

# Appendix A: Management Considerations

This appendix of Management Considerations is provided for informational purposes only. These views, submitted by the authors, do not necessarily represent the views of either the California Department of Fish and Game or the California Fish and Game Commission, and no endorsement of any of these views by these agencies is implied.

## **Abalone**

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

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

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

- tection of the resource, in order to apply these costs to the fishery.
- A constituent involvement process that assists in evaluating the best uses of the resource. Such a process would also enable information-exchange between the DFG and interested parties.
- An evaluation of the consequences of reoccupation of the sea otter into southern California waters.

### Albacore

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

## **Angel Shark**

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

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

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

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

## **Barred Sand Bass**

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

## **Bay Shrimp**

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

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

#### **Bocaccio**

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

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

## **Bull Kelp**

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

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

## Cabezon

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

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

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

## Calico Rockfish

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

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

### California Barracuda

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

## California Corbina

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

## California Halibut

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

## California Sheephead

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

## **Coonstripe Shrimp**

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

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

## **Coastal Cutthroat Trout**

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

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

## Dolphin

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

## **Eel Grass**

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

## **Flatfish**

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

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

## Gaper Clam

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

## Geoduck Clam

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

## Giant Kelp

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

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

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

## **Giant Sea Bass**

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

#### Gracilaria

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

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

#### Grunion

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

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

## **Jack Mackerel**

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

## Kelp Bass

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

### Louvar

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

## **Monkeyface Prickleback**

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

## Mussels

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

## **Opah**

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

### Other Nearshore Rockfish

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

## **Pacific Bonito**

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

## **Pacific Hake**

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

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

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

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

## **Pacific Herring**

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

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

- the legislature, the commission was given management authority for the herring fishery during the roe fishery's second year. This allows the regulations to be changed on an annual basis and new issues to be addressed as they arise.
- Director's Herring Advisory Committee. This committee was established to seek valuable industry input on fishery-related matters.

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

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

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

## **Pacific Razor Clam**

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

## Pismo Clam

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

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

## **Purple Sea Urchin**

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

## **Red Rock Shrimp**

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

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

## **Red Sea Urchin**

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

 Expand existing fishery-dependent and -independent monitoring programs. Logbook data needs to be collected at a higher spatial resolution using GPS technology. Fishery-independent needs to be expanded to allow managers to assess density and size distributions. Fishery-dependent monitoring will detect trends in harvest, but is confounded by harvest levels, which are strongly affected by quality of urchin gonads and market conditions. Fishery-independent monitoring will allow managers to assess abundance of size classes and poor quality urchins not sampled within the fishery. Continuation and expansion of long-term monitoring of settlement patterns is crucial to providing a relative measure of settlement supply and should be continued and expanded. Reestablishment of an industry-based revenue system would assist in funding these programs.

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

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

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

## Ridgeback Prawn

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

## **Rock Crabs**

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

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

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

## **Rock Scallop**

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

#### Salmon

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

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

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

## Sand Crab

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

## Scorpionfish

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

#### Sea Cucumber

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

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

## **Sheep Crab**

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

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

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

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

## **Shortfin Mako**

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

## **Silversides**

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

## **Skates and Rays**

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

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

## Skipjack Tuna

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

## **Spiny Lobster**

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

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

## **Spot Prawn**

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

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

## **Spotfin Croaker**

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

## **Spotted Sand Bass**

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

## Steelhead

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

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

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

## **Striped Marlin**

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

## **Swordfish**

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

## **Smelts**

#### **Delta Smelt**

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

#### Eulachon

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

#### **Longfin Smelt**

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

## Night Smelt

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

#### Surf Smelt

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

#### Wakasagi

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

#### Whitebait Smelt

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

## **Washington Clam**

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

## **Wavy Turban Snails**

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

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

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

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

## White Croaker

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

## **Yellowfin Tuna**

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

## Yellowfin croaker

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

## **Yellowtail**

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

# Appendix B: Glossary

- ABC See Acceptable Biological Catch.
- Abyss The deepest part of the ocean.
- Acceptable Biological Catch (ABC)- A term used by a management agency which refers to the range of allowable catch for a species or species group. It is set each year by a scientific group created by the management agency. The agency then takes the ABC estimate and sets the annual total allowable catch (TAC).
- Advection Horizontal or vertical movement of water.
- **Allele -** One of several variants of a gene that can occupy a locus on a chromosome.
- Allozyme A variant of an enzyme coded by a different allele.
- Amphipod Laterally compressed, planktonic or benthic crustaceans.
- **Anadromous -** Fish that migrate from saltwater to fresh water to spawn.
- Anaerobic Living in the absence of oxygen.
- **Angler -** A person catching fish or shellfish with no intent to sell. This includes people releasing the catch.
- **Annuli** Annual variations in the pattern of growth rings on fish scales.
- Aquaculture The raising of fish or shellfish under some controls. Feed and ponds, pens, tanks, or other containers may be used. A hatchery is also aquaculture, but the fish are released before harvest size is reached.
- **Artisanal fishery -** Commercial fishing using traditional or small scale manually-operated gear and boats.
- Ascidiacea See Tunicate.
- **Bag limit -** The number and/or size of a species that a person can legally take in a day or trip. This may or may not be the same as a possession limit.
- **Baitboat -** Refers to a vessel that fishes with live bait.

  Examples of target catch for baitboats include albacore and other tunas.
- **Baleen -** A specialized plate of horny material used by some species of whales (Mysticetes) to filter-feed.
- **Barbel -** A slender flesh "chin whisker" found in many kinds of fishes. Barbels function primarily as sensory organs for locating food.
- **Bathymetry -** The science of measuring depths in the ocean.
- Batoid A skate or ray.

- **Beam trawl -** A conical-shaped net held open by an horizontal beam. At each end of the beam are iron frameworks that hold the net open in a vertical direction.
- **Benthic** Of, relating to, or occurring at the bottom of a body of water (including the ocean).
- Berried Bearing eggs.
- **Bight** A name for the water body found abutting a large indentation in the coast. A bight is less enclosed than a bay.
- **Billfishes -** The family of fish that includes marlins, sailfish and spearfish.
- **Bioaccumulation -** The build-up over time of substances (like metals) that cannot be excreted by an organism.
- **Biomass -** The total weight or volume of a species in a given area.
- **Biosystematics -** The study of relationships with reference to the laws of classification of organisms; taxonomy.
- **Biota** Refers to any and all living organisms and the ecosystems in which they exist.
- **Biotoxin -** Substances produced by organisms that can seriously impair living processes and in some cases cause death.
- **Bioturbation -** Disturbance of soft sediments by the movements and feeding activities of infauna (animals that live just beneath the surface of the sea bed).
- **Bivalve -** A mollusk with the shell divided into two halves; e.g. clams, mussels.
- **Brachiopod** A bivalve mollusk distinguished by having, on each side of the mouth, a long spiral arm, used to obtain food.
- **Brackish water -** Water of reduced salinity resulting from a mixture of freshwater and seawater.
- **Brail net -** A small dip net used to scoop out portions of the catch from the main net and haul these portions aboard. Brail nets are used to transfer tuna, salmon, and sometimes menhaden from the purse seine to the boat's hold.
- **Broken and burnt otolith method -** Otoliths are broken and burned, revealing more accurate information about the age of a fish.
- **Bryozoa** A group of sessile colonial animals that are colonial invertebrates and live on hard surfaces.
- **Bycatch** The harvest of fish or shellfish other than the species for which the fishing gear was set. Bycatch is also often called incidental catch. Some bycatch is kept for sale.
- CEQA California Environmental Quality Act.

