-balance models of predation and/or life tables based on maximum age, age and growth data, and environmental information and by measuring changes in size frequency distributions over time.

spatially explicit - a type of analysis that takes into account the specific geographic location of its components.

Specific EFI needed to gauge total mortality includes catch data that are taxonomically and geographically specific; commercial landings by fishing method; bycatch; explicit descriptions of discarded catch; discard mortality rates by species, depth, and gear type; catch by size; and estimates of mortality from predation, disease, starvation, environmental variables, or oceanographic conditions. Mortality information gives managers insight on the dynamics of abundance estimates and is essential for calculating the fishery control rules.

Adequacy of Current Information

Existing data on total mortality and mortality by cause for the 19 NFMP species do not provide sufficiently specific information on location or species. Ongoing research may help resolve how specific data on the location of mortality needs to be. New tracking methods, reporting requirements and intensified on-board observations will likely be needed for collecting and verifying location-specific fishing mortality data. Similarly, a **spatially-explicit** approach will likely be needed to collect or confirm location-specific data for natural and pollution-induced mortalities.

Age and Growth Characteristics

Combining age and growth information with information on catches and mortality makes it possible to create models which can predict changes in population size over time. These changes are also dependent on oceanographic conditions, habitat quality, species interactions, and fishing regulations that select for size. This information, in turn, can assist in assessing the status of a population and in guiding management.

Essential Fishery Information on age and growth characteristics includes information on length/weight and age/length, age and size at sexual maturity, age and size when recruited to the fishery, and longevity. Age and growth characteristics can be estimated using length-frequency distributions from abundance estimates and tagging studies, but must at some point be validated using tissue analysis (such as otoliths, scales, or bone). These validations must be repeated periodically to ensure that established techniques remain biologically valid over time and across a given species' range. Samples for age and growth studies can be collected from commercial catch, recreational catch, or experimental fishery studies.

Adequacy of Current Information

Length-weight relationships have been calculated for all species in the NFMP except rock greenling. Regional differences in length-weight relationships have been noted for 12 species. With the exception of treefish rockfish, ageing studies have been performed on all the NFMP species (Cailliet et al. 2000). Age validation procedures, a vital part of all ageing studies, have been performed on only 8 species: California sheephead, black-and-yellow rockfish, blue rockfish, gopher rockfish, grass rockfish, kelp rockfish, olive rockfish, and the California scorpionfish (Cailliet et al. 2000).

Recruitment

Recruitment refers to the addition of fish to a population or to a fishery. Generally, when a fish reaches a certain age or size or takes up residence in a particular habitat, it becomes vulnerable to capture and is said to recruit to the fishery. Recruitment to a population occurs when larval fish that have been adrift in ocean currents assume their adult form and settle into adult habitat. Whether considering recruitment to a population or to a fishery, measuring recruitment generally focuses on tracking individual cohorts or year-classes (individuals of a species released during the same season or spawning event). Because the successful recruitment of a year class can be greatly influenced by oceanographic conditions on the distribution of eggs and larvae and on the movement of juveniles, oceanographic monitoring can elucidate fluctuations in populations. Observations of annual recruitment strength along with mortality information can supply additional information regarding the age structure of stocks.

Recruitment is a dynamic factor that must be measured at the level of sub-stock, or in the absence of **stock structure** data, in at least several geographical areas. Thus, the study of recruitment, like other EFI, must be integrated with the study of ecological interactions and the spatial distribution of stocks. Recruitment is best understood through the combined use of sampling programs for larvae, pelagic juveniles, and the visual census of juveniles following settlement. Estimates of recruitment can be back-calculated (validated) using **stock-production models** coupled to oceanographic and environmental models of recruit survivorship.

Specific types of EFI needed for understanding recruitment include: adult reproductive potential, the distribution and length of time spent as eggs or larvae, their size when they settle out of the water column to the sea floor, the timing of their settlement, the relative strength of individual cohorts, the availability of habitats, and the abundance of predators and prey.

stock structure - 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 production models - fishery models based on the spawning stock size. The model assumes that maximum population production (biomass) will occur somewhere around the spawning population mean. When the spawning population deviates from the mean, productivity declines. Some models have parameters that allow the productivity to decline at various rates or not at all at higher population levels.

