Chapter 7. Fishery Research Protocols

Fisheries sustainability is an elusive goal for marine resource managers. The cornerstone of effective resource management is a comprehensive spatial-temporal knowledge of the resource. However, there is a paucity of this knowledge for most marine resources, mainly because of our limited powers of direct observation. In the ocean most processes occur out of our view, thus our knowledge of marine communities, species abundance patterns and ecological interactions is fragmentary.

Fishery research is necessary to understand the many complex factors that contribute to the health and decline of our resources. This research is needed to provide management with guidance in making decisions to ensure sustainable fisheries. The MLMA recognizes the importance of research and requires all FMPs to contain fishery research protocols (§7081 FGC). These research protocols must:

- describe past and ongoing monitoring of the fishery;
- identify essential fishery information (EFI) for the fishery, and if any is lacking, identify resources and time to acquire it; and
- indicate steps to monitor the fishery and obtain EFI.

Little biological information on white seabass has been gathered in the past 30 years. Thus, EFI is lacking in many areas. Future research should work toward acquiring this EFI, and involve collaborative efforts of the fishing industry (both commercial and recreational) and qualified university or private fisheries research companies. In accordance with MLMA, this chapter describes fishery research protocols designed to implement the WSFMP; it identifies gaps in the current knowledge of white seabass stocks and fisheries and the steps needed to obtain this information for implementation to be successful.

7.1 Essential Fishery Information

The MLMA provides an opportunity for fishermen, scientists, fishery managers, conservationists, and other concerned constituents to develop a new approach for managing our marine resources. The MLMA recognizes the importance of a collective body of biological, ecological, physical, economic and social information known as "essential fishery information" (EFI). This information is critical for the sustainable use and successful management of the State's marine resources. The MLMA calls for the Department to base FMPs on the best available scientific information (§7072(b) FGC). In addition, any gaps in EFI of a fishery are to be identified, along with steps to close those gaps (§7081 FGC). Essential fishery information generally falls into two broad categories based on how the data were obtained: fishery-dependent (related to the take of fishermen), and fishery-independent information (data gathered independent of the fishery).

7.1.1 Grouping Essential Fishery Information

There are numerous parameters that comprise EFI. In an attempt to identify which EFI the Department should focus its resources on, nine broad EFI groups were created. It is important to emphasize that these groups are not mutually exclusive of one another since one group may include components that also fall under another. These groups were formed so EFI could be prioritized based on what information was most crucial for management. The nine EFI groups are:

<u>Age and growth characteristics</u>:
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. This information is often essential for stock assessments and models that guide management strategies. Specific EFI includes von Bertalanffy growth parameters (k), length/weight ratios, longevity, age/length ratios, age/size at sexual maturity, and age/length at recruitment into the fishery.

<u>Distribution of stocks</u>:
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. Specific EFI includes the depth and geographic range of a species, the amount of gene flow and genetic structure of the stock, and whether stocks are separate or continuous.

<u>Ecological interactions</u>:
This information identifies the interaction of fishes within the environment, habitat, and ecological community. Ecological relationships include the effects of oceanographic regimes and anthropogenic perturbations on physiological, energetic, or behavioral variables; ecological niches and placement in food webs (prey and predators); density-dependent and density-independent interrelationships within and among species; and the importance of essential fish habitat and habitat quality to a species. Estimation of any ecological relationship demands a species-specific within-habitat approach due to environment and organism cross correlations.

<u>Estimates of abundance</u>:
This information helps to determine how many individuals of a population are out there and available to the fishery. This information is essential for all predictive modeling of marine resources. Estimates of stock size can be determined through direct (e.g., surveys) or indirect (e.g., examination of the exploitation history) means. Specific EFI includes relative densities of target and non-target species, habitat-specific absolute

densities, length frequency distributions, relative density estimates of life stages (i.e., eggs, larvae, young-of-the-year, juveniles, or adults), recapture rates of tagged fish, and catch-per-unit-effort information.

Movement patterns:
This information identifies the spatial distribution of fish and their residence time in specific habitats. Many species may exhibit movement patterns that are associated with specific oceanographic conditions. Certain species may aggregate in specific areas for spawning, move in predictable patterns, or move to certain locales that make them especially vulnerable to harvest. Insights into the movement patterns of fish are important to the development of management strategies based on regional catch quotas or marine protected areas. Specific EFI includes the home range, homing ability, seasonal migrations, environmental cues, and spawning grounds of a species.

