Chapter 4. Data Collection: Past and Present Activities and Future Needs

4.1 Sustainability and Essential Fishery Information

Multiple uses, increased harvests, and lack of information have increased concern that many of California's diverse marine living resources are being exploited in an unsustainable manner. Sustainability is defined in the Marine Life Management Act (MLMA) as: "(a) continuous replacement of resources, taking into account fluctuations in abundance and environmental variability; (b) securing the fullest possible range of present and long-term economic, social, biological and ecological benefits, maintaining biological diversity, and in the case of fisheries management based on maximum sustainable yield, taking in a fishery that does not exceed optimum yield" [§99.5(a)(b)FGC].

The MLMA identifies a collective body of biological, ecological, physical, and socioeconomic information known as "essential fishery information" (EFI) which is to be used in the development of fishery management plans (FMPs). Each FMP is to summarize the best scientific and other relevant information available, and to collect necessary additional information if this does not significantly delay FMP preparation [§7072(b) FGC]. Fishery management plans will designate sustainable levels of harvest and include appropriate management strategies to achieve those levels. This will allow the Department of Fish and Game (DFG) to be proactive and adaptive in its management of California's marine fisheries. The DFG will develop FMPs, as funding allows, to achieve the goal of sustainable resources.

The MLMA requires that the Master Plan identify both past and current monitoring and research activities related to the state's fisheries, as well as future activities focused on the highest priority fisheries [§7073(b)(3) FGC]. The DFG, to the extent feasible, must collect essential fishery information for all marine fisheries managed by the state [§7060(a)(b)].

4.2 Definition of Essential Fishery Information and Relationship to Management

Essential fishery information is information about the biology and harvest of a fish species that is required for sustainable fisheries management (§93 FGC). This may include, but is not limited to, information on age and growth, reproduction, habitat requirements, ocean conditions, ecosystem relationships, and trends in the fishery. The DFG collaborated with scientists from other fisheries agencies and academia to identify broad, inclusive biological and socioeconomic EFI groupings for managing fisheries. They are:

<u>Biological EFI</u>
Age and growth
Stock distribution
Ecological interactions
Indices of abundance
Movement patterns
Recruitment
Reproduction
Total mortality

<u>Socioeconomic EFI</u>
Employment
Expenditures
Resource demand
Revenue
User/industry demographics

These broad groupings are not mutually exclusive, and some components may fall under more than one category. The relevance of biological and socioeconomic EFI to fishery managers is discussed in the following chapter sections.

4.2.1 Biological Essential Fishery Information

Age and growth

Age and growth studies typically measure how long a species lives, the age at which it reproduces, and how fast individuals grow. This information is very important to determine a population's ability to replenish itself, at what rate it might be harvested, and when individuals will reach a harvestable size. Changes in the age structure and growth rate of a population also serve as indicators of that population's health. Fish age often cannot be determined externally, so individuals must be harvested for age information.

Stock distribution

A stock is a population unit that is selected for management purposes. It may be defined based on its ecology, genetics, and/or geographic separation. Discrete stocks of a given species may have very different growth rates, reproductive schedules and capacity, and even ecological relationships. Stock distribution refers to where a stock is found, and is important in addressing jurisdictional issues.

Ecological interactions

Studies of ecological interactions assess the relationship of the species with other animal and plant species and its physical environment. For example, the harvest of an organism has an effect on its predators and on the prey organisms upon which it feeds. In addition, fishing activity may have unintended effects on fish habitat or on other species inhabiting the area. Ecosystem-based studies consider how oceanographic parameters, habitat, trophic (food and energy) dynamics, community structure, competition, or fishing mortality affect the health and abundance of organisms.

Oceanographic features include many biological (e.g. primary production, nutrient levels) or physical variables (e.g. current, temperature, salinity patterns) that can provide valuable insights into the abundance, distribution, and condition of a particular species or stock. Their predictive value makes long-term trends in oceanographic data, coupled with other biological information parameters, especially important in fisheries management.

Pristine habitat is integral to maintaining the productivity and diversity of marine ecosystems. Habitat investigations are useful to fisheries managers because they can identify the importance of specific physical parameters to the species of interest, and to associated biological assemblages.