- CPFV Commercial passenger fishing vessel.
- CPS Coastal pelagic species.
- CPUE See Catch Per Unit of Effort.
- **Calanoid copepod -** A crustacean zooplankton that has a barrel-shaped body, is found in all oceans of the world, and is an important food source for many fishes.
- Calcareous Made of calcium carbonate.
- **Capelin -** A small silvery fish, most common in the North Atlantic.
- **Caridean** An infraorder of the decapod crustaceans. Examples include many shrimps and prawns.
- **Catadromous** Refers to fish that migrate from fresh water to saltwater to spawn.
- **Catch -** The total number or poundage of fish captured from an area over some period of time. This includes fish that are caught but released or discarded instead of being landed. The catch may take place in an area different from where the fish are landed. Note that catch, harvest, and landings are different terms with different definitions.
- Catch Per Unit of Effort (CPUE) The number of fish caught by an amount of effort. Typically, effort is a combination of gear type, gear size, and the length of time gear is used. Catch per unit of effort is often used as a measurement of relative abundance for a particular fish.
- Caudal fin Tail fin.
- **Caudal peduncle -** The tapered, posterior fleshy part of a fish just in front of the tail fin.
- **Cephalopod -** Organisms belonging to the phylum Mollusca that are nearly always carnivorous and are characterized by complex behavior, a well-organized nervous system, a circle of grasping arms, and a powerful beak. Examples include squid and octopus.
- **Cetacean -** A member of the order of marine mammals that includes whales, porpoises, and dolphins.
- **Chimaera -** A member of a group of bottom-dwelling, invertebrate-feeding fishes. Distinctive characteristics include an operculum that covers four gill openings, an upper jaw fused to the skull, teeth consisting only of a few large, flat plates, and no scales.
- **Chitin -** A horny substance forming the hard part of the outer skeleton of crustacea.
- **Chiton -** Mollusks found commonly on hard substrates that are ovalshaped and flattened, have eight dorsal plates which cover the dorsal mantle, and are herbivores.
- **Chum -** To attract fish to a hook by throwing whole or chopped fish or shellfish into the water.

- **Cilia -** Hair-like structures used for locomotion, and in some species, for feeding.
- **Cladogenesis** The branching of an ancestral lineage to form equal sister taxa (species, genera, families, etc.).
- **Cladocera -** Planktonic crustacea with a bivalved outer skeleton.
- **Clupeid -** A member of the Clupeidae family of fishes. Clupeids include herrings, shads, sardines, and menhaden. They can be readily recognized by their keeled (sawtooth) bellies and silvery, deciduous scales.
- **Codend -** The end of a trawl net. Fish are eventually pushed into the codend as the net is dragged along.
- **Cohort -** A group of fish spawned during a given period, usually within a year.
- **Coliform -** A bacteria commonly associated with food poisoning.
- **Community -** An ecological unit composed of the various populations of micro-organisms, plants, and animals that inhabit a particular area.
- Congener A member of the same genus.
- **Convergence -** The contact at the sea surface between two water masses converging, one plunging below the other.
- **Copepod -** A group of small planktonic, benthic or parasitic crustaceans. Copepods that spend their entire life in the water column are usually the numerically dominant group of zooplankton captured by nets in most marine
- **Coriolis effect -** The deflection of air or water bodies, relative to the solid earth beneath, as a result of the earth's eastward rotation.
- Creel A container used by anglers to hold fish.
- **Crustacean -** A group of freshwater and saltwater animals having no backbone, with jointed legs and a hard shell made of chitin. Includes shrimp, crabs, lobsters, and crayfish.
- **Ctenophore -** Gelatinous zooplankton having eight longitudinal rows of fused cilia ('ctenes') used in swimming.
- **Cultch -** Material (as oyster shells) laid down on oyster grounds that furnish points of attachment for the young oyster.
- **Cycloid -** A round, flat, and thin fish scale found on fish such as trout, minnow, and herring.
- **Davit -** A fixed or movable crane that projects over the side of a boat or over a hatchway. It is used for hauling nets, anchors, boats or cargo.
- **Demersal -** Describes fish and animals that live near water bottoms. Examples of demersal fish are flounder and croaker.

- **Density** dependent factors Factors, such as resource availablilty, that vary with population density.
- **Depuration -** Cleansing of bivalve shellfish by moving them from polluted waters to clean waters.
- Detritivore An organism that feeds on detritus.
- **Detritus -** Any loose material produced directly from rock disintegration.
- **Diatom -** One-celled phytoplankton with an external skeleton of silica.
- **Dinoflagellate -** Unicellular plankton having two flagella and, in some species, a cellulose test.
- **Doliolaria -** The second stage of the echinoderm (which include starfish and sea urchins) larvae.
- **Dorsal fin -** An unpaired fin on the dorsal or upper side of the body, between the head and the tail.
- **Dory -** A flat-bottomed boat with high flaring sides, a sharp bow, and a deep V-shaped transom.
- Downwelling The sinking of water.
- **Drum seine -** Similar to a purse seine but the seine is stored on a large drum mounted at the stern. The drum is particularly successful in handling shallow nets.
- EPA Environmental Protection Agency.
- ESA Endangered Species Act.
- **Ecosystem -** A group of organisms that interact among themselves and with their nonliving environment
- **Effort -** The amount of time and fishing power used to harvest fish. Fishing power includes gear size, boat size, and horsepower.
- **Ekman circulation -** Movement of surface water at an angle from the wind, as a result of the Coriolis effect.
- El Niño Condition in which warm surface water moves into the eastern Pacific, collapsing upwelling and increasing surface-water temperatures and precipitation along the west coast of North and South America.
- **Elasmobranch -** Describes a group of fish without a hard bony skeleton, including sharks, skates, and rays.
- **Electrophoresis -** A method of determining the genetic differences or similarities between individual fish or groups of fish by using tissue samples.
- **Embayment -** Formation of a bay. Also, the portion of water or coast that forms a bay.
- **Endangered species -** A classification under the Endangered Species Act. A species is considered endangered if it is in danger of extinction throughout a significant portion of its range.
- **Entrainment -** Mixing of salt water into fresh water, as in an estuary.

- **Epipelagic zone** The upper region of the sea from the surface to about 200-300 meters depth.
- Epiphyte A plant that grows on another plant.
- **Epipodium** A ridge or fold in the lateral edges of each side of the foot of certain gastropod mollusks.
- **Escapement -** The percentage of fish in a particular fishery that escape from an inshore habitat and move offshore, where they eventually spawn.
- **Estuary -** A partially enclosed body of water having a free connection with the open sea; within it salt water and fresh water mix.
- Etiology All the causes of a disease or abnormality.
- **Euphausiid** Shrimplike crustaceans that spend their entire lives in the sea; "krill".
- Extirpation Situation when something is no longer present.
- Exclusive Economic Zone (EEZ) The region from 3-200 nautical miles searward of the 48 contiguous states, Alaska, Hawaii, and U.S.-affiliated islands. The U.S. National Marine Fisheries Service (NMFS) regulates fisheries within this area.
- **Ex-vessel -** Refers to activities that occur when a commercial fishing boat lands or unloads a catch. For example, the price received by a captain for the catch is an exvessel price.
- FL See Fork Length.
- Falcate Shaped like a sickle.
- **Fathom -** A unit of measurement. One fathom equals six feet or 1.83 meters.
- Filter feed See Suspension Feed.
- **Finfish** A common term to define fish as separate from shellfish.
- **Fingerling -** A term commonly used for any juvenile fish, most commonly used for a life stage in trout and salmon. A fingerling is the stage after fry and before smolt.
- **Finlet -** Small fins located posterior to the anal and dorsal fins. Examples are found in the mackerels (family Scombridae).
- **Fishery -** All the activities involved in catching a species of fish or group of species.
- **Fishery-dependent -** Describes data about fish resources collected by sampling commercial and recreational catches.
- **Fishery-independent -** Describes data about fish resources collected by methods other than sampling commercial and recreational catches. An example of such a method is sampling in marine reserves.

- **Food chain -** A linear sequence of organisms in which each is food for the next member in the sequence.
- **Food web -** A network describing the feeding interactions of the species in an area.
- **Fork length -** The length of a fish as measured from the tip of its snout to the fork in the tail.
- **Front -** A major discontinuity separating ocean currents and water masses in any combination.
- **Fully utilized -** Situation when the amount of fishing effort used is about equal to the amount needed to achieve the LTPY.
- Gaff A pole with a large hook at its end.
- **Galactans -** Plant polysaccharides. Examples are agaragar and carrageenan.
- Gamete An egg or a sperm.
- **Gammarid** A member of the suborder Gammaridea and the order Amphipoda. Distinctive gammarid characteristics include that the first segment of the thorax is fused to the head and that they live in salt water, fresh water, and tropical forests. An example is the beach hopper.
- **Gastropod -** A member of the class Gastropoda. Gastropods have a flattened foot, usually a cap-shaped or coiled shell, a mouth apparatus known as a radula, and are characterized by a twisting of the body, known as torsion. Examples include limpets, whelks, and periwinkles.
- Gastrula A stage in the development of a fertilized egg.
- **Gel chromatography -** A method for comparing DNA or genes of different organisms.
- **Genetic introgression -** The transfer of a small amount of genetic material from one (usually plant) species to another as a result of hybridization between them and repeated back-crossing.
- **Ghost fishing -** Situation when abandoned fishing gear continues to catch organisms.
- **Gillnet -** A curtainlike net suspended in the water with mesh openings large enough to permit only the heads of the fish to pass through, ensnaring them around the gills when they attempt to escape.
- Gill rakers Bony, tooth-like structures on the anterior edges of gill arches. Used for protection or for straining out food.
- **Gonad -** Animal organs which produce gametes (eggs or spermatazoa). Female gonads are ovaries; male gonads are testes.
- **Gonosomatic index -** The ratio of the weight of a fish's eggs or sperm to its body weight. The index is used to dermine the spawning time of a species of fish.
- **Gravid -** Heavy with eggs or young.