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. In this context, recruitment refers to both recruitment to the fishery and recruitment to the population. Many species depend on successful recruitment events for replenishment of the stock. 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. Specific EFI includes the duration and distribution of egg and larvae, size and timing of settlement, and annual cohort success. Information on the availability of habitats and levels of predators and prey items is also important.

Reproductive characteristics:
This information helps describe the reproductive potential of a fish stock and its ability to replenish itself. Understanding key reproductive characteristics allows managers to set appropriate open and closed seasons as well as opened and closed areas based on important spawning habitat. This information is also crucial in selecting size/slot limits, escape mechanisms for traps, and mesh-size restrictions. Specific EFI for a species includes the number of eggs released, size at maturity, fertilization and spawning period, geographic spawning area, and the nature of mating systems.

Total mortality:
This information refers to all removals of fish from the biomass, and is used to predict how many animals remain to reproduce and replenish the population. Mortality figures are essential for stock assessments and models to determine the number or weight (biomass) which may be safely harvested from a population or stock on a sustainable basis. Total mortality is traditionally separated into natural mortality and fishing 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 number of animals which are removed from the population by fishing. Natural mortality refers to all other forms of removal of fish from the population such as predation, old age, starvation, or disease. Specific EFI includes catch data by species and area, amount and sizes of discarded catch, landings by gear type, and survivability of fish that are released.

Socioeconomic:
The economic stability of coastal communities and quality of life may be affected by changes in activities related to recreational fishing, or commercial fishing and processing. These changes may be caused by indirect factors or regulatory changes that directly affect fishing activities. Indirect factors include triggers from consumer or financial markets such as 1) changes in consumer demand due to the favorable pricing and supply of a substitute item for a fishery product(s); 2) inflation; and, 3) tax changes that affect business investments or activities. These effects may be manifested locally through resultant changes in business output, employment, population, and public service demand. The four broad categories of socioeconomic information include:

1. Employment:
Overall impacts to local community earnings and employment can be gauged using input-output multipliers to project the changes to local personal income and the number of local jobs. This procedure takes the direct change in final demand for an industry product or service in revenue or sales dollars and multiplies this direct change by a total income coefficient to estimate total change in local personal income. Similarly, multiplying the direct change by an employment coefficient yields estimates of changes in the number of local jobs.

2. Expenditures:
Regulatory changes that directly affect recreational or commercial fishing revenues in local economies have a downstream effect on other economic sectors which receive and re-spend those revenues. This turnover refers to the number of times a dollar changes hands in the local economy. Output multipliers are used to describe the turnover effect and interrelationships between the basic-sector and downstream business sectors in the local economy.

Additionally, changes that directly affect end-user demand for recreational fishing activities or commercial fisheries products may change end-user 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, we would expect end-users to spend more if the quantity or quality was improved. These changes in spending patterns may also affect purchases of related or ancillary goods or services provided in the local economy.

For example, a recreational fisherman may value a charter fishing trip limited to ten fish at $50 per trip. The fisherman may value this trip more than a fishing trip that is restricted to only five fish, for which the fisherman is only willing to pay $35.

Furthermore, the recreational fisherman who plans to take six $50 charter trips per year may take only three trips per year if the price is raised to $80 per trip.

Lastly, the costs (usually expenditures) of production of a good, 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 production where we have maximum economic benefit (or "profits"). This is important in creating harvest guidelines which foster optimum economic yield and economic efficiency in the fishing fleet. Economic efficiency equates to cost and waste minimizing practices.

3. Resource Demand:
Changes in the quantity or quality of available 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 aggregate demand, based on the combined responses of individuals to changes in a good or service, yields an overall demand function for a good or service. 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 end-users derive from a good. Consequently, the effects of in-season adjustments to harvest limits, or changes in bag limits, can be projected in terms of the anticipated response of the target group of end-users, as well as changes in the corresponding revenue streams.

4. Revenue:
This category includes revenue from the sale of local goods or services within the community and those goods or services which are exported out of the 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. Revenue generated by fishery-dependent activities (e.g., by commercial landings, recreational direct expenditures, or end-user consumption of commercial products) provides basic information for calculating contributions to local economies and a means to compare relative values of goods and services derived from the fishery.