Adequacy of Current Information

No statewide recruitment information exist for the 19 NFMP species. Several small-scale trawl surveys and one scuba survey on the central coast have collected this type of data. These studies contain valuable regional time series, and have well-documented sampling methods. There have been no attempts to standardize methods, data recording, or analysis among surveys, however. Few of the studies have been reported in peer-reviewed literature, but all have been summarized in Department in-house reports.

Since 1987, the Department has collected information on the annual recruitment success of nearshore kelp forest species in central California—black-and-yellow, blue, copper, gopher, kelp, and olive rockfish, and California sheephead. The occurrence of large groups of young-of-the-year rockfishes

has been correlated with later recruitment of large numbers of rockfish into the CPFV fishery. Periodic beam trawl surveys in Alamitos Bay in Orange County and otter trawl surveys in Monterey Bay and Morro Bay also have identified years of high abundances of young-of-the-year fishes.

Ecological Interactions

The MLMA recognizes that fisheries are part of a larger system and calls for conserving "the health and diversity of marine ecosystems and marine living resources" (FGC §7050). Fisheries are embedded in a web of ecological relationships that include the effects of oceanographic regimes and human disturbances on physiological, energetic, or behavioral aspects of organisms, relationships with prey and predators, interrelationships among species due to relative density of different populations, and the distribution and quality of habitat that is key to reproduction and recruitment.

Ecological interactions are complex and dynamic, and may be best understood by integrating various sampling methodologies (Hallacher and Roberts 1985). In general, interactions between fish and their environment, their habitat, other organisms, and other fish can be studied using the results of scuba and ROV studies which examine trophic (feeding), spatial, and behavioral interactions; and tagging studies among a variety of habitats and environments. This level of specificity is needed since a particular ecological interaction for a given species may be highly positive in one habitat type and highly negative in another.

Adequacy of Current Information

Ecological interactions of the 19 NFMP species have not been studied in a coordinated manner or using standard methods. As a result, little is known about regional impacts of oceanographic events or human disturbances on the physiological, energetic, and behavioral aspects of these 19 NFMP species or associated species. The Department has conducted some small-scale surveys using scuba, ROVs, and submersibles, as well as hook-and-line CPUE studies, which have collected oceanographic and/or habitat information. The methodology of data collection and analysis has not been standardized among these studies. Few of these studies have been reported in the peer-reviewed literature, although all have been summarized in Departmental reports.

The Department has been conducting studies that will contribute to understanding the distribution of habitat for the 19 NFMP species. Specifically, the Department has been using geographic information system (GIS) technology to describe, quantify and map the physical substrates of selected nearshore areas. These maps will assist with estimating fish density and the spatial distribution of nearshore populations.

gene flow - the spread of genes within or between populations as the result of cross-fertilization and natural selection.

genetic structure - the genetic constitution of a population. Described by the frequency of genes (units of inherited material), and frequency of genotypes (all the genetic characteristics that determine structure and function) found in a population.

genetic heterogeneity - the genetic diversity of a population as measured by the variability in possible expressive traits of a gene.

Distribution of Stocks

Effective management strategies require knowing the spatial distribution of stocks. Are there a large number of small, discrete stocks of a population or species, or fewer, larger stocks? Depending upon the answers to such questions, management will need to be tailored to different geographic scales. EFI that can elucidate these questions includes **gene flow** and **genetic structure** of stocks, depth and range of species along the coast, and whether distinct stocks are separate or continuous.

Knowledge of the number and size of fish stocks sets the spatial scale for management. If **genetic heterogeneity** is low (indicating a large, single stock), fishery regulations can be simplified, assessment costs reduced and allowable catch maximized. Conversely, if one or more nearshore species have numerous distinct populations, then management may well have to be more restrictive and regional. Other, more conventional types of research can contribute to identifying stocks. For instance, the majority of the nearshore species move very little after becoming established in a area. Over time, this behavior might lead to isolation and the development of distinct populations. Balanced against this is the fact that rockfishes produce large numbers of pelagic larvae capable of being transported great distances. Because discrete adult populations may be capable of seeding distant areas populations would tend to be homogeneous.

Adequacy of Current Information

There has been little research concerning the genetics of nearshore fish populations in California that would help delineate different stocks along the coast (Cailliet et al. 2000).