- **Green mud** Greenish sand deposits in which glauconite is abundant.
- **Groundfish** A species or group of fish that lives most of its life on or near the sea bottom.
- **Gurdy -** Spool used in trolling upon which the fishing line is wound. The gurdies are usually powered, but on some of the smaller boats, like salmon dories, they are often hand-operated.
- Haplosporidian A member of the phylum Haplosporidia, which contains spore-forming parasitic protists. One member of this group, Haplosporidium nelsoni, also called MSX disease, has recently caused widespread disease in Crassostrea virginica, the eastern oyster, on the U.S. east coast.
- **Haplotype -** A set of genes that determines different antigens but are closely enough linked to be inherited as a unit.
- Haptera Basal outgrowths that form part of a holdfast.
- **Harvest -** The total number or poundage of fish caught and kept from an area over a period of time. Note that landings, catch and harvest are different.
- **Heterosis -** Segmentation in which the parts are different. Also, the tendency of cross-breeding to produce an animal or plant with a greater hardiness and capacity for growth than either of the parents; hybrid vigor.
- **Hermaphrodite** An individual with both male and female organs.
- **Histology -** A branch of anatomy that deals with the minute structure of animal and plant tissues as discernible with a microscope.
- **Holdfast** The rootlike structure at the base of an alga that attaches to rocky substrate.
- **Hydroacoustics -** Sound waves travelling through water.
- **Hydrography -** The arrangement and movement of bodies of water, such as currents and water masses.
- **Hydroid -** Benthic colonial cnidarians (a phylum that includes jellyfish, sea anemones and corals), some of which produce free-swimming jellyfish.
- INPFC International North Pacific Fisheries Commission.
- IWC International Whaling Commission.
- Immunodiffusion Any of several techniques for obtaining a precipitate between an antibody and its specific antigen. One technique is to suspend one in a gel and letting the other migrate through it from a well; another is to let both antibody and antigen migrate through the gel from separate wells to form an area of precipitation.
- **Intertidal** Between the high and low tide marks and periodically exposed to air.

- **Isopods -** An order of crustaceans characterized by a small flattened bodies, sessile eyes, and both benthic and planktonic species.
- **Isotherm** An imaginary line passing through points on the earth's surface having the same mean temperature.
- **Jetty -** A rocky structure constructed from land into the sea to protect shore-based property.
- **Jig -** An artificial lure made to simulate live bait. It is usually made with a lead head cast on a single hook and is heavier than most other lures.
- **Juvenile** A young fish or animal that has not reached sexual maturity.
- **Keystone species -** A species that maintains community structure through its feeding activities, and without which large changes would occur in the community.
- Knot A unit of speed equal to one nautical mile per hour (approximately 51 centimeters per second).
- LTPY Long-term potential yield.
- La Niña An episode of strong trade winds and unusually low sea surface temperature in the central and eastern tropical Pacific. The antithesis of El Nino.
- Lampara net An encircling net (similar to purse seine yet that does not close completely) used in shallow water.
- Landing The number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the points at which fish are brought to shore. Note that landings, catch, and harvest define different things.
- **Lateen -** A sailing rig used by early salmon fishing vessels off California.
- **Leader -** A length of monofilament or wire that connects the main fishing line to the hook used for capturing fish.
- **Limited entry -** A program that changes a common property resource like fish into private property for individual fishermen. License limitation and the individual transferable quota (ITQ) are two forms of limited entry.
- Limiting factor A factor primarily responsible for determining the growth and/or reproduction of an organism or a population. The limiting factor may be a physical factor (such as temperature or light), a chemical factor (such as a particular nutrient), or a biological factor (such as a competing species). The limiting factor may differ at different times and places.
- **Limnology -** The study of freshwater ecosystems, especially lakes.
- Littoral zone The intertidal zone.
- Longline See Setline.

- Long-term potential yield The maximum long-term average yield that can be achieved through conscientious stewardship, by controlling the proportion of the population removed by harvesting by regulating fishing effort or total catch levels.
- **Lunate** Refers to the caudal fin shape that is indented and looks like a crescent.
- MLMA Marine Life Management Act.
- MLPA Marine Life Protection Act.
- MMPA Marine Mammal Protection Act.
- MRFSS Marine Recreational Fisheries Statistics Survey.
- MSY See Maximum Sustainable Yield.
- **Macrophyte -** A plant that is large enough to be seen with the naked eye.
- Mariculture The raising of marine finfish or shellfish under some controls. Feed and ponds, pens, tanks or other containers may be used. A hatchery is also mariculture but the fish are released before harvest size is reached.
- Maturity The age at which reproduction is possible.
- **Maximum sustainable yield -** The largest average catch that can be taken continuously (sustained) from a stock under average environmental conditions. This is often used as a management goal.
- **Mean -** The sum of the data divided by the number of pieces of data; the average.
- **Median -** Within a data set, the median is the the number that divides the bottom 50% of the data from the top 50%.
- **Megalopa -** A larval stage of crabs that follow the zoea stages.
- **Meristem -** The point or region from which active growth takes place.
- **Mesohaline -** A zone of water from 1.8% salinity to .5% salinity.
- **Mesopelagic -** A somewhat arbitrary depth zone in offshore or oceanic waters, usually below 600 feet and above 3,000 (200-1000 meters).
- Metric ton 2200 pounds.
- **Midden -** A refuse heap left by prehistoric Native Americans, usually marking campsites.
- **Milt** A term for the sperm of fish such as salmon, trout, and herring.
- **Mollusk** A group of freashwater and saltwater animals with no skeleton and usually one or two hard shells made of calcium carbonate. Includes the oyster, clam, mussel, snail, conch, scallop, squid, and octopus.

- **Mooching -** A method of salmon fishing from a drifting or propelled boat. The bait is sunk deep with a heavy sinker then brought upward at an angle as the boat is maneuvered forward a few yards or the line retrieved. The bait is then allowed to sink once again to the bottom and the procedure repeated.
- Morphology The physical characteristics of an individual.
- **Myctophid** A member of the Myctophidae family of fishes. Commonly called lanternfishes, they are abundant in all oceans of the world, usually at 200-1000 meters depth.
- **Mysid** A member of an order of shrimplike crustaceans, mostly epibenthic.
- NEPA National Environmental Policy Act.
- NFMP Nearshore Fishery Management Plan.
- NISA National Invasive Species Act.
- NMFS National Marine Fisheries Service.
- NPDES National Pollutant Discharge Elimination System.
- **Nacre** A smooth, shining, iridescent substance forming the inner layer in many shells; mother-of-pearl.
- **Nekton -** Organisms with swimming abilities that permit them to move actively throught the water column and to move against currents. Examples include adult squid, fish and marine mammals.
- **Neuston -** Organisms that inhabit the uppermost few millimeters of the surface water.
- **Non-point source -** Sources of pollution such as general runoff of sediments, fertilizer, pesticides, and other materials from farms and urban areas as compared to specific points of discharge such as factories.
- **Nudibranch -** Sea slug. A member of the mollusk class
  Gastropoda that has no protective covering as an adult.
  Respiration is carried on by gills or other projections on the dorsal surface.
- **Nursery -** Habitat suitable for protection and growth during an organism's early life stages.
- **Nutricline -** The depth zone where nutrient concentrations increase rapidly with depth.
- Occyte An egg before the completion of maturation.
- **Oophagy -** The first young to "hatch" in each of the two oviducts proceed to eat the other embryos in the oviduct with them.
- **Open access -** A fishery in which no restrictions on entry or gear occur. Licenses may be required in an open access fishery, but if no quotas on fishermen exist the fishery is still considered to be open access.
- **Operculum -** The covering of the gills of a fish. Found in higher order fishes.