Indices of abundance

By its very nature and size, the ocean prevents highly accurate animal population counts. Managers and scientists rely instead on estimates and indices of abundance. An index of abundance is an indirect measure of the size of a population, and is often obtained by counting a portion of the population in the same way each year, or by comparing counts between areas using similar techniques. This information is used by managers to calculate estimates of the total population size that are then used to determine appropriate harvest levels.

Movement patterns

Information on distribution patterns and movement of fish is important to resource managers because of the insights gained on a stock's vulnerability to harvest. Certain species may aggregate in specific areas for spawning, or travel in predictable patterns, or move to certain locales that make them especially vulnerable. Insights into the movement patterns of fish are vital to the development of management strategies based on regional catch quotas or marine protected areas.

Recruitment

Recruitment refers to a measure of the number of fish that survive to a particular life stage, and is often used to predict future population size. Some examples include: the number of offspring that reach the juvenile stage (larval recruitment), the number of individuals that survive (i.e., recruit) to the next year (e.g., age 2 recruits), the number of fish that reach sexual maturity (i.e., recruit to the spawning population), or in the case of a fishery, the number of fish that recruit to the catchable component of the population. Young-of-the-year (individuals less than one year old) are frequently counted for many fish species and used as an index of larval recruitment success.

Many highly-valued species depend on successful recruitment events for replenishment. Recruitment success can be highly variable because it depends on the proper combination of many factors. As a result, sustainable harvest of the fishery may depend on only a few strong cohorts (born the same year) to provide harvestable stocks until the next successful recruitment event. Resource managers must consider this variable recruitment success when setting harvest levels by allowing sufficient portions of stocks to "escape" harvest and provide spawning biomass for future recruitment successes.

Reproduction

Reproduction encompasses information such as the number of eggs a female produces, the average age an individual becomes sexually mature, and whether a female bears live young or broadcasts eggs in the water. This type of information helps managers determine the ability of a population to replenish itself, and at what level it might be harvested. This knowledge allows them to set appropriate open seasons, areas, size limits, escape mechanisms for traps, and net mesh-size restrictions based on spawning considerations.

Total mortality

Natural and fishing mortality rates comprise the sum of all individuals removed from a population over a fixed period of time (often over one year). Fishing mortality is the rate at which animals are removed from the population by fishing, and can be calculated from landings information if the population size can be estimated. Natural mortality refers to all other forms of removal of fish from the population such as predation, old age, or disease. This information is used to predict how many animals remain to reproduce and replenish the population. Mortality figures are used by managers to calculate the number or weight (biomass) which may be safely harvested from a population or stock on a sustainable basis.

4.2.2 Socioeconomic Essential Fishery Information

One of the objectives of fishery management under the MLMA is to minimize adverse impacts on small-scale fisheries, coastal communities, and local economies [§7056(j) FGC]. The economic stability and social diversity of coastal communities may be affected by changes to marine resource use patterns including non-consumptive pursuits, sport fishing, commercial fishing, and fish marketing/processing activities. Economic repercussions arise from regulatory changes that directly alter the public's use and enjoyment of marine organisms, or from indirect effects on resource-use activities, such as shifts in financial markets, consumer demand, inflation, or tax changes that influence business investment or activities. These effects may ultimately contribute to changes in local business output (production), employment, population, and demand for public services.

It is imperative that fisheries managers have a clear understanding of the current economic condition of the community and fishery under regulation, and of the likely socioeconomic consequences of regulatory changes to the fishery. This includes direct impacts to resource users, such as reduction in landings revenue due to lower catch quotas and shorter fishing seasons, as well as indirect or "downstream" economic impacts to local employment or associated industries. Socioeconomic EFI can be grouped into five general categories: Employment, Expenditures, Resource demand, Revenue, and User/industry demographics.

<u>Employment</u>

Changes in user activities related to non-consumptive uses, as well as commercial and recreational pursuits trickle through local economies and may cause changes to local economic output (e.g., production or product demand) and local employment. That is, each job that is lost in a community directly and indirectly influences other related jobs in the community. Resource managers use local employment information to help predict the ultimate outcome of regulatory changes to overall employment in local communities.

<u>Expenditures</u>

There are two general expenditure categories of importance to resource managers: direct expenditures on resource-related activities, and indirect expenditures associated with those activities. Resource managers and others tend to focus on the relative value of landed catch and not on the realm of expenditures associated with the end product (e.g., market seafood or sport fisherman's catch). A broader perspective regarding expenditures related to resource use is warranted and important because local economies or communities are dependent on both direct and ancillary expenditures.