Movement Patterns

The movement of different species throughout their lives greatly influences the management of fishing. Similarly, knowledge of the movement patterns of different species will influence the placement and boundaries for MPAs. Generally, the movement of fish is linked to oceanographic conditions, availability of prey, and life history characteristics.

Most adult rockfish are believe to move little, exhibiting a high degree of territoriality (Hallacher 1984; Larson 1980a, b, c). Spatial patterns can be found for species or populations through tagging, genetic studies that test for **reproductive isolation**, scuba and ROV surveys, and spatial modeling studies. Specific EFI includes: home range of individual species, ability to return to favored areas, seasonal migrations, environmental cues, spawning grounds, and depth distributions. Gathering such information requires specific, targeted, multi-year, fishery-independent and fishery-dependent research.

reproductive isolation - separation in space or time of two parts of a population which are normally capable of interbreeding. Considered a normal precursor for the evolution of new species.

Adequacy of Current Information

Tagged blue, copper, black-and-yellow, gopher, and other bottom-dwelling rockfishes have generally been recaptured within the same kelp beds where they were tagged (Miller and Geibel 1973). Likewise, fish tagged and then released at a different location returned within a short time to the original capture location.

There is anecdotal information suggesting that juveniles and adults of some species such as gopher rockfish move into vacant areas where intense fishing effort has reduced the numbers of fish. It is not known how far individuals of such species may move to occupy depleted habitat. There would likely be little such movement where appropriate habitat is sparse and scattered.

fecundity - the reproductive capacity of an individual female animal, generally expressed as the number of eggs or larvae per unit weight or per individual.

gonadosomatic index - an index rating the reproductive condition or state of a fish; a measure of an individual's investment in gamete production, sometimes expressed as the ratio of gonad weight to total body

Reproductive Characteristics

Knowledge about such reproductive characteristics as size at maturity can assist in setting open and closed seasons and areas, size limits, escape mechanisms for traps, and other restrictions aimed at protecting the reproductive capacity of nearshore populations. Relevant EFI includes **fecundity**, size at maturity, fertilization and spawning period, geographic spawning area, and specific reproductive behavior. All these factors are greatly affected by environmental conditions, and they should be considered jointly.

Reproductive characteristics can be quantified using models, estimates of recruitment (as validation), genetics, and tissue analysis (**gonadosomatic index**, etc.). Samples for the study of reproductive characteristics can be obtained from commercial catch, recreational catch, and experimental fishery studies.

Adequacy of Current Information

The Department has not developed standard methods for collecting, recording, and analyzing reproductive data for the 19 species. Lea et al. (1999) conducted the most pertinent recent study on the central coast from 1978 to 1985. In this study, the Department used fishery-independent and fishery-dependent methods to collect reproductive information from the following nearshore kelp-forest species: black-and-yellow, blue, copper, gopher, kelp, and olive rockfishes, and California sheephead. As a result of this study, the timing of reproductive development and release of gonadal products is well known for central California species. Such information is lacking for populations elsewhere.

Future Monitoring and Assessment of the Nearshore Ecosystem

The MLMA requires that an FMP's research protocol include a description of the steps the Department will take in monitoring a fishery and filling gaps in EFI (FGC §7081). The following sections describe a monitoring and assessment system that will meet this requirement and will assist the Department in monitoring and managing other components of the nearshore ecosystem, including sea urchins, abalone, and kelp.

This system expands upon existing fishery-dependent and fishery-independent programs of the Department and supports additional cooperative and collaborative opportunities for gathering EFI.

The Department recognizes the need for significant changes in current methods of collecting and analyzing EFI on the nearshore fishery and ecosystem. Development of research protocols will be consistent with the EFI needs described in this chapter, and a framework should be established that ensures data are collected using standardized protocols. Data management and analysis plans should ensure that data are current and available in a timely manner for management decisions.

Both fishery-independent and fishery-dependent methodologies are essential for assessing nearshore fish and nearshore ecosystems. Understanding multi-species relationships in nearshore communities requires a sophisticated experimental procedure with integrated research methodologies. Likewise, the MLMA's mandate for adaptive management requires observing, analyzing, and refining management actions. The Department proposes a research plan that combines these ecosystem and adaptive perspectives.