7.2 Past and Ongoing Monitoring of the Commercial and Recreational Fishery

Three major categories of monitoring have been employed by the Department. These include dockside/skiff surveys, landings/market sampling, and onboard observer programs. These types of data collection activities have been ongoing for several years in both the commercial and recreational sectors of fisheries, and form the bulk of the Department's data collection for white seabass.

Along these lines, the Department has also coordinated with other agencies and research institutions to augment its own monitoring of the fisheries. One of the largest such projects is the Marine Recreational Fisheries Statistics Survey (MRFSS), which started in 1979. The MRFSS is coordinated by the Pacific States Marine Fisheries Comission (PSMFC) and funded by the National Marine Fisheries Service (NMFS). The MRFSS samples finfish taken by recreational fishing (i.e., party boat, shore fisherman, etc.) from Crescent City to San Diego.

7.2.1 Past Fishery-Dependent Monitoring

Fishery dependent data for white seabass have been collected from the commercial and recreational sectors of the fishery since 1916 and 1936, respectfully (Thomas 1968; Hill and Schneider 1999). Commercial data in the form of landing receipts or "fish tickets," which are filled out when the catch is sold to fish businesses or by fishermen selling directly to the public, are a major source of information on the amount of fish landed, landing location, gear used and value of the catch. Landing receipts to date have provided little essential fisheries information other than a broad idea of when and where fishing activity occurs and total dressed (gutted) catch. Logbooks are another useful tool for tracking fishing activity and one that helps to supplement and ground truth data gathered from landing receipts. In the case of white seabass, logbook information is gathered from the set and drift gill net fishery. The information recorded on the logs consists of date, boat name and identification number, crew size, catch location, numbers or pounds of fish, gear type used, mesh size, principle target species, associated species taken and landing receipt number. For the recreational sector of the white seabass fishery, the Commercial Passenger Fishing Vessel (CPFV) logbook has been the primary source for recreational fishing activity. Data entered on these logs includes date, vessel name and number, port of landing, number of anglers, species and number caught, hours fished, and catch location (Young 1969).

In addition to the collection of passive data sets, the Department has actively collected fishery dependent data on white seabass through dockside and at-sea interception of commercial and recreational fishermen. The typical data collected are species identification, size, weight, and disposition (i.e., kept, discarded), fishing method, catch location, and date. Additional data gathered whenever possible consist of sex, maturity through gonad collection, prey items through examination of stomachs, and ageing from otoliths.

For the commercial component of the white seabass fishery, biological data have been collected at commercial fish businesses from San Diego to Santa Barbara during the mid-1970s and through an at-sea commercial gill net observation project between 1983 and 1989. Data have been collected from various segments of the recreational fishery by the Department since 1962. Included in these surveys are a launch-ramp study, an at-sea CPFV survey, and a survey of private boat owners' catch and effort. As mentioned above, recreational catch data have been collected through the MRFSS program continuously since 1979 with the exception of a three-year period from 1990 to

1993.

7.2.2 Problems with Past and Ongoing Fishery-Dependent Monitoring

Currently, some fishery-dependent data suffer from being of limited use or inaccurate. Fishery-dependent monitoring, through the use of landing receipts and logbooks, does not provide adequate information about fishing location. The fishing blocks used by the Department are 10 nautical miles (nm) by 10 nm representing 100 square nautical miles of area. The size of the blocks is too large to identify specific fishing locations and/or populations of white seabass and does not lend itself to ecosystem management. In addition, the tendency among some fishermen is to alter the location data to prevent identification of "secret" fishing sites. In general, fish businesses have no idea where fishing activity has occurred and will use either a favorite block code to identify fishing location or fail to record catch information. Spatially explicit understanding of fishing spots can lead to identification of stocks, localized fishing mortality, and areas of stock depletion--all of which are important elements for proper fishery management.

Another problem area for fishery managers is inconsistent fishery dependent research and sampling effort. Fishery-dependent research of white seabass is plagued by a lack of consistent sampling effort that results from unstable funding, the inability to retain sampling personnel, and the changing nature of the fishing industry. Most fishery dependent research is funded through a mixture of state and federal programs. Budget shortfalls from one year to the next often result in reduced allocation of funds. This in turn leads to either reduced monitoring and sampling effort or complete cessation. In addition, most sampling programs rely on temporary employees, who can only work up to nine months per year and receive relatively low pay. Thus, constant turn over of temporary staff causes cessation of research and sampling activities, while permanent staff expends time hiring and training new temporary employees.