Information on direct expenditures for fishing such as bait and fuel can be derived from the ongoing Marine Recreational Fisheries Statistics Survey (MRFSS) or DFG databases. However, indirect expenditures associated with commercial fishing operating costs, expenses of non-consumptive users, or travel and lodging expenses for a sportfishing trip must be captured through field interviews of users. Examples of indirect expenditures might include vessel taxes, medical insurance or worker's compensation – all necessary to fishing. This information is used to estimate the likely changes to user expenditures and local economic output arising from changes in resource availability or regulations.

Resource demand

Resource demand is the relationship between the quantity and quality of a good or service, and demand by the user at various market prices or costs. For instance, a sport fisherman may be willing to pay a considerable sum to expect to catch ten fish in a single trip. But, the same fisherman may not value any additional fish at the same incremental cost as paid for the first ten. As another example, a recreational diver may be willing to pay more to visit an area where the marine resources are in pristine condition (more species, greater size diversity). Resource managers must be aware of these demand relationships for user groups in order to make efficient allocations of limited resources and optimal use of public resources.

Revenue

This category includes revenue from the sale of local goods or services within the community, as well as those goods or services which are exported out of the community. Those exports represent new money entering the local economy from outside. An influx of money from outside the community is crucial to each local economy since it offsets the monetary outflow for goods and services purchased from outside that community. Revenue information allows resource managers to assess how changes in resources or regulations may affect industry-sector revenues and ultimately, the local community's economic output and vitality.

User/industry demographics

Local fishing community and user-group information, such as population size, average income levels, age distribution, and industry composition, are used to gauge the potential impact of regulatory changes on local economies and individuals. Much of this information is obtained through surveys conducted by state or federal government agencies; however, more detailed information may entail targeted surveys of the resource users or other groups of interest.

4.3 Fishery Data Collection Techniques

Two major categories of data collection exist in the field of fisheries science, fishery-dependent and fishery-independent, which differ in their underlying assumptions, expense, strengths, and weaknesses. Our intent is to provide the reader with a summary of the primary techniques utilized by the DFG to collect EFI, the benefits of such techniques, and the value in pursuing multiple methods. The DFG's collection and monitoring efforts have been thoroughly summarized in the CERES database (see References).

A general summary of the methods of collecting both biological and socioeconomic EFI is presented in Table 4-1. The table illustrates the potential for numerous types of EFI to be collected by a single sampling method or study. The quality of EFI collected is dependent on a well-designed sampling protocol and the collection of data over a time period sufficient to assess annual variation in the resource. Historically, EFI quality has varied with species and/or fishery of concern and collection method. Comprehensive data collection programs should contain both fishery-dependent and fishery-independent components.

Table 4-1. Methods commonly used to obtain essential fishery information (EFI).

Methods / EFI	Age and growth	Stock distribution	Ecological interactions	Indices of abundance	Movement patterns	Recruitment	Reproduction	Socioeconomics	Total mortality
Creel	P	P	S	P	S	P	P	P	P
Dockside/market	P	P	S	P	S	P	P	P	P
On-board	S	P	S	S	S	P	P	P	P
Landing receipts		S	S	P				P	P
Logbooks		S	S	P				P	P
Fishing	P	P	P	P	P	P			S
Egg abundance		P	P	P	S	P	P		P
Underwater	S	P	P	P	P	P	P		
Hydroacoustic surveys		P	P	P	P	S	P		P
Laboratory	P		S			S	P		P
Genetic		P			S				

P - Denotes methods that are primary sources of EFI
S - Denotes methods that are secondary sources of EFI

4.3.1 Fishery-Dependent Techniques

Fishery-dependent data is information collected from direct observation of a fishery. The DFG has historically employed five categories of monitoring to collect EFI: creel (pier/skiff) surveys, dockside/market sampling, on-board observer programs, landing receipts, and logbooks. These activities have continued for many years in both commercial and recreational sectors of California's fisheries, and provide the DFG with vital insights on the status of both the fishery and the exploited species.

Fishery-dependent data collection provides many types of EFI. Some of this information is useful when collected over short periods of time, but its greatest value in understanding fisheries and harvested resources is in analyses of long-term trends. Resource managers make inferences about population trends using landings data, although its unique limitations can make interpretation of trends difficult. Fishery landings comprise only a portion of the population, and gear selectivity, skill of fishermen, and allowable harvest levels all determine what portion is caught. As a result, population estimates can only be indirectly calculated. It is difficult to obtain standardized measures of fishing effort, and species identification can be imprecise or inaccurate.