The Department's research plan rests on two bases: improvement of existing fishery-dependent and fishery-independent monitoring and assessment, and a systematic program of research and monitoring in a discrete set of reference sites.

Improvements in Fishery-Dependent and Fishery-Independent Activities

The NFMP research protocol calls for improvement in, and integration of, fishery-dependent and fishery-independent monitoring and assessment. Toward that end, the Department's Marine Region will collect pertinent EFI and coordinate Department, outside agency, and academic partnerships and active involvement of interested constituents. Data sources will include Department programs, most of which will include significant collaboration, and programs conducted by other agencies and academic institutions. All methodologies will be based on standardized procedures, with data entered into standardized databases with spatial references compatible with GIS format.

Approaches that the Department and its partners will use, and the types of EFI that they will generate, include:

- nearshore habitat mapping using sonar, ROV video transects, and novel imaging technologies for spatially specific information on habitat
- geo-referenced databases
- remotely operated vehicles, scuba, and experimental fishing studies to acquire spatially specific information on biomass, density, abundance, age structure, recruitment, life history, and ecological information
- Global Positioning Systems technologies for spatially-specific catch information
- improved port sampling protocols for more accurate sport and commercial catch information

Study Area Selection

To identify areas for focused study, the Department will work with collaborators to evaluate both open and existing fishing areas. The Department will follow three sets of criteria to rank potential areas for study. The criteria are listed in order of importance:

For all areas:

1. Area contains an appropriate array of habitat, and is subject to representative oceanographic conditions for the region.
2. Area has not been the target of unique or abnormal human-caused disturbance.
3. Area is of appropriate size and shape and depth range.
4. Area is readily accessible by scuba and boat.
5. Area has been subject of previous long-term research.
6. Area has recently been selected as a subject for long-term research.
7. Area is suitable for use in the assessment/management process for both invertebrates and finfish of management importance.

For open areas:

1. Area is subject to fishing pressure that is representative of regional trends and proximity to port.
2. Productivity of area is representative of regional trends.

For closed areas:

1. Area currently obtains some protection by the state or federal government.
2. Area currently represents a Marine Protected Area in the state of California.

- improved CPFV and commercial logbook systems for more useful information on catch composition and location
- socio-economic studies to determine resource demand, costs-of-production, and the contribution of the commercial and recreational fisheries to local economies
- genetic and tagging studies using estimates of effective population size and movement rates to learn boundaries of different stocks
- species-specific and gear-specific studies of discard survival
- diet, stable isotope, behavioral, and bioenergetics studies for information on ecological relationships
- physical oceanographic information collected by the National Oceanographic and Atmospheric Administration (NOAA) and a variety of other institutions to anticipate effects on the fishery and nearshore environment from changing ocean conditions.

In the near term, Department efforts to acquire EFI will include:

- mapping and evaluating existing and proposed study areas subject to different levels of fishing effort, including marine

Consideration of Ecological Species Guilds as Functional Groups

The NFMP covers 19 different finfishes. The geographical ranges, ecological niches, and life histories of these species vary. In order to monitor and assess nearshore fish species in the future, it makes ecological and management sense to consider these 19 species not as one group, but rather as geographical and/or ecological "guilds". These guilds are composed of certain species that only occur in the southern portion of California and others that only occur in the northern portion of the state. For the purposes of organizing and analyzing future monitoring and assessment data, the NFMP Project divides the state into four regions. The guilds in each region primarily reflect patterns of associations or co-occurrences of species by location and habitat.

reserves; continued habitat mapping of the California coast

- developing a collaborative nearshore research program, emphasizing scuba, ROV, and CPUE comparisons of areas subject to different levels of fishing effort, including marine reserves, to be used for evaluation of management and long-term assessment of the health of the nearshore environment
- initiating nearshore assessment studies in areas subject to different levels of fishing effort, including existing marine reserves that meet design criteria as reference reserves
- publishing relevant data for peer review and use in future justification of fishery management regimes
- preparing previously-collected data for review. A considerable amount of useful data collected by the Department, other agencies, and marine science institutions awaits analysis. Preliminary review of some of these existing data indicates that they have substantial value for nearshore fishery management.
- coordinating and improving commercial and CPFV logbook systems
- refining and coordinating statewide commercial and recreational sampling programs and implementing short-term sampling plans

The Department's long-term approach to fishery-dependent monitoring will involve a concerted effort to improve and expand existing state and federal sampling programs, and to refine and re-evaluate fishery sampling needs over time. The long-term approach to fishery-independent EFI and assessment of nearshore finfish and other nearshore resources will be based on surveys in areas of representative habitat subject to different levels of fishing effort, ranging from heavily fished areas to marine reserves (reference reserves). These sites will be compared using ROV, scuba, and fishery-independent CPUE survey methodologies.