Finally, there has been a change in the way fish businesses operate. Traditionally, fish businesses operated out of a fixed location where sampling of offloaded catch was relatively easy. In the past twenty years, however, there has been a transition to mobility commonly known as the white-van fleet. Fish businesses, using large vans or trucks, now go to various locations within a port complex to meet fishing vessels. This shift makes it difficult to sample the catch since there are multiple locations where it can be offloaded. As a result, a large proportion is often offloaded and driven to market without being sampled.

In general, fishery-dependent data when used alone has performed poorly in predicting stock decline, especially for residential species (National Research Council 2000). Imprecise recording of fish landings, which are documented by fishery-dependent data, can actually hide precipitous declines in fished populations (Karpov et al. 2000). Vigorous and refined ecosystem-based sampling is needed to help adequately address the complex issues now faced by fishery managers.

7.2.3 Past Fishery Independent-Research

Fishery-independent data are important because they yield estimates of the abundance and distribution and the life history characteristics of the stocks that are more objective than those obtained from fishery-dependent data. Fishery-independent data: 1) provide measures of the relative abundance, trends, and estimates of the size and age structure of fish stocks which are not affected by fishing practices or management regulations; 2) calibrate trends in fishery-dependent estimates and tune assessment models; and 3) encompass a broad suite of information on the biological community, the physical environment and the ecosystem as a whole, that cannot be obtained directly via fishery-dependent measures. These data facilitate alternatives to classical demographic modeling (e.g., bioenergetic, mass-balance, and dynamic modeling). More powerful and sophisticated models can, in turn, enhance the accuracy of stock estimates and the predictability of fishable biomass.

There have been few fishery-independent studies on white seabass. Over the years, these studies have been limited to collecting data on age and growth in the 1920s, 1930s and 1990s; movement patterns, fecundity, and genetics in the mid-1970s (Maxwell 1977b); the effects of gear to quantify at-sea observations of the commercial fishery in the mid-1980s; and settlement patterns and habitat of young-of-the-year in the late 1980s and early 1990s. Over the past ten years, fishery-independent research has mainly focused on ways to improve hatchery operations and survivability of hatchery-reared fish. This research has included studies on genetics, aquaculture commercialization, feeding ecology, and the distribution and abundance of juvenile fish (HSWRI 2001).

7.2.4 Problems with past and Ongoing Fishery Independent-Research

Fishery-independent research has, and continues to be, conducted by a multitude of organizations through a diverse set of funding sources. Unfortunately, the bulk of the research suffers from the following problems:

- It has limited spatial coverage;
- It has been collected using a multitude of techniques;
- It has been conducted on some subset of the ecosystem;
- It cannot easily be compared with other data sets; and
- It can be very expensive.

Further, many of the samples and data sets previously amassed have yet to be fully analyzed. Resource limitations (i.e., personnel, financial) often prohibit the completion of projects and their integration across large spatial, temporal, or ecological scales. In addition, earlier fishery-independent research was sharply constrained as a result of being considered a minor component of the overall assessment strategy, too costly, or too difficult to approach due to the complexity of interacting natural and anthropogenic factors.

7.3 Current Knowledge of Essential Fishery Information

Currently, EFI for white seabass is limited for management purposes. More data and analyses are needed for stock assessments, life history, ecological interactions, and socioeconomics. A description of the data currently available on white seabass is outlined below:

Estimates of abundance:
A current stock assessment has not been done for white seabass. There is only limited indirect information regarding current abundances from catch data only. MacCall et al. (1976) estimated the abundance of white seabass in the mid-1970s, and a pre-exploitation abundance was estimated by Dayton and MacCall (1992).

Distribution of stocks:
Little information on stock distribution exists for white seabass other than the work done by Allen and Franklin (1988) and Franklin (1997).

Movement patterns:
Adult white seabass are believed to move northward with seasonally warming ocean temperatures (Skogsberg 1939). Little data exist for migration of the wild stock of juvenile and adult white seabass and how they are affected by oceanographic changes; however, there is increasing data for the movement of hatchery-reared white seabass.

Reproductive characteristics:
Some of the reproductive characteristics of white seabass have been identified. Fecundity and preferred spawning temperatures are known from laboratory studies; however, size at first maturity information is limited to a study done many years ago with very few samples (Clark 1930).