While these methods are generally less expensive than fishery-independent methods, they provide only part of the information necessary to make management decisions. They are most useful when they are part of a comprehensive management program that employs both fishery-dependent and fishery-independent studies in a complementary fashion.

Creel surveys

These surveys are conducted by DFG or contract staff who interview sport fishermen at boat-launching ramps or at points where they are fishing from land (e.g., beaches, piers, and rocky coastline). Samplers typically gather information on: number of each species caught, number of each species kept, size and sex of kept fish, number of fish returned to the water, type of gear used, number of fishermen in the party, and total hours fished. Certain creel surveys may also collect socioeconomic data such as distance traveled from home or from port, length of stay in the area, and expenditures. The accuracy and precision of these surveys depend largely on a good working relationship between DFG staff and the fishermen being surveyed. Information collected on catch composition, catch-per-unit-of-effort, size limits, and fishing mortality are used to determine how the recreational sector of a fishery affects a resource.

Dockside/market sampling

Dockside or fish market sampling is used to collect commercial landings data after the catch has been off-loaded and, in the case of multiple-species landings, separated into market categories. These data provide important information on total weight, species composition, size, sex, age, and maturity of the species being landed. It is important to note, however, that this type of sampling provides imprecise estimates of fishing effort, and little or no information on bycatch or discards. Fishery landing statistics collected from this sampling allow fishing mortality rates to be calculated (excluding any discard mortality).

On-board sampling

Scientific observers accompany commercial and sport fishermen on fishing trips to collect biological and socioeconomic data at sea. Observers collect information on the location fished, total catches (not just landed), and the species, size, sex, and maturity of fish caught. In some fisheries they also collect (or have collected in the past) data on bycatch, discards, and interactions with birds and marine mammals. This information also can be used to verify logbook and creel survey data. On-board sampling also has the potential to address socioeconomic gaps in EFI. On-board observers collect EFI that cannot be obtained by other means (e.g., bycatch, precise fishing locations of each unit of fishing effort, etc.).

Landing receipts

The DFG's first major attempt to gather EFI began in 1916 with the use of landing receipts, or "fish tickets," as they are commonly known. Commercial buyers are required to complete landing receipts when the catch is off-loaded onshore to track the amount of fish landed by weight or number, along with the tax due on those landings. These forms contain information on the species, general location fished, weight of the catch, and price paid for the catch. Many fish species are often grouped into multi-species market categories, based on similar market value, rather than separated into species-specific categories. Although limited in scope and accuracy, they are often the only information available on a particular fishery. The DFG has used direct sampling of market categories to improve species-specific landings information of many fisheries for over forty years.

Logbooks

Logbooks were developed to augment information obtained from landing receipts and require that fishermen record information such as catch, location fished, and time spent fishing for each time their fishing gear is deployed. The log is then sent to the DFG. Logbooks seek to access the professional knowledge and observations of fishermen to improve fishery management. The utility of the information that they provide is dependent on its accuracy, timeliness, and return rate. Appendix J lists fisheries that currently require logbooks.

4.3.2 Fishery-Independent Techniques

Fishery-independent data is information collected from sources other than directly from the fishery. In other words, scientists collect data from direct observation, or studies, of the species and ecosystem of interest. While fishery-independent methods may capture rather diverse data types, they often focus on: population size, life history information, habitat requirements, distribution and movement, and fishing gear characteristics and effectiveness. Research has also been conducted on new techniques to evaluate management strategies and fishing methods, as well as to develop new *in situ* population studies.

The DFG routinely uses fishery-independent methods when needs arise and resources are available. Many projects are conducted in collaboration with other fisheries agencies and academic scientists to pool expertise and minimize costs. Like fishery-dependent information that they complement, these data collection activities possess their own unique limitations and assumptions. Fishery-independent research collects standardized information, often on all life stages, not just what is marketable or utilized by the fishery. Often greater technology and more sophisticated equipment are required than for typical fishery-dependent data collection. Managers require comprehensive data of both types to make well-informed management decisions. The following are many of the fishery-independent methods the DFG uses to collect EFI:

Fishing surveys

Rather than rely on a commercial or recreational fishery to provide the DFG with samples, biologists often collect their own using a variety of gear. Since fisheries often use gear that selects certain sizes or a sex of fish or invertebrates, their catches usually do not represent the entire population. By using gear that catches a representative sample of the entire population, such as trawls for some fisheries, the DFG avoids such limitations of fishery-dependent samples. The DFG may also use this method to experiment with gear types that may be recommended for use in commercial or sport fisheries.