The long-term comparison of areas subject to different levels of fishing pressure, including marine reserves, will permit regional evaluation of management measures, distinguishing between natural and human-induced change, evaluation of the complex direct and indirect effects of fisheries on the nearshore environment, and anticipation of the effects of environmental change on the fishery.

In the near-term, areas open to fishing and suitable existing marine reserves can serve as initial survey sites. A primary consideration will be that these areas represent habitat for as many of the nearshore species of management importance as possible, including finfish, invertebrates, and kelp. Other criteria include accessibility for research and, for reference reserves, enforceable boundaries, and existence of long-term baseline studies. Existing marine reserves under consideration to be reference reserves include Point Cabrillo Reserve, Bodega Marine Life Refuge, Point Lobos Ecological Reserve, Big Creek Ecological Reserve, Anacapa Island Ecological Reserve, Catalina Marine Science Center Marine Life Refuge, and San Diego-La Jolla Ecological Reserve (see Appendix K, Revised Protocols for Fishery-Dependent Monitoring and Fishery-Independent Assessment).

A longer-term approach to the incorporation of nearshore reference reserves will be established in conjunction with the Marine Life Protection Act process.

Benefits of the NFMP Project Research Plan

Compared to traditional approaches, the NFMP Project approach offers the following advantages:

- This approach will provide an ecosystem perspective for marine life management (FGC § 7050(b)(1) and 99.5). The traditional approach looks at a subset of the community that reflects the limits and biases of the techniques used to provide fishery-dependent and fishery-independent information.
- Comparing areas subject to different levels of fishing pressure, from heavily fished to reference reserves, helps to distinguish natural changes from fishery-induced changes.
- Comparing fished and unfished areas provides key information for evaluating the effectiveness of the fishery management regime.
- Surveys of all nearshore species of economic or ecological importance can provide data useful for management of species other than those in the NFMP, and for those considered for future FMPs.
- The approach will allow detection of sporadic recruitment into the population. Conventional approaches often cannot discern recruits until they are large enough to be captured by fishing gear.
- By monitoring recruitment into nearshore populations, the approach provides more lead-time for management to adjust to increases or decreases in populations. The lack of adequate lead-time for decisions is a problem endemic to traditional fisheries management.
- Over a period of years, this approach combined with improved fishery-dependent information, will yield sufficient information to advance the nearshore fishery from data-poor to data-moderate (Stage II), and ultimately to a data-rich (Stage III) management (Chapter 3). A summary of current, short-term and long-term research activities is contained in Table 1.4-3.

Table 1.4-3. Goals and current, short-term, and long-term research implementation

	Current	Short-term	Long-term		
			Phase 1	Phase 2	Phase 3
Goals	*Increase recreational fishery-dependent sampling *Coordinate activities of various groups collecting fishery-independent data	*Improve fishery-dependent sampling data *Implement and coordinate fishery-independent studies *Incorporate environmental data	*Continue to improve fishery-dependent data *Continue independent studies *Incorporate other types of data	*Continue monitoring *Incorporate environmental and remote sensing information into models *Begin developing multi-component fishery tools *Refine/re-evaluate techniques	*Continue monitoring *Implement use of multi-component fishery tools

Table 1.4-3. Goals and current, short-term, and long-term research implementation