- Optimum yield The harvest level for a species that acheives the greatest overall benefits, including economic, social, and biological considerations. Optimum yield is different from maximum sustainable yield in that MSY considers only the biology of the species. The term includes both commercial and sport yields.
- Organic Deriving from living organisms.
- Otolith Calcareous concretions in the inner ear of a fish, functioning as organs of hearing and balance. There are three pairs of otoliths in the skull of each fish, and these are termed sagittae, lapilli, and asterisci. Otoliths are used by fishery biologists for numerous studies.
- Otter trawl A cone-shaped net that is dragged along the sea bottom. Its mouth is kept open by floats, weights and by two otter boards which shear outward as the net is towed.
- **Overfishing -** Harvesting at a rate greater than that which will meet the management goal.
- **Overutilized -** When more fishing effort is employed than is necessary to achieve LTPY.
- **Oviparous -** Producing eggs that hatch outside the female's body.
- Oviphagous Refers to an organism that consumes eggs.
- Oviposit To lay or deposit eggs, especially by means of a specialized organ, as found on certain insects and fishes.
- **Ovoviviparous -** Pertaining to an animal that incubates eggs inside the mother until they hatch.
- PFMC Pacific Fishery Management Council.
- PSMFC Pacific States Marine Fisheries Commission.
- PacFIN Pacific Fishery Information Network. A database containing West Coast fishing landings that is maintained by the Pacific States Marine Fisheries Commission.
- Palp Any of various sensory and usually fleshy appendages near the oral aperture of certain invertebrates.
- Papilla A nipplelike protuberance of the skin.
- Paranzella net A bag-shaped net towed by two vessels that run at various distances apart to keep the mouth open and at various speeds according to the depth desired. The paranzella net initiated the West Coast trawl fishery in 1876 but by World War II it had been replaced by the less expensive otter trawl.
- Parturition Birth.
- **Patchy distribution -** A condition in which organisms occur in aggregations.
- Pectoral fins Paired fins on the front lower sides of the chest.

- Pedicle In jointed brachiopods, a short stalk, composed mostly of tough connective tissue, that emerges through a hole or notch in the posterior part of the larger valve. Muscles that are inserted into the pedicle make it possible for an jointed brachiopod to change its orientation.
- **Pelagic -** Refers to fish and animals that live in the open sea, away from the sea bottom.
- Pelecypod A bivalve.
- **Penaid -** Member of a family of shrimp, used in shrimp culture.
- Periostracum A protective layer of chitin covering the outer portion of the shell in many mollusks, especially freshwater forms
- **Pharyngeal -** Of, pertaining to, or connected with the pharynx.
- **Pharyngeal teeth -** Teeth developed on the pharyngeal bone in many fishes.
- Phycocolloid A colloidal substance obtained from seaweeds.
- **Phytoplankton -** Microscopic planktonic plants. Examples include diatoms and dinoflagellates.
- **Pinniped -** A member of the order of marine mammals that includes the seals, sea lions, and walruses, all having four swimming flippers.
- Piscivorous An organism that feeds on fish.
- **Planktivorous -** An organism that feeds on planktonic organisms.
- **Plankton -** Plants or animals that live in the water column and are incapable of swimming against a current.
- **Pleopod -** One of the swimming limbs attached to the abdomen in crustaceans.
- **Plug -** A nonspecific term for any artificial lure having a distinct "body" made of wood or plastic and having one or more sets of single, double, or triple hooks hattached. Most plugs are designed to wobble or create a commotion in the water when retrieved.
- **Pneumatocyst -** A gas-filled bladder at the base of each kelp blade that helps buoy the frond in the water column.
- **Point source -** Specific points of origin of pollutants, such as factory drains or outlets from sewage-treatment plants.
- **Polychaete -** Marine segmented worms belonging to the phylum Annelida; some are planktonic, but most are benthic.
- **Population -** Fish of the same species inhabiting a specified geographic area.
- **Potamodromous -** Refers to fish that migrate entirely within fresh water.

- Potential yield The yield estimated to be available for exploitation.
- **Procaryote -** A member of a group of unicellular organisms comprising the bacteria and the cyanophyceae, whose cell structures differs from all other organisms.
- **Productivity -** The rate at which a given quantity of organic material is produced by organisms.
- **Protandry -** An organism functions first as a male, then as a female.
- **Protogynous -** Female in the first phase of one's life.
- **Pteropod -** A holoplanktonic (permanent resident of the plankton community) snail having two swimming wings.
- **Purse seine -** A net that is cast in a circle around a school of fish. When the fish are surrounded, the bottom of the net is closed up, preventing escape.
- **RecFIN -** Recreational Fisheries Information Network.

  A database of the National Marine Fisheries Service (NMFS).
- Recruit An individual fish that has moved into a certain class, such as the spawning class or fishing-size class.
- **Recruitment -** A measure of the number of fish that enter a class during some time period, such as the spawning class or fishing-size class.
- **Red tide -** A red coloration of seawater caused by high concentrations of certain species of micro-organisms, usually dinoflagellates, some of which release toxins.
- **Reduction fishery -** Harvested fish are processed into fish meal, oils, or fertilizer.
- **Regime shift -** A long-term change in marine ecosystems and/or in biological production resulting from a change in the physical environment.
- **Riffle -** A shallow extending across the bed of a stream over which the water flows swiftly so that the surface of the water is broken in waves.
- Riprap Piles of rock used to support river banks.
- **River-run -** Describes upstream migration of anadromous fish.
- **Roller trawl** A trawl net equipped with rollers that enable the net to go over rocky areas without snagging.
- **Round haul net -** A net, such as a purse seine, that encircles schools of fish.
- Running-ripe A high state of reproductive readiness.
- Sac-roe Fish eggs that are encased in a clear membrane. Sac-roe are found in herring, among other species.
- **Salinity -** The total amount of dissolved material (salts) in seawater.

- **Salmonid -** A member of the Salmonidae family of fishes. Salmonids are the dominant fishes in the coldwater streams and lakes of North America, Europe, and Asia, where they support large recreational and commercial fisheries.
- **Satellite pop-up tag -** A specialized tag usually used to mark pelagic fish to study their migrations. Data from the tag is transmitted to researchers via a satellite.
- **Scaphopod** A member of the phylum Mollusca and class Scaphopoda which have an elongate conical shell and live buried within the sediment, feeding on foraminiferans and other small animals.
- **Scute** A type of sharp scale found on fish such as sturgeon and jackmackerel.
- **Sea wall -** Any solid structure onshore used to protect the land from wave damage and erosion.
- **Seed -** Juvenile shellfish, such as clams, oysters, and mussels.
- **Serological** An adjective referring to the branch of science dealing with the properties and reactions of blood sera.
- **Sessile** Referring to animals that are permanently attached to a substrate.
- **Set gillnet -** A gillnet that is anchored on both ends.
- Setline Fishing gear made up of a long main line attached to which are a large number of short branch lines. At the end of each branch line is a baited hook. When catching groundfish, setlines are laid on the seafloor. When catching swordfish, shark or tuna they are buoyed near the surface. Setlines can be twenty or more miles long. They are also called longlines.
- **Sexual dimorphism -** A phenomenon in which males and females differ markedly in shape, size, color, or other ways.
- Short ton 2000 pounds.
- **Single rig gear -** Refers to a boat using a single trawl net (instead of two trawl nets) when fishing for shrimp.
- **Simple random sampling -** A sampling procedure for which each possible sample is equally likely to be the one selected. A sample obtained by simple random sampling is called a simple random sample.
- **Skiff -** Any of various small boats, especially a flat-bot-tomed rowboat.
- **Slough -** A place of deep mud or mire. Also, a small backwater.
- Smolt A term for a specific life stage in salmonids. In anadromous populations parr (small active fish with series of bars on their sides) transform into silvery smolts and migrate to the sea. Once in the ocean (or