Tagging

Tagging animals provides EFI such as their movement, age, growth, and population size. Fish or invertebrates are captured alive, size and catch location recorded, tagged externally (typically), and released. If they are recaptured at a later date, information can be obtained on how far they traveled, how much they grew, and how old they are since being released. Tagging studies are most frequently conducted with the advice and participation of fishermen, who are most likely to recapture tagged animals and return the tag, and/or the animal, to the DFG. Information on distribution patterns and movement of fish is valuable to resource managers because it allows insight into the areas and times that stocks are most vulnerable to harvest or environmental effects.

Egg abundance surveys

Surveys to estimate the abundance of eggs spawned by a particular species of fish or invertebrate are also used to estimate the size of a population, especially the reproductive portion of a population. This method also provides information on the amount of reproduction that has occurred, its locations, and spawning habitat preferences.

Underwater (*in situ*) surveys

The ability to deploy divers or equipment underwater to make direct observations of animals and habitats is indispensable to the DFG. These methods allow a variety of EFI to be collected which cannot be collected in any other way such as: detailed habitat preferences, many ecological interactions, movement patterns, and non-lethal size/abundance information. The most widely-used method to gather data underwater is scuba. Scuba-based projects are equipment-intensive, and require a relatively large staff to ensure the requisite sampling effort. Intensive scuba surveys are strictly limited by depth (to approximately 60 feet) and bottom time, and are also constrained by weather and sea conditions.

Submarines and remotely operated vehicles (ROVs) are also capable of direct, *in situ* observation of the environment and living resources. Unlike divers, however, their operation is not as severely constrained by depth, ocean conditions, or operating time. In addition, these units are capable of carrying a wide array of sensory and recording instrumentation such as: CTD[1], habitat mapping, video, and navigational equipment. These are powerful investigatory tools for fishery-independent research, and have been used successfully by the DFG.

Hydroacoustic surveys

Hydroacoustic technology is familiar to most fishermen because it is the same technology used by depth finders and sonar to locate schooling fish or the ocean bottom. This method can be used to measure the size, distribution, and movement of fish schools, and to map and characterize the associated bottom or habitat type. It is most useful for species that exhibit schooling behavior. "Ground-truthing," or validating, hydroacoustic surveys is accomplished by using nets to catch, identify, and quantify the species being surveyed. Divers are also used to identify and quantify habitat.

Laboratory studies

Laboratory studies provide EFI that cannot be collected in the field. They are sometimes experimental in nature, and may require collaboration with non-DFG scientists for the necessary expertise. They include topics such as: age determination and validation, genetics, behavior, food and environmental requirements, reproduction and growth.

Genetic investigations

Recently, scientists have refined genetic assessment techniques to sample populations to differentiate discrete fish or invertebrate stocks. Separate stocks of a given species may have very different life histories and this type of EFI may be used by resource managers in regional management strategies.

4.4 Future Essential Fishery Information Needs for Highest Priority Fisheries

All FMPs will have different EFI requirements and data needs which will affect their costs. In the context of the Master Plan, it is not possible to determine EFI requirements for all future FMPs. However, it is possible to briefly discuss EFI relative to each proposed FMP. In order to do this effectively, subject-area experts were sent a questionnaire inquiring about the status of knowledge for all EFI for a species or group of species. The questionnaire results were then used to subjectively assess EFI categories as either data-rich (R), data-moderate (M), or data-poor (P), in order to identify future data needs for the proposed FMPs (Table 4-2). These categories are defined as: data-rich – able to proceed with FMP development with a high degree of confidence; data-moderate – able to proceed with FMP development with some confidence; and data-poor – unable to proceed with FMP development with any confidence. The following is a brief discussion of EFI needs and the most efficient means of collecting missing data.

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[1]Conductivity, temperature, depth

Table 4-2. Status of essential fishery information (EFI) for the 10 highest priority fishery management plans (FMPs) identified in the Master Plan. R = data-rich, M = data-moderate, and P = data-poor (see text for definitions of these categories).