	Current	Short-term	Long-term		
			Phase 1	Phase 2	Phase 3
Fishery-dependent	*Enhance MRFSS sampling *Evaluate current data sampling and existing databases *Develop recreational and commercial short-term and long-term plans *Plan collaborative field and laboratory studies to gather EFI on the nearshore fishery	*Coordinate and improve logbook system *Refine and coordinate statewide sampling programs Implement short-term sampling plans (e.g. develop and implement pilot study for skiffs) *Evaluate improved CPFV sampling *Implement collaborative field and laboratory studies to gather EFI	*Implement long-term sampling plans *Evaluate skiff study	*Refine/re-evaluate techniques	
Fishery-independent	*Coordinate activities of various groups through Nearshore Cooperative Monitoring Group *Develop ROV/scuba protocols *Develop tagging studies *Identify ways to incorporate novel survey data into management *Plan database to utilize a spatial and temporal framework *Plan collaborative field and laboratory studies to gather EFI on the nearshore fishery *Develop collaborative studies with fishermen, academics, and agencies	*Implement coordinated ROV/scuba and tagging studies *Incorporate MPA network into survey *Begin incorporating other survey data into management *Develop and update database *Implement collaborative field and laboratory studies to gather EFI *Implement fishermen/academic/agency collaborative studies	Expand survey data	Refine/re-evaluate techniques	

Table 1.4-3. Goals and current, short-term, and long-term research implementation

	Current	Short-term	Long-term		
			Phase 1	Phase 2	Phase 3
Environ-mental/ remote sensing	*Consolidate and catalog in-house and Department-associated habitat and environmental data sources *High-resolution, geo-referenced mapping of nearshore habitat	*Identify additional data sources *Design database on a spatial and temporal framework *Begin incorporating environmental data *Investigate technologies for incorporating satellite information	*Make environmental data available for fishery managers *Develop technologies for incorporating satellite information	*Make environmental data and remote sensing data available for fishery managers *Refine/re-evaluate techniques	
Socio-economic studies	*Identify needed socio-economic studies *Identify collaborative approaches *Plan collaborative field studies to gather EFI on the nearshore fishery	*Develop Request for Proposal/Invitation for Bid and bid calendar for socio-economic (SE) surveys *Advertise for bids	*Review and evaluate bid packs *Select successful bid	*Refine/re-evaluate techniques *Refine technical approach with successful bidder	*Collect SE survey information *Analyze SE information, in concert with other fishery information *Develop demand functions for discrete user-groups
Modeling- including ecosystem models	*Investigate use of models	*Expand data assimilation to provide inputs for models	*Develop single-species models using new inputs	*Integrate fisheries environmental/ satellite data, etc. into models	*Develop ecosystem models
fisheries management strategies	*Develop using fishery-dependent data	*Develop using fishery-dependent data and some survey, fishery-independent, and environmental data	*Develop using fishery-dependent, survey, and environmental data and some fishery-independent data	*Develop using fishery-independent and fishery-dependent data, environmental data, satellite data, and model inputs	*Develop using a multi-component approach on a spatial and temporal framework

Socio-economic Dimensions of the Fishery

The economic stability and quality of life in coastal communities may be affected by changes in recreational fishing or commercial fishing and processing. These changes, which may be unique to certain areas, may be caused directly by regulatory changes or indirectly by other factors, such as changes in consumer demand due to favorable pricing and supply of a substitute for a fishery product(s), inflation, or tax changes that affect business investment or activities. Changes in fishing and related activities may lead to local changes in business output, employment, population, and public service demand.

Comprehensive socio-economic appraisals evaluate all major uses and benefits derived from the nearshore ecosystem and fishery, including extractive, non-extractive, and passive uses. Accordingly, these appraisals entail essential information on resource value, user-demand for the resource, expenditures, employment, revenues,

and contribution to local economies. By monitoring this information, resource managers can better promote the economic health of industry-sectors and the local community in setting allocations or catch levels.

Existing sources provide some useful information in calculating employment, expenditures, and revenue for basic-sector industries. These sources include the periodic surveys and reports prepared by the Bureau of the Census, the Bureau of Labor and Statistics, the Bureau of Economic Analyses, the U.S. Fish and Wildlife Service, NOAA, the Department, and local institutions and academic affiliates. Information from these sources allows analyses of impacts or contributions to local economies by commercial fishing activities, and to some degree, by recreational charter activities. However, these sources do not provide adequate information for thorough analyses of the economic contribution of the nearshore fishery, and economic import to major user-sectors.

There is little or no existing information about resource demand by recreational fishermen, consumer end-users, or the commercial industry. Consequently, we have no means to analyze or predict reactions of these user groups to changes in the costs, quantity, or quality of goods, services, or raw materials derived from the fishery. This information is essential for making decisions on catch levels or allocation between competing user groups.