- large lakes), the smolts gradually become mature and return to their home streams for spawning.
- **Somatic cell -** All cells other than those in sexual gametes (egg and sperm).
- Spat A flat young oyster.
- **Spatfall -** Attachment of shellfish larvae to substrate where they develop into their adult forms.
- Spawn The term for reproduction in fishes.
- **Spermatophore -** An aggregation of sperm held together by gelatinous material, or a gelatinous packet of sperm which is inserted into or attached to the female as part of reproductive behavior.
- **Spinning gear -** A type of recreational fishing reel with an open spool on the front end.
- **Spoon -** An artificial lure with a curved or dished out body that wobbles but does not revolve. A spoon attracts fish by its movements as well as color.
- Sporophyte A plant that produces spores.
- Stipe The stem-like part that connects the holdfast and blade of a frondose alga.
- **Stock -** A grouping of fish usually based on genetic relationship, geographic distribution, and movement patterns. Also a managed unit of fish.
- Stratified random sampling A sampling method in which one (1) divides the population into subpopulations (called strata), (2) obtains from each stratum a simple random sample of size proportional to the size of the stratum, and (3) uses all of the members obtained in step 2 as the sample.
- **Substrate** A solid surface on which an organism lives or to which it is attached (also called substratum); or, a chemical that forms the basis of a biochemical reaction or acts as a nutrient for microorganisms.
- **Subtidal zone -** The benthic zone extending from the low tide mark to the outer edge of the continental shelf.
- **Suspension feeder -** An organism that feeds by capturing particles suspended in the water column.
- **Sympatry -** The common occurrence of two taxa (closely related forms) in the same geographic area.
- TAC See Total Allowable Catch.
- TL Total length.
- **Telemetry -** The process of tracking movements of organisms using transmitting tags.
- **Territorial sea -** A zone extending seaward from the shore or internal waters of a nation for a distance of twelve miles (19.3 km) as defined by the United Nations Conference on the Law of the Sea (UNCLOS). The coastal

- state has full authority over this zone but must allow rights of innocent passage.
- Test The shell of a sea urchin.
- **Thermocline -** The water layer in which temperature changes most rapidly with increasing depth.
- **Threatened species -** A classification under the Endangered Species Act. A species is considered threatened if it is likely to become an endangered species in the foreseeable future through a significant portion of its range.
- **Tidal prism -** The volume of water between the high tide level and low tide level.
- **Total allowable catch (TAC) -** The annual recommended catch for a species or species group. The regional fishery management council sets the TAC from the range of the allowable biological catch.
- **Trammel net -** An entangling net that hangs down in several curtains.
- **Trawl -** A sturdy bag or net that can be dragged along the ocean bottom, or at various depths above the bottom, to catch fish.
- **Trematode** Any of a class (Trematoda) of parasitic flatworms including the flukes.
- **Trocophore -** A free-swimming larval stage of polychaete worms and some mollusks, characterized by having bands of cilia (hair-like structures) around the body.
- **Troll -** To trail artificial or natural baits behind a moving boat. The bait can be made to skip along the surface or trailed below at any depth to just above the bottom. A bait or lure trailed behind an angler walking along a pier, bridge, or breakwater is also called trolling.
- **Trophic level -** The nutritional position occupied by an organism in a food chain or food web; e.g. primary producers (plants); primary consumers (herbivores); secondary consumers (carnivores), etc.
- **Tunicate -** Sessile benthic animals belonging to the phylum Chordata.
- **Turbidity -** Reduced visibility in water due to the presence of suspended particles.
- **Underutilized -** When more fishing effort is required to achieve the LTPY.
- **Upwelling -** A rising of nutrient-rich water toward the sea surface.
- **VPA -** See Virtual Population Analysis.
- **Vector -** A physical quantity that has magnitude and direction. Examples are force, acceleration, and velocity.
- **Veliger -** A free-swimming larval stage of mollusks.
- Velum A ciliated, sail-like appendage of a veliger larva.

- Ventral fins Paired fins on the lower part of the body; they may be near the anus, below the pectoral fins, or near the throat. They are also called pelvic fins.
- Virtual population analysis (VPA) A type of analysis that uses the number of fish caught at various ages or lengths and an estimate of natural mortality to estimate fishing mortality in a cohort. It also provides an estimate of the number of fish in a cohort at various ages.
- **Viviparous -** Bringing forth living young, rather than being an egg-layer.
- **Water column -** The water from the surface to the bottom at a given point.
- Weir A low dam or barrier made across a water channel to raise the level of water for different purposes. Also, a barricade.
- Wrack zone A bank of accumulated litter at the strandline.
- YOY Young-of-the-year.
- Year-class The fish spawned and hatched in a given year, a "generation" of fish.
- **Zoea -** A planktonic larval stage of crabs with characteristic spines on the exoskeleton.
- Zooplankton Animal members of the plankton.
- **Zoospore** A motile spore with one or more flagella or cilia by the vibration of which it swims.

## Kristen Sortais University of California, Davis

## References

Dawson, E.Y. 1966. Seashore plants of northern California. University of California Press, Berkeley, CA, 103pp.

Fitch, J.E. and R.J. Lavenberg. 1968. Deep-water fishes of California. University of California Press, Berkeley, CA, 155pp.

Fitch, J.E. and R.J. Lavenberg. 1975. Tidepool and nearshore fishes of California. University of California Press, Berkeley, CA, 156pp.

Food and Agriculture Organization of the United Nations. Fisheries Division. 1960. Trilingual dictionary of fisheries technological terms - curing. FAO, Rome, Italy, 85pp.

Kramer, D.E., W.H. Barss, B.C. Paust, and B.E. Bracken. 1995. Guide to northeast Pacific flatfishes: families Bothidae, Cynoglossidae, and Pleuronectidae. Alaska Sea Grant College Program, University of Alaska, Fairbanks, AK, 104pp.

Lalli, C.M. and T.R. Parsons. 1993. Biological oceanography: an introduction. 1st ed. Pergamon Press, New York, NY, 301pp.

Levinton, J.S. 1995. Marine biology: function, biodiversity, ecology. Oxford University Press, New York, NY, 420pp.,

Meltzer, M. 1980. The world of the small commercial fishermen: their lives and their boats. Dover Publications, Inc., New York, NY, 86pp.

Merriam-Webster's collegiate dictionary. 10th ed. 1998. Merriam-Webster, Springfield, MA, 1559pp.

Moyle, P.B. and J.J. Cech, Jr. 2000. Fishes: an introduction to ichthyology. 4th ed. Prentice- Hall, Uppersaddle River, NJ, 612pp.

Nebel, B.J. 1987. Environmental science: the way the world works. 2nd ed. Prentice-Hall, Englewood Cliffs, NJ, 671pp.

Newell, G.E. and R.C. Newell. 1963. Marine plankton, a practical guide. Hutchinson Educational, London, 206pp.

Parker, S.P. (editor). 1984. McGraw-Hill dictionary of biology. McGraw-Hill, New York, NY, 384pp.

Simpson, J.A. and E.S.C. Weiner (editors). 1998. The Oxford English dictionary. 2nd ed. Oxford University Press, New York, NY.

Squire, J.L. and S.M. Smith. 1977. Anglers' guide to the United States Pacific coast: marine fish, fishing grounds

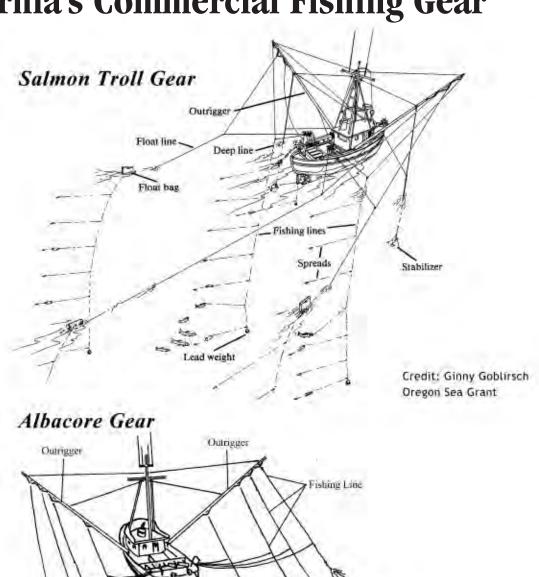
& facilities. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, WA, 139pp.

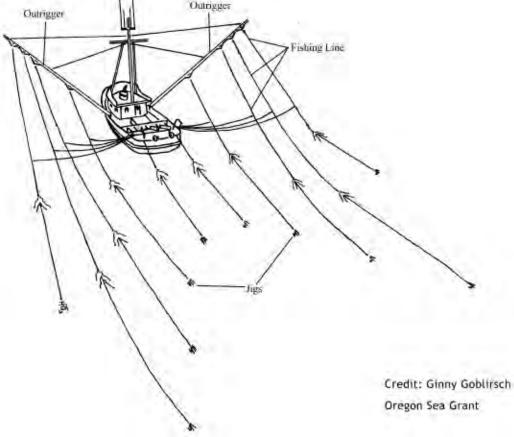
U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1999. Our living oceans: Report on the status of U.S. living marine resources, 1999. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, D.C., 301pp.