FMP	Species (EFI)	Age and growth	Stock distribution	Ecological interactions	Indices of abundance	Movement patterns	Recruitment	Reproduction	Socioeconomics	Total mortality
Sea Urchins	Red sea urchin	R	P	M	M	R	M	R	P	M
	Purple sea urchin	R	P	M	M	R	M	R	P	M
California Halibut	California halibut	R	R	R	M	R	M	R	P	M
Nearshore Sharks and Rays	Brown smoothhound	M	P	P	P	P	P	M	P	P
	Gray smoothhound	M	P	P	P	P	P	M	P	P
	Pacific angel shark	M	P	P	P	M	P	M	P	P
	Shovelnose guitarfish	M	P	P	P	P	P	P	P	P
	Bat ray	M	P	P	P	P	P	M	P	P
Surfperches	White seaperch	P	P	M	P	P	P	M	P	P
	Redtail surfperch	P	P	P	M	P	P	M	P	M
	Pile perch	P	P	M	P	P	P	M	P	P
	Shiner perch	M	P	M	M	M	P	M	P	P
	Walleye perch	P	P	M	P	M	P	M	P	P
	Black perch	P	P	M	P	M	P	M	P	P
	Barred surfperch	M	P	P	M	M	P	M	P	M
	Rainbow surfperch	P	P	P	P	P	P	M	P	P
	Striped seaperch	M	P	M	P	M	P	M	P	P
	Rubberlip seaperch	P	P	P	P	P	P	P	P	P
Sea Basses	Barred sand bass	R	R	M	M	M	P	R	P	M
	Kelp bass	R	R	M	M	M	P	R	P	M
Spiny Lobster	California spiny lobster	R	P	M	M	M	P	R	P	M
Sea Cucumbers	Giant red sea cucumber	M	P	P	P	P	P	M	P	P
	Warty sea cucumber	P	P	M	P	P	P	P	P	P
Subtidal Snails	Kellet's whelk	P	P	P	P	P	P	P	P	P
	Wavy top shell	P	P	P	P	P	P	P	P	P
Intertidal Invertebrates	Top shells (*Tegula spp.*)	P	P	M	P	P	P	P	P	M
	Giant owl limpet	M	P	M	M	M	P	P	P	P
Kelp	Giant Kelp	R	R	M	R	R	R	R	P	R
	Bull Kelp	R	R	R	M	M	R	R	P	M

Sea urchins

Age and growth, reproduction, and movement patterns are well documented for both red and purple sea urchins. Other categories of EFI are considered data-moderate with the exception of stock distribution and socioeconomics, which are classified as data-poor.

Further research is needed on wasting disease, which is fatal. Research is also needed to determine longevity and to study the interrelationship of purple and red sea urchins, because purple sea urchin populations tend to greatly expand following harvest of red sea urchins. Sea urchin research is well suited for a DFG program, with certain research components, such as genetic studies, better suited to outside experts.

California halibut

Age and growth, reproductive characteristics, food habits, distribution, movement patterns, and ecological relationships of California halibut are well known. More research is required on the remaining EFI categories because past research has been limited to southern or central California waters, with little EFI from Mexico or northern California. In addition, most of the known research on halibut was completed before1990, and no socioeconomic analysis of this fishery has been undertaken.

Abundance surveys and recruitment estimates have focused on larval halibut and on juvenile halibut off southern and central California. The only published estimate of population size was obtained in the late 1980s.
Unpublished data are available on halibut abundance from a 1994 DFG trawl survey conducted off southern and central California.

Fishery-independent trawling is the most efficient method of obtaining missing EFI for this species. Information on nearly all EFI categories, except socioeconomics, can be obtained directly by trawling. Trawling can also provide samples for other research, such as genetics, movement patterns, and age and growth studies.

Nearshore sharks and rays

Essential fishery information for the nearshore sharks and rays, when considered as a species group, is data-poor. The exceptions are age and growth information and reproductive characteristics, which are moderately known for all species. Validation of ageing techniques and further work on spatial and temporal aspects of reproduction are needed to improve these categories of information for management. There are also moderate exceptions to the data-poor categorization of movement patterns for brown smoothhound, Pacific angel shark, and bat ray; although most studies are limited both spatially and temporally. Most of the information on the southern California Pacific angel shark fishery was accumulated in the 1980s.