While general socio-economic data can be obtained or derived from existing sources, any decision to allocate finite resources among competing users requires analyses of resource demand by each respective user-group. To date, this kind of information has not been collected in any deliberate, objective, and systematic manner in California. To adequately describe the socio-economic dimensions of a fishery to managers and constituents requires resource-demand surveys of the primary user groups, namely commercial fishermen and processors, recreational fishermen, end-users of commercial products, and non-extractive users. Furthermore, due to California's ever-changing demographic features such as changes in major population centers, cultural and ethnic changes, and age strata, this resource demand information must be updated on a regular basis.

To address these needs, the Department will conduct periodic user surveys in order to derive user-group demand functions for discrete fishery uses. In addition, costs-of-production for major user-sectors shall be obtained from Department-initiated surveys or information collected by other state or federal agencies.

Essential Socio-economic Information and Planned Research

Descriptions of four broad categories of socio-economic information intended to fill this information gap follow. Each description discusses the relevance of the information to monitoring socio-economic changes, the general kinds of information necessary for conducting analyses, and schedules for conducting such analyses over time.

<u>Employment</u>

Information on employment in each local economy linked to the nearshore fishery provides an important measure of a community's dependence on a particular

user-sector's activities. Input-output multipliers can be used to gauge overall impacts to community earnings and employment, and to estimate changes to local personal income and the number of local jobs. In this type of analysis, estimated direct changes in output, as measured by revenue or sales by sector, are multiplied by a total income coefficient to estimate total change in local personal income. Similarly, estimates of changes in the number of local jobs can be calculated. The Department will employ the Regional Input-Output Modeling System (RIMS II), developed by the Federal Bureau of Economic Analyses, to obtain multipliers appropriate to each coastal county.

Expenditures and Fishery Costs

Information on expenditures by each sector of a fishery provides key information for evaluating the relative costs of goods or services derived from a fishery. By collecting individual expenditure information for major user-sectors, production costs at various levels of output can be estimated, and projections on the relative mobility of capital and labor can be made. Each sector's expenditures for raw materials used in producing fishery-related goods or services, together with revenue generated at various levels of output, allow for monitoring economic efficiency. This economic efficiency indicator makes it possible to evaluate the success of the management of a commercial fishery.

Changes that directly affect end-user demand for recreational fishing activities or commercial fisheries products may change end-user investment and spending patterns. Depending on the nature of end-user demand for a given service or product, end-users may spend less if the quantity or quality of the service or product is decreased. Conversely, end-users are likely to spend more if the quantity or quality of the product or service is increased. These changes in spending patterns may also affect purchases of related goods or services in the local economy.

Production costs of a product, service, or activity provide a means to compare the relationship between resources used to benefits derived. Often, this is expressed as the benefits-to-cost comparison. In the case of commercial fishing activities, by monitoring costs of production at various levels of output, we can define that level of production that generates maximum economic benefit (or "profits"). This type of analysis is important in designing fishery management strategies that promote optimum economic yield and economic efficiency in the fishing fleet. Economic efficiency results partly from cost- and waste-minimizing practices.

Resource Demand and Net Economic Value

Information on resource demand measures user preferences at each quantity or quality of fishery goods or services used. User demand information yields insights into how allocation strategies affect overall benefits to Californians from the uses and services supported by the public resource.

Changes in the quantity or quality of fishery-related goods or services affect the individual end-user's demand for those goods or services. How much this demand may be affected depends on individual income, tastes, preferences, and the accessibility to substitute goods or services. The combined responses of individuals to changes in goods and services in an area—known as aggregate demand—yield an overall

demand function for those goods and services. This demand function is used to predict the reactions of end-users to changes in the quantity or quality of goods or services, and to estimate the relative value and benefits that end-users derive from a product. Using this measure, it is possible to project the impact of in-season adjustments to quotas or changes in bag limits, for instance, in terms of the anticipated response of the target group of end-users and the consequent changes in revenue streams.

While some information relevant to tracking changes in end-user demand may already have been assembled by the State, the Department will undertake periodic surveys of major user sectors, in order to construct aggregate demand and relative values for goods or services derived from the nearshore ecosystem. These estimates will be used to predict the reactions of end-users to changes in the quantity or quality of uses of the nearshore area. These analyses will also help in allocating resources among competing users so that overall benefits to Californians are maximized.

producer surplus - economic profit, that portion of the revenues received for a product or service, above and beyond the costs of producing that product or service at a given level of production.