Age and growth characteristics:
Length-at-age and length-weight relationships have been calculated for white seabass but need to be verified by further age and growth studies. Thomas (1968) produced the best known estimate of a length-weight relationship for white seabass, which has been supplemented by work done by Donohoe (1997) and otolith ageing conducted by the Department (unpublished data).

Recruitment:
Some recruitment information is available. CalCOFI surveys between 1950 and 1978 identified the distribution of eggs and larvae along the Baja/California coast (Moser et al. 1983). In addition, work by Allen and Franklin (1997) and Allen et al. (2001) have furthered our knowledge of the rates, patterns and magnitude of white seabass recruitment.

Total mortality:
The current level of total mortality for white seabass is unknown. However, there are a few studies which provide estimates of total mortality for various time periods throughout the fishery (Thomas 1968; MacCall et al. 1976)

Ecological interactions:
No statewide coordination exists for studies of ecological interactions of white seabass. Consequently, little is known about the region-specific effects of oceanographic regimes and anthropogenic effects on the physiological, energetic, and behavioral characteristics of white seabass, or the species that they interact with as prey, predators, or competitors.

Socioeconomic:
Adequate information on employment, expenditures, and revenues for certain basic-sector industries are readily available or can be derived from existing sources. Such 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 USFWS, the California Department of Fish and Game, and local institutions and academic affiliates. Combined 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 relevant for a thorough recreational fishing analysis in the California nearshore area.

In addition, there is little information available regarding resource demand by the recreational community, commercial industry, or consumer end users. Consequently, there are no means of analyzing or predicting reactions of these user groups when faced with changes in the costs, quantity, or quality of goods, services, or raw materials derived from the fishery. This is essential information which must be considered when deciding harvest levels or the allocation of fisheries resources between competing user groups.

7.4 Research Needed to Obtain Essential Fishery Information

The following research needs are necessary to fill white seabass EFI gaps identified above. The overall goal is to bring our knowledge of white seabass stocks up from data-poor to data-rich; data-poor management using MSY control rules should be considered an interim solution. In order to better allocate the Department's limited resources (i.e., staff), research needs are categorized in terms of short-term operational and long-term strategic goals. From the standpoint of maintaining healthy white seabass stocks, the research needs identified under short-term goals should be addressed first by the WSSCAP following the adoption of this FMP.

7.4.1 Short-Term Research Goals and Needs

Goal: Perform white seabass stock assessment
Successful implementation of this WSFMP requires a current stock assessment. To date, only one stock assessment has been done for white seabass, which was based on a simple model using fishery dependent data collected from 1947-1973 (MacCall et al. 1976). We recommend, at a minimum, repeating the approach used by MacCall et al. (1976), using current fishery dependent data to calculate a more current estimate of MSY. We also suggest improvements to this model by devising better estimates of total mortality (see below), and improving the catch/effort estimates and biological sampling of the commercial and recreational fisheries.

A formal stock assessment using fishery independent data is also recommended. This will enable the Department and WSSCAP to better evaluate the plan's preferred alternative and recommended default MSY control rule. This stock assessment should strive to determine total mortality, a current stock size relative to B_{msy}, and a minimum stock size threshold (MSST). These resultant data can then be used instead of proxies to develop a better-fitted MSY control rule. Deciding upon the exact nature of the stock assessment (e.g., the data collected and type of model used) will be one of the first tasks for the Department and WSSCAP upon implementation of this FMP. Some of the models to consider involve catch-at-age data, egg and larval surveys, and yield per recruit analyses. As a starting point, it is strongly recommended that existing and ongoing data sets, such as the OREHP recruitment studies (Allen et al. 2001) and CalCOFI surveys, be evaluated as potential inputs.

Goal: Evaluate current white seabass regulations
As mentioned in 4.2, there are several management measures currently in place to manage the white seabass resource. The 28 inch minimum size regulation for recreational and commercial fisheries was put in place to allow for spawning of individual white seabass at least once before being taken by the fisheries. The data indicating this size limit, however, was based on only a few samples many years ago. Many feel 28 inches is below minimum size at maturity. Age/length at first maturity and at what size 50% of the white seabass are mature are questions that need to be answered with more data.