Considerable fishery-dependent monitoring and fishery-independent assessment activities need to be implemented, and existing efforts bolstered, to ensure the sustainability of nearshore sharks and rays. Fishery-dependent recreational creel surveys, improved commercial landings records, onboard observers (to gather information on effort and discards), and tagging programs could improve knowledge of stock distribution, movement patterns, and total mortality.

Fishery-independent assessments need to be undertaken on genetic stock structure, indices of abundance, ecological interactions, movements and recruitment. In some cases, these programs could work in cooperation with commercial and sport fisheries. Socioeconomic information needed for management can be developed from a variety of fishery-dependent queries and analyses.

Surfperches

Most of the EFI for surfperches, when considered as a species group, is data-poor. However, information on reproductive characteristics, ecological interactions, and movement patterns may be considered data-moderate. Shiner perch, striped seaperch, barred surfperch, black perch, redtail surfperch and walleye perch have relatively more EFI available on a species-specific basis.

Much work needs to be done to fill EFI data gaps in order to ensure a sustainable surfperch FMP. Current fishery-dependent monitoring can contribute to age and growth, stock distribution, indices of abundance, movement patterns and total mortality EFI categories, if improved and expanded in both the sport and commercial sectors of the fishery (e.g., species and location-specific landings information, and biological sampling).

Fishery-independent assessment work is necessary on genetic stock structure, ecological interactions, indices of abundance, recruitment and movement patterns, and total mortality EFI categories. Depending on the species, such programs could make use of *in situ* research techniques (e.g., scuba, remotely-operated vessels or ROVs), as well as mid-water trawl and seine capture techniques. In addition, joint studies with commercial and sport fishermen, such as tagging programs, have considerable promise. Management-related socioeconomic information can be acquired from a variety of fishery-dependent queries and analyses.

Sea basses

For both kelp and barred sand basses, age and growth, stock distribution, and reproduction are well known. Data on recruitment and socioeconomic EFI is considered poor, but all other EFI categories are considered data-moderate.

The regional nature of this fishery is conducive to a DFG research program utilizing collaboration with other agencies, academia, and sport fishermen. Fishery-independent work is needed to collect better information on abundance, recruitment, and total mortality. Both species are well suited for tagging studies and are easily observed during scuba surveys.

Spiny lobster

Age, growth, and reproductive characteristics of spiny lobster are well known. Existing data for the other EFI categories are not current and are therefore considered moderate to poor. Information is needed on inter-relationships with other species, and effects of oceanographic regimes and human-caused disturbances on their populations. Like the sea basses, lobster research is also well suited to a DFG program using a collaborative approach since it is also a regional fishery. Essential fishery information on stock distribution and recruitment is needed. This may require collaboration with scientists from Mexico since a large portion of the lobster's range occurs off of Baja California.

Sea cucumbers

Essential fishery information for giant red and warty sea cucumbers is generally data-poor. However, there is a moderate amount of data on age and growth, indices of abundance, and reproductive characteristics for the giant red sea cucumber. There is also a moderate amount of data on age and growth and ecological interactions for the warty sea cucumber.

Further research on interspecific relationships, effects of oceanographic regimes, and effects of human-caused disturbances on their populations is required. Population monitoring is recommended for both species via fishery-independent studies using underwater techniques and trawling surveys.

Subtidal snails

All categories of EFI are poorly known for wavy turban snails and Kellet's whelk. The harvest of wavy turban snails and Kellet's whelk has yet to be sufficiently quantified. Population estimates and basic life history information would be best obtained through cooperative research studies with universities. Fishery-independent work using a variety of underwater techniques would be the best method to obtain much of their needed EFI.

Intertidal invertebrates

Essential fishery information for top snails (*Tegula* spp.) is poorly understood. *Tegula funebralis* is the only species for which indices of abundance, age and growth, recruitment, and reproductive characteristics are available.

Studies of giant owl limpets at many sites off central and southern California have increased our knowledge base to the data-moderate level on indices of abundance, age and growth, movement patterns, and ecological interactions. However, information is absent or poor for total mortality, recruitment, and stock distribution.

The harvest of *Tegula* spp. and owl limpets needs to be quantified and monitored by the DFG. Information on the effects of human perturbations and oceanographic conditions on the abundance and health of their populations is needed. Mark and recapture is the most efficient method of obtaining age and growth data. All of these studies are well suited for cooperative research programs with universities.