Revenue

Revenue information provides one measure of net economic benefits (surplus) associated with the allocation or re-allocation of fish stocks among competing users, for instance. Together with information on costs or expenditures, gross revenue information can be used to estimate **producer surplus** or net economic benefits. In turn, these measures aid in evaluating the consequences of management strategies.

Revenue generated by fishery-dependent activities such as commercial fishermen's income from the sale of their catches, direct recreational expenditures, or end-user consumption of commercial products, provides basic information for calculating contributions to local economies. Such information on revenues and expenditures, which should be spatially explicit, also allows comparing the relative values of goods and services derived from the fishery.

The Department will use reported revenues generated by major nearshore uses in calculating their contributions to local economies. In part, this will be accomplished through using RIMS II to obtain output multipliers specific to each coastal county. In addition, the Department will conduct periodic surveys of major user sectors in order to obtain information on revenues and expenditures.

Constituent Involvement in Gathering Essential Fishery Information

Conservation efforts can succeed only if scientific knowledge is better translated, and if scientists learn to communicate more effectively not only with each other, but also with policymakers, the media, and the public. The inclusion of fishermen, industry professionals and other constituents in the process of planning and gathering EFI necessary to develop sustainable fisheries, contributes to support for management decisions by those directly affected by the policies. The involvement of constituents in gathering EFI for the nearshore fishery will cultivate increased confidence in the data being used to make management decisions.

The MLMA recognizes the importance of collaboration [7060(a) and (b)]: "... Acquiring essential fisheries information can best be accomplished through the ongoing cooperation and collaboration of participants in fisheries," and "The Department to the extent feasible, shall encourage the participation of fishermen in fisheries research within a framework that ensures the objective collection and analysis of data, the collaboration of fishermen in research design, and the cooperation of fishermen in carrying out research."

In the past, individual Department projects have made efforts to involve the public in research efforts. This involvement has usually taken the form of volunteers helping to collect EFI. Below are examples of several volunteer programs.

- The Central California Marine Sportfish Survey and Dr. Jim Grass, a professor at a local college, developed a memorandum of understanding in which the Department acted as facilitator of a private research activity to collect information on marine fish populations along the central California coast. This alliance resulted in improving communication with the public by disseminating Department expertise and information, encouraging students to pursue careers in marine biology, and augmenting the Department's information on marine resources.
- Since the 1950s, the Central California Marine Sportfish Survey has monitored spearfish meets held throughout the State. The diver organizations that sponsor these meets (Central California Council of Divers and the Greater Los Angeles Divers) have actively supported the Department research efforts by involving Department staff in the examination of landings from competitions. Divers and biologists work side-by-side to collect EFI, thus reducing the financial burden on the Department. Divers and the public are educated as to the life history aspects of the fish, and the Department obtains valuable time series information relatively inexpensively.
- In 1995, the Nearshore Reef Fish Tagging Study tagged and recaptured nearshore reef fish through an alliance between the Department and sport and commercial fishermen. Fishermen were trained and educated by Department staff in the rationale and procedure of mark-and-recapture studies. Fishermen provided vessels as platforms for fish tagging expeditions, assisting Department biologists to tag and release nearshore reef fish. Constituent involvement during this program was exemplified by fishermen's involvement in developing scientific protocol, which helped them to understand resource management. Fishermen also became competent in identifying different species of nearshore reef fishes.
- Starting in 1997, the Department led a collaborative project with scientists at California State University (Monterey Bay), Humboldt State University, and Stanford University (through Hopkins Marine Laboratory) to inventory habitat and species of management importance at Punta Gorda Ecological Reserve (Humboldt County). A diverse set of goals were accomplished during this project: mapping the substrate and bathymetry of the Reserve using side-scan sonar, producing underwater ROV-based video of the Reserve, and conducting scuba surveys to ground-truth sonar readings, collect specimens, and

qualitatively assess habitat. This is one example of the potential inherent in multi-institutional, cooperative research projects.

In implementing this research plan, the Department will encourage similar collaboration and seek out the views, advice, and expertise of constituents in designing and implementing research and monitoring.