Wallace, R.K. and K.M. Fletcher. 2000. Understanding fisheries management: a manual for understanding the federal fisheries management process, including analysis of the 1996 Sustainable Fisheries Act. Mississippi-Alabama Sea Grant Consortium, Mobile, AL and University, MS, 53pp.

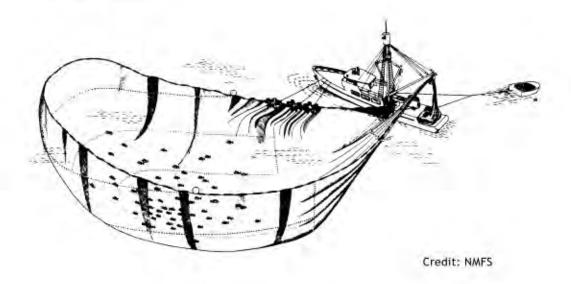
Weiss, N.A.; biographies by C. Weiss. 1995. Introductory statistics. 4th ed. Addison Wesley, Reading, MA, 939pp.

# Appendix C: California's Commercial Fishing Gear

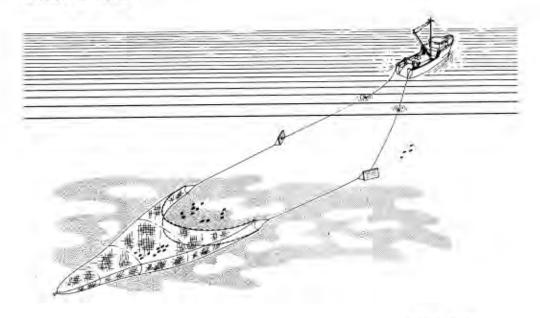




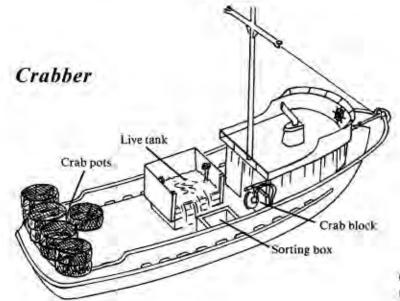
## Purse Seine



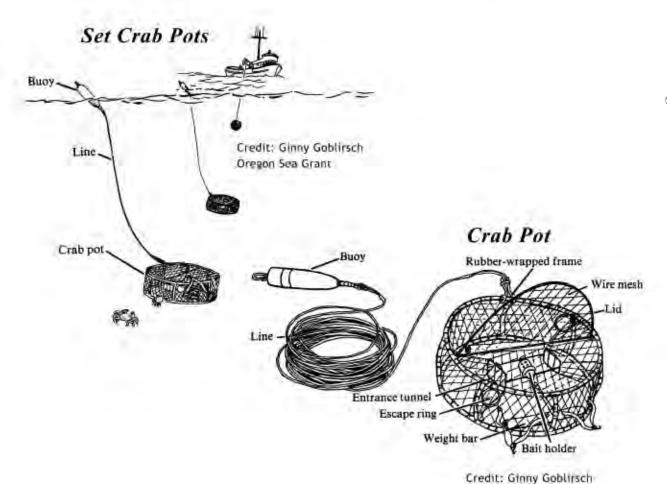
## Otter Trawl



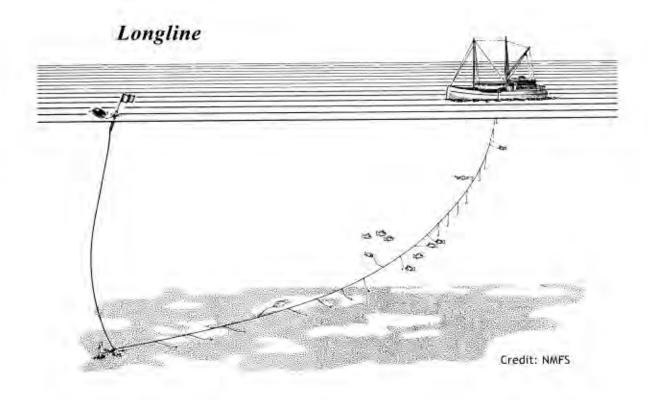
Credit: NMFS



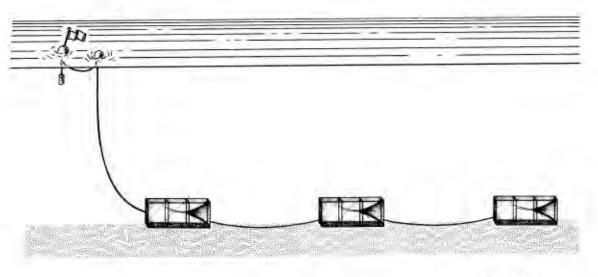
Credit: Ginny Goblirsch Oregon Sea Grant



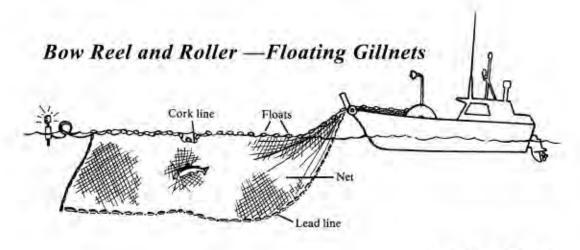
Oregon Sea Grant



Trap

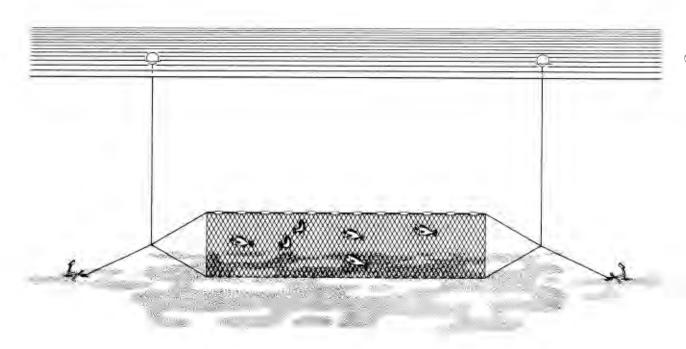


Credit: NMFS



Credit: Ginny Goblirsch Oregon Sea Grant

## Gillnet



Credit: NMFS

# Appendix D: Reviewers

The editors wish to thank the reviewers for their invaluable assistance in compiling this book.

#### Alaska Sea Grant Extension Program

Brian Paust

#### California Aquaculture Association

Justin Malan

#### California Dept of Fish and Game

Alan Baracco (retired)

Kristine Barsky

Dennis Bedford

L.B. Boydston

Pat Collier

Steve Crooke

Paul Gregory

Doyle Hanan (retired)

**Bob Hardy** 

Emma Hatfield (Squid Fishery Scientific Committee)

Frank Henry (retired)

Bob Hulbrock

**DeWayne Johnston** 

Rick Klingbeil

Mary Larson

Bob Lea

Mike Malone (Nearshore Advisory Committee)

Ken Oda

Dave Ono

Dave Parker

Christine Pattison

Connie Ryan

Jerry Spratt (now deceased)

Dale Sweetnam

Ian Taniguchi

Bob Tasto

Carl Wilcox

Deb Wilson-Vandenberg

#### California Fish and Game Commission

John Duffy

Mike Weber (Advisor)

## California Marine Life Management Project

Burr Heneman

#### California Sea Grant Extension Program

Susan McBride

Paul Olin

Jim Waldvogel

#### California State University, Humboldt

Ron Fritzche

Dave Hankin

Tim Mulligan

#### California State University, Long Beach

Chris Lowe

#### California State University, San Diego

Tom Ebert

#### California State Unversity, San Francisco

Ralph Larson

#### Commercial Fisherman

Peter Halmay

Richard Young

Pietro Parravano

#### **Ducks Unlimited**

Ryan Broddrick

#### Fishermen's Marketing Association

Pete Leipzig

#### **Hubbs-Sea World Research Institute**

Mark Drawbridge

## Inter-American Tropical Tuna Commission

Bob Olson

#### Monterey Bay Aquarium Research Institute

Judith Connor

## Moss Landing Marine Laboratory (CSU)

Greg Cailliet

Mike Foster

John Oliver

#### National Marine Fisheries Service

John Butler

Gonzalo Castillo

Jim Hastie

Bob Hoffman

Dave Holts

. . . . .