Because there is a minimum size limit, immature or undersized white seabass caught by recreational and commercial fisheries are released or discarded. It is unknown how often this occurs or the level of associated mortality. More accurate data on size frequency and mortality of released or discarded white seabass are needed for several reasons. First, regulatory improvements could be made to reduce this impact . For example, if it was determined that smaller hooks have a higher tendency to catch undersized fish, a regulation could be adopted to eliminate their use in the fishery. Likewise, conventional hooks could be prohibited from use when targeting white seabass if they are found to produce higher rates of injury to white seabass than circle hooks. Striped bass mortality, for example, was reduced considerably when circle hooks were used versus conventional hooks (Lukacovic 1999). Second, if mortality of released or discarded white seabass is high, then total mortality estimates could be greatly underestimated. For some species, such as coho salmon, hooking mortality may be particularly high, up to 25% of the fish released. This can have drastic effects on stock assessments since most models use estimates of total mortality. In addition, some models such as Virtual Population Analysis (VPA) or cohort analysis require catch-at-age data for assessing mortality on individual age classes. This necessitates data collection on size frequency and mortality of white seabass following regulatory and voluntary release from recreational and commercial fisheries.

Goal: Determine accurate estimates of bycatch
Limiting the type and amount of bycatch is one of the objectives for sustainable fisheries management under the MLMA (FGC 7056 (d)). This is also one of the specific goals of the WSFMP (see section 1.2.2). The WSFMP addresses bycatch in section 6.4.4, however, most of the data on the commercial fishery come from past gill net studies done inshore of current fishing efforts. Implementation of Proposition 132 in 1994 eliminated all gill nets from nearshore waters south of Point Conception. Therefore, present gill netting for white seabass takes place offshore and may have interactions with a very different assemblage of animals. It is necessary to investigate these interactions, particularly with regard to pinnipeds, birds, and sea turtles through an at-sea observer program.

Goal: Collect age/growth data
Age and growth of fishes is critical EFI for fisheries management. This information from scales (Thomas 1968) and otoliths (Department unpubl. data) is available for white seabass, but more information is needed. Few data exist for larger fish and more work on validating ages, especially for older age classes is desired. The age structure of the white seabass population is also needed. Catch at-age-data collected over a time series (years) provides the basis for assessing stock size using techniques such as VPA.

7.4.2 Long-Term Research Goals and Needs

Goal: Develop more sophisticated stock assessments and models
As mentioned above, a first step to assessing current white seabass stock size is through a simple model using data that are currently collected by the Department. However, the goal for white seabass management is to develop a more sophisticated model as more and better data becomes available. For example, white seabass catches have fluctuated considerably over the years, partly in response to changing oceanographic conditions. If a relationship can be found between temperature,

productivity, or some other variable and white seabass abundance, then this would provide valuable information for predictive modeling. Also, analysis of the recruitment data currently being collected (Allen et al. 2001), and other fishery-independent data can be input into models to yield better stock assessments.

Goal: Move toward ecosystem-based management approach
Although the WSFMP is a single species FMP, the Department's goal is to move toward ecosystem-based management. The development of more sophisticated models with more variables is a step in this direction. Analysis of the relationship between white seabass and important prey such as coastal pelagic species, especially the California market squid, involves several FMPs and will provide a better understanding of ecosystem functioning. It is also important to identify the habitat preferences, environmental conditions, and human impacts (e.g., pollution, dredging, and beach replenishment) that affect white seabass, especially the spawning and early life history stages. The end result may be the evolution of the WSFMP into a multispecies ecosystem-based FMP.

Goal: Expand studies of hatchery-reared white seabass
The Ocean Resources Enhancement and Hatchery Program (OREHP) realized their best production year in 2001 regarding numbers of white seabass released to the wild. As this production success continues, more legal-sized white seabass will be available to recreational and commercial fishermen. With more data, the efficacy of using cultured white seabass to restore native stocks should be fully evaluated, including cost/benefit analyses.

In addition to distinguishing hatchery-reared white seabass from wild stock fish, the tagging of individuals provides useful information for management. Mark-recapture data on white seabass provides information on inshore/offshore and along shore migration patterns. It can also be used in deriving population estimates. It is recommended that tagging of hatchery-reared white seabass continue and a wild stock tagging program be re-initiated.

Goal: Expand socioeconomic data collection and analyses
Much of the necessary socioeconomic data can be obtained or derived from existing sources. However, much of this information, including resource demand data, is not specific to the white seabass fishery. Resource-demand surveys of the primary user groups, namely commercial fishers and processors, recreational fishers, end-users of commercial products, and non-extractive users are necessary to adequately describe the socioeconomics of a particular fishery to managers and constituents. This information is particularly important when allocation of resources is necessary. To date, this kind of information has not been collected for white seabass in any deliberate, objective, or systematic manner.