Kelp

Essential fishery information for giant kelp and bull kelp are well known. Aerial surveys are the most efficient method of determining annual health, distribution, and abundance of both giant kelp and bull kelp. Scuba surveys are well-suited for estimating growth rates and recruitment, "ground-truthing" other abundance estimation techniques, and studying ecological relationships. Movement pattern data is only applicable to drift kelp. Harvest-related mortality may not apply to giant kelp because only the canopy is removed. However, when bull kelp is harvested, the entire plant is removed. Both species are susceptible to heavy mortality during storms or high surf conditions.

4.5 Prioritizing Essential Fishery Information

While all of the previously mentioned fishery information is important for sustainable management, the DFG recognizes that it has quite limited fiscal and staff resources for the collection of EFI for individual FMPs. The following factors influence where, and in what priority, those resources will be directed for collecting EFI: cost, available technology, appropriate expertise, jurisdictional limitations, prior availability and quality of baseline information, and the relative importance of specific EFI for managing a particular fishery.

Many monitoring and assessment techniques (e.g., creel, market, or dockside monitoring) can collect EFI from many categories simultaneously (Table 4-1), whereas the logistics of some techniques (e.g., landing receipts, laboratory studies) may allow collection of a fewer number of EFI parameters. Many EFI parameters require long-term investigation to be most valuable (e.g., comparing catch rates to oceanographic parameters and growth rates). The most efficient method of collecting EFI begins by balancing specific informational needs with the resources available to collect that information (including methodology, expertise and budget).

As an example of how EFI can be prioritized, the DFG's Nearshore FMP ranked biological EFI needed for sustainable fisheries management of 19 species. Eight EFI categories were ranked as follows:

1. Indices of abundance
2. Total mortality
3. Age and growth
4. Recruitment
5. Ecological interactions
6. Reproduction
7. Stock distribution
8. Movement patterns

In this case, the ranking methodology was developed specifically for fisheries that directly exploit nearshore finfish. It was determined that the first three EFI categories (Indices of abundance, Total mortality, and Age and growth) provided core information, regardless of which management tool was applied to this fishery (e.g., harvest control rules, regional management, restricted access, or marine protected areas), and that an emphasis should be placed on collecting these EFI.

4.6 Public Involvement in Collecting Essential Fishery Information

The MLMA states that the public shall be involved in the design and conduct of research. It is important that the scientific "deductive" method of information gathering be augmented by the direct observations and experience of others with specialized knowledge of the resource. The public at large, and more specifically members of the fishing community, have a collective knowledge of fisheries which should be used by resource managers. Similarly, members of non-consumptive "user-groups" offer a unique perspective, and their knowledge can also be used to fill data gaps.

The DFG fosters and encourages public involvement in fisheries monitoring and research. This is best accomplished within a framework that ensures the collaboration of divers, fishermen, and others in research design, the objective collection and analysis of data, and the cooperation of all in carrying out these activities (see Chapter 5).

Department of Fish and Game/public cooperative projects can have many benefits. They may: (a) enhance monitoring and research efforts; (b) foster communication and cooperation; (c) consolidate costs; (d) enhance resource stewardship; and (e) build trust and understanding during the development of long-term conservation goals. Some examples of activities that could incorporate members of the public (fishermen, processors, trade associations, non-consumptive users, etc.) in their design and execution are:

- Conduct educational workshops on fish identification, biology, or regulations;
- Assist in the development of commercial and sport fishing gear that reduces discards or habitat damage;
- Share vessels with other agency research programs;
- Utilize sport and commercial fishermen to develop observer programs;
- Support collaboration with other agencies and universities;
- Encourage projects and ideas suggested by the public;
- Encourage volunteer programs to collect data from sport and commercial fisheries;
- Use volunteer scuba divers to conduct habitat and fish abundance surveys.

Uncertainty in assessing the dynamics of fisheries will likely remain. However, cooperative EFI investigations invoke confidence by members of the public that the best information available, scientific and otherwise, is being used in marine resource management. This, in turn, encourages consultation and cooperation in the FMP development process. Furthermore, better understanding of EFI parameters through public involvement can diminish uncertainty, and help agencies progress toward adaptive and proactive management essential to achieving sustainable fisheries.