Larry Jacobson

Sus Kato (retired)

Mike Laurs

Bill Lenarz (retired)

Nancy Lo

Geoff Moser

Lisa Natanson

Richard Parrish

Gary Sakagawa

Mike Sigler

Sue Smith

Cindy Thomson

Chris Toole

Jack Turnock

Russ Vetter

## Occidental College

John Stephens (retired)

## Oregon Department of Fish and Wildlife

Dave Fox

The Ocean Conservancy

Tim Eichenberg

**Oregon State University** 

Dave Sampson

Gil Sylvia

**Pacific Coast Federation of Fishermens** 

Associations, Inc.

Zeke Grader

Pepperdine University

Karen Martin

Point Reyes Bird Observatory

David Ainley

Point Reyes-Farallon Island National Marine Sanctuary

Dan Howard

Jan Roletto

**Processor** 

Dave Rudie

San Francisco Estuary Institute

Andy Cohen

Santa Barbara Museum of Natural History

Eric Hochberg

Southern California Coastal Water Research Project

James Allen

**Stillwater Associates** 

Sharon Kramer

University of California, Berkeley

Dick Moe

Julie Reynolds

University of California, Davis

Joe Cech

Gary Cherr

Fred Conte

Frank Gress

Pete Klimley

Peter Moyle

University of California, San Diego

Mike Mullin (now deceased)

Richard Rosenblatt

University of California, Santa Barbara

Carrie Culver

Milton Love

John Richards

Steve Schroeter

University of South Carolina

Joe Hightower

University of Southern California

Kathy Ann Miller

**Washington Department of Fisheries** 

Dick Burge

Wayne Palsson

## Index

Abalone, 19, 25, 48, 51, 56-57, 59-61, 70, 73-74, 79, 87-97, 101-103, 113, 131, 142, 144-145, 147-148, 155, 158, 256, 273, 280, 282, 347, 471, 493-495, 499, 515, 522, 538, 553-554,

**Abalone culture, 493, 495, 515** 

Acipenser medirostris, 465

Acipenser transmontanus, 467, 469

Agarophytes, 286-287

Ahnfeltia, 286

Albacore, 48, 57, 67, 215-216, 291, 315, 317-321, 325-326, 332, 348, 352, 354-355, 357, 567

Alopias vulpinus, 339

Amphistichus argenteus, 229, 236

Amphistichus koelzi, 236-237

Amphistichus rhodoterus, 236, 238

Angel shark, 149-150, 248-251, 553-554

Anoplopoma fimbria, 390, 392

Appendices, 20, 417, 123, 551

Aquaculture: overview, 493

Arctocephalus townsendi, 523, 525

Arrowtooth flounder, 119, 203-204, 264, 266, 268, 556

Atheresthes stomias, 203

Atherinops affinis, 243

Atherinopsis californiensis, 243, 245

**Atractoscion nobilis, 206, 208, 510, 512** 

Balaenoptera acutorostrata, 531

Balaenoptera musculus, 530-531

Balaenoptera physalus, 531

Bank rockfish, 378-379

Barracuda, 19, 27, 53-54, 63, 79, 127, 149-150, 219-221, 263-264, 269, 301, 323, 326, 363, 555

Barred sand bass, 113, 149, 151, 198, 222-227, 269-272, 554

Barred surfperch, 138, 229, 236-237, 239

Basking shark, 345-347

Bat ray, 257-258, 260

Bay and Estuarine Plants: Overview, 481-482

Bay and Estuary Ecosystems, 431, 435-436, 481, 491

Bay and Estuary Finfish Resources, 455

Bay and Estuary Invertebrate Resources, 437-438

Bay shrimp, 439-442, 453, 467, 476, 514, 554

Big skate, 257-258, 441

Bigmouth sole, 203

Birds, 26, 32-35, 37, 45, 138, 158, 163, 176-177, 179, 182, 202, 211, 247, 293, 297, 301, 305, 310, 366, 370, 380-381, 435, 455, 458, 472, 476, 484, 486-487, 505, 511, 514-516, 521-522, 538, 541-550

Black abalone, 90, 92-94, 96, 188

Black perch, 236

Black rockfish, 68, 79, 162-164, 167-168

Black-and-yellow rockfish, 173, 185-187

Blackgill rockfish, 368-369, 378

Blue rockfish, 26, 68, 162-168, 187, 194, 372

Blue shark, 342-344

Blue whale, 530-532

Bluefin tuna, 215-217, 235, 299, 308, 315, 325-327

**Bocaccio,** 22, 26, 166, 359, 361-363, 366-367, 372, 380, 398-400, 402, 404, 554

Bonito, 27, 54, 79, 149, 215-218, 263-264, 269, 301, 363, 558

Bottlenose dolphin, 533

Brachyistius frenatus, 236

Brown rock crab, 112, 114

Brown rockfish, 68, 170-174, 188, 441, 455

Bull kelp, 25, 79, 91, 102, 273, 282-284, 554

Butter clam, 447-448

Butter sole, 203

Butterfly ray, 260

Cabezon, 19, 68, 79, 91, 95, 99, 109, 113, 116, 150-151, 157-159, 177, 179, 181-182, 263-264, 269, 449, 554

Calico rockfish, 68, 149, 179-180, 555

Calico surfperch, 236-237

California Barracuda, 19, 79, 149-150, 219-221, 555

California corbina, 136, 149, 228-229, 231, 555

**California halibut,** 19, 21, 69, 149-151, 165, 195-200, 203, 236, 248, 363, 435, 455, 510-511, 555

California market squid, 295-298

California scorpionfish, 53-54, 68, 149-150, 160-161, 562

California sea lion, 310, 523-524, 526-527

California sheephead, 56, 68, 149-150, 155-156, 555-556

California skate, 258, 261

California tonguefish, 203

California s Variable Ocean Environment, 21-28

Callorhinus ursinus, 523, 525

Canary rockfish, 175-176, 359, 372, 554

Cancer antennarius, 114

Cancer anthonyi, 112, 114
Cancer magister, 107
Cancer productus, 112

Carcharodon carcharias, 345, 347

Carrageenophytes, 286-287 Cebidichthys violaceus, 181-182 Cetorhinus maximus, 345, 347

Chilipepper, 170, 359, 362-363, 366-367, 398-399,

China rockfish, 68, 185-187

Chinook salmon, 32, 109, 176, 193, 370, 407, 409-414, 417-418, 424, 460, 463, 466, 508-509,

Chione, 451-452

Chione californiensis, 451 Chione fluctifraga, 451 Chione undatella, 451 Chondrus crispus, 286-287 Chum salmon, 405, 407

Citharichthys fragilis, 201-202 Citharichthys sordidus, 201-202 Citharichthys stigmaeus, 201-202 Citharichthys xanthostigma, 201

Clupea pallasi, 456, 459

**C-O turbot**, 202

Coastal Pelagic Species: overview, 293-294 Coastal Wetlands, 29, 32, 35, 483-486, 546,

Coho salmon, 29, 69, 405, 410, 412-413, 415-417, 507-508

Commercial Fishing Gear, 206, 215, 577-582

Common dolphin, 533

Coonstripe shrimp, 129-130, 555 Copper rockfish, 68, 173-174, 177 Coryphaena hippurus, 352-353

Cow shark, 470

Cowcod, 359, 363-365, 401-402 Crangon franciscorum, 439-440, 442

Crangon nigricauda, 440, 442 Crangon nigromaculata, 440 Crassostrea gigas, 500

Crassostrea sikamea, 501

Crassostrea virginica, 500, 506, 570

Curlfin turbot, 203

Dall's porpoise, 534-535

Dasyatis brevis, 260

Delphinus capensis, 533
Delphinus delphis, 533

Delta smelt, 463, 472-473, 475-479, 564

Diamond stingray, 260 Diamond turbot, 203

Dolphin, 331-332, 352-353, 356-357, 533-534, 555

Dolphinfish, 315, 471

Dolphins, 179, 291, 331-332, 470-471, 521, 529-535, 568

Dorado, 323, 352-353

Dover sole, 27, 359-360, 374, 382-384, 389-390,

Dungeness crab, 71, 73-74, 87-88, 107-112, 129, 435, 437, 455, 514

Dwarf perch, 236

Eelgrass, 33-34, 37, 177, 193, 207, 226, 243-244, 384, 435, 459, 481, 484, 487-490, 502, 505, 516, 555-556

Embiotoca jacksoni, 236 Embiotoca lateralis, 236, 239 Emergent Marshes, 483-486 Emerita analoga, 138-139 English sole, 200 384-385, 441 Engraulis mordax, 293, 303, 305 Enhydra lutris, 101, 536, 540