To address this need, periodic user surveys should be conducted to derive user-group demand functions for discrete white seabass uses. In addition, costs-of-production for major user-sectors should be obtained from Department-initiated surveys or possibly from information collected by other state or federal agencies. These data will enhance our understanding of the economic and social repercussions to user groups brought on by management changes to the white seabass fishery.

Goal: Develop cooperative research with Mexico
As mentioned in Section 6.7.1, the California fisheries for white seabass target fish whose center of population appears to be off central Baja California, Mexico, and could be greatly affected by the Mexican fishery. The present and historical size of the Mexican fishery for white seabass is unknown; however, current Mexican regulations recommend that fishing effort not be increased for the artisan fishery, which takes white seabass. The magnitude of the commercial and recreational Mexican fisheries could have serious consequences for California's fishery.

Cooperative research with Mexico is needed and would enable us to understand the extent of their fisheries for white seabass and their effects on California's fishery. In addition, collaboration with Mexican fishery scientists would enable us to conduct more sophisticated stock assessments, better understand the essential habitats for white seabass, and learn how white seabass respond to changing oceanographic conditions.

Management of trans-boundary species, such as white seabass, is difficult. There are several issues that need to be resolved before cooperative research with Mexico is successful. These issues include differences in management philosophies, logistical problems (e.g., expenses), differences in socioeconomics of the fisheries, and distrust of intentions stemming back to 1982 when the Mexican government banned the United States commercial fleet from its territorial waters. However, if these issues can be resolved, the resulting information would be invaluable, and perhaps essential for the successful management of the white seabass resource in California.

7.5 Resources and Time Needed to Fill Essential Fishery Information Gaps

Resources and time are critical factors and potential obstacles to obtaining data necessary to fill EFI gaps. There needs to be a commitment of stable, long term funding to filling EFI needs for white seabass as well as other finfish that inhabit the same ecosystem. Once this commitment is made, effective use of the funds can be accomplished through coordination of research within the Department and with outside researchers. In addition to funding, an estimated one to three scientific aides per major Southern California port area (San Diego, Orange, Los Angeles, Ventura and Santa Barbara Counties) will be needed to gather biological information adequately. One to two biologists would also be needed to analyze the data and update the FMP. An economist could also be used to better determine socioeconomic factors of the fishery.

If improvements are to be made in data collection, fishermen and the public must be willing to shoulder a share of the costs by allowing more intrusive methods of collecting that data. The Commission must also be willing to implement new strategies in fishery management, and to provide for heavy penalties for non-compliance.

Depending on the availability of Department resources and the cooperation of the fishing industry (both commercial and sport), the time needed to gather sufficient EFI information could take anywhere from two to five years.

7.6 Steps to Monitor the Fishery and Obtain Essential Fishery Information

The Department will have to provide more personnel than are currently available in order to begin some of the research needed to address EFI issues. This may be accomplished by shifting priorities away from other fisheries and/or increasing the number of biologists and scientific aide positions. To effectively monitor the fisheries and maintain a well trained, efficient cadre of samplers, the Department will have to develop a permanent fishery technician classification to reduce the high turnover rate of scientific aides that currently impedes research and monitoring. The repeated hiring and training of personnel for at-sea sampling, ageing otoliths, and collecting other biological data is expensive and time consuming.

In addition to the steps identified above, several more steps need to be initiated that will benefit the Department's efforts to manage white seabass and other marine resources. The Department should in the next few years:

- Develop an infra-structure to facilitate communication, logistical support, standardization of data collection methods, preliminary analysis, and reporting;
- Initiate educational outreach programs to include angling ethics, fish identification and ecosystem management;
- Assess the effectiveness of enforcement and adjust as necessary to better manage resource (i.e., increasing penalties and/or enforcement);
- Obtain recommendations from WSSCAP of the best data collection activities and models for white seabass stock assessment;
- Assess relevance of previously collected data, publish for peer review, and use in management decisions;
- Collaborate with other state and federal agencies, academia, and the user groups to conduct EFI research; and
- Seek external funding sources.

These recommendations work toward providing needed EFI and bringing the Department closer to an ecosystem-based approach to the management of white seabass fisheries.