Eopsetta exilis, 203

Eopsetta jordani, 386-387, 389

Errex zachirus, 388

Eschrichtius robustus, 531, 535

Eucheuma, 286

Eulachon, 472, 477-478, 564 Eumetopias jubatus, 523-524

Exotic Species, 30, 437, 473, 477, 493, 518

Fantail sole, 203 Fat gaper, 445 Fin whale, 531 Finfish culture, 510

Fishing Gear, 20, 37, 53, 64, 67-68, 73, 140, 150, 206, 215, 220, 232, 243, 328, 332, 336, 345, 467, 521, 523, 544, 567, 570, 574, 577-582

Galeorhinus galeus, 255

Gaper clams, 445-447, 449, 556 Genyonemus lineatus, 234-235 Geoduck, 437, 449-450, 556

Giant kelp, 25, 28, 79, 91, 101-102, 140, 164, 194, 207, 273, 277-284, 288, 457, 495, 556

Giant sea bass, 99, 149-150, 209-211, 220, 235, 258, 308, 363, 510-511, 557

Girella nigricans, 241-242

Globicephala macrorhynchus, 532-533

Glossary, 20, 567-576

Gopher rockfish, 68, 173, 185-188

Grampus griseus, 533-534

Grass rockfish, 68, 172, 182, 185-188, 271

Gray whale, 522, 529, 531-532, 535

Green abalone, 92-93, 96

Green sturgeon, 465-466

Groundfish: Overview, 359-360

Grunion, 34, 149, 151, 220, 232, 243, 246-247, 341, 472, 557

Guadalupe fur seal, 522-523, 525-526

Gulf sanddab, 201

Gull, 542-5454

Gymnogongrus, 286

Gymnura marmorata, 260

Halfmoon, 79, 112, 149, 241-242, 279

Halibut, 19, 21, 69, 125, 149-151, 165, 195-200, 203-204, 209, 232, 235-236, 248, 259, 263-264, 270,348, 363, 396, 435, 455, 478, 510-511, 536, 555-556

Haliotis corrugata, 89

Haliotis cracherodii, 89

Haliotis fulgens, 89

Haliotis rufescens, 91, 96-97, 494-495,

Haliotis sorensensi, 89

Harbor porpoise, 527, 534

Herring, 19, 27, 48, 51, 53, 55-57, 59-60, 63, 69, 73-74, 129, 183, 193, 207, 244, 253, 259, 300, 341, 386, 409, 427, 435, 455-459, 468, 480, 487, 489, 491, 521, 523-524, 531, 545, 559, 568, 571, 573

Hexagrammos decagrammus, 183-184

Hexanchus griseus, 470-471

Highly Migratory Species: overview, 315-316

Hinnites multirugosus, 142 Hippoglossina stomata, 203

Hippoglossus stenolepsis, 203

Hornyhead turbot, 203 Human Ecosystem, 47-66

Humpback whale, 530

Hyperprosopon anale, 236

Hyperprosopon argenteum, 236

Hyperprosopon ellipticum, 236

Hypomesus pretiosus, 474

Hypomesus nipponensis, 474, 479

Hypomesus transpacificus, 472, 479

Hypsopsetta guttulata, 203

Hypsurus caryi, 236

Invasive Species, 34, 435, 486, 488, 498, 513-520, 572

Iridaea, 286

Isurus oxyrinchus, 336, 338

Jack mackerel, 27, 212, 216, 220, 293-294, 299, 304, 306, 308-311, 341, 361, 557

Jacksmelt, 243-246, 253, 472, 563

Japanese littleneck, 451

Katsuwonus pelamis, 328, 330

Kelp, 21, 25, 28, 30-31, 33-34, 36, 47, 68-69, 79, 90-92, 95, 99, 101-103, 105-106, 116, 128, 132, 140-141, 143, 149-151, 155-158, 163-166, 168, 170, 174, 181, 183-187, 190-191, 193-194, 206-207, 209-210, 212, 220, 222-227, 232, 236, 239, 241, 243-244, 252, 259-260, 269-273, 277-285, 288, 307, 361, 363, 366, 435, 457, 470, 495, 516, 532, 537, 554, 556-557, 573

Kelp bass, 21, 25, 79, 99, 149, 151, 222-227, 259, 269-272,

Kelp greenling, 149, 183-184, 191, 193

Kelp perch, 236

Kelp rockfish, 25, 68, 165, 185-187

Killer whale, 470, 532

Kumamoto oyster, 501-502, 504-506

Lagenorhynchus obliquidens, 534

Lamna ditropis, 345, 347

Lampris guttatus, 348

Law Enforcement, 20, 67-72

Leopard shark, 252-254, 435, 441, 455,

Leuresthes tenuis, 246-247

Lingcod, 22, 27, 54-55, 66, 68, 109, 124, 129, 149-151, 158, 163-166, 177, 179, 183, 188, 190-194, 263-264, 270, 359, 366, 381, 388, 396, 554, 565

Lissodelphis borealis, 534

Littleneck clam, 451

Loligo opalescens, 293, 295, 297-298

Longfin sanddab, 201

Longfin smelt, 472-473, 476-479, 564

Longnose skate, 258

Longspine thornyhead, 374-375 Louvar, 341, 350-351, 356, 557 Loxorhynchus grandis, 115, 117 Luvarus imperialis, 350-351 Lysmata californica, 127

Mackerel sharks, 345-347

Macrocystis pyrifera, 164, 194, 273, 277, 283

Mahi mahi, 352

Mako shark, 336-339, 354-355

Management Considerations, 553-566

Manila clam, 451-452

**Marine Birds,** 33-35, 163, 177, 310, 366, 455, 458, 521-522, 541-550

Marine Birds and Mammals: overview, 521-522

Medialuna californiensis, 241-242 Megaptera novaeangliae, 530

Megastrea undosa, 140

Merluccius productus, 393, 397, 120

Micrometrus aurora, 236 Micrometrus minimus, 236

Microstomus pacificus, 382-383, 389

Minke whale, 531

Mirounga angurstirostris, 525

Mobula, 260

Mobula japonica, 260

Monkeyface prickleback, 149, 181-182, 557

Morone saxatilis, 460, 463-464

Mussel culture, 496

Myliobatis californica, 257, 260

Mytilus californianus, 496

Mytilus galloprovincialis, 496, 499

Mytilus trossulus, 496

Nearshore Marine Plant Resources, 17, 273

Nearshore rockfishes, 164-165, 169, 174, 178-179, 185-188, 190

Nereocystis luetkeana, 282, 284

Night smelt, 472, 474, 476, 478, 480, 564

Nonindigenous Species, 34, 37-38, 435

Northern anchovy, 21, 24, 28, 216, 220, 293, 302-307, 309-310, 545

Northern bluefin tuna, 325-327

Northern elephant seal, 523, 525-527

Northern fur seal, 523, 525-526

Northern right-whale dolphin, 534

Notorynchus cepedianus, 470-471

Ocean shrimp, 87-88, 118-120, 129

Offshore ecosystem, 26, 289, 291-292

Olive rockfish, 68, 79, 168-169

Oncorhynchus gorbuscha, 405

Oncorhynchus keta, 405

Oncorhynchus kisutch, 405, 417, 507

Oncorhynchus mykiss, 405, 411, 418, 507

Oncorhynchus nerka, 405

Oncorhynchus tshawytscha, 405, 407, 417

Opah, 348-349, 356, 558

Opaleye, 127, 138, 149, 241-242, 265-266, 279

Ophiodon elongatus, 191, 194

Orcinus orca, 532

Ostreola conchaphila, 500

Ostreola lurida, 500

Other flatfishes, 386, 150, 198, 201, 203-205

Other nearshore rockfishes, 185-188

Oyster culture, 496, 500-502, 504, 506

Pacific angel shark, 149, 248-251

Pacific bonito, 79, 149, 215-218, 558

Pacific gaper, 445-446

Pacific hake, 21, 27, 119-120, 341, 366, 393-397, 399, 402, 404, 558

Pacific halibut, 348, 396, 203-204, 556

Pacific harbor seal, 523-524, 526-527

Pacific herring, 48, 69, 207, 435, 455-459, 487, 489, 491, 559

Pacific mackerel, 22, 27, 207, 212, 216, 220, 223, 293-294, 304, 306-310, 314,

Pacific northern bluefin tuna, 325-327

Pacific oyster, 500-501, 504

Pacific razor clam, 443-444, 559

Pacific salmon, 341, 407-419, 426-427

Pacific sanddab, 341, 201-202

**Pacific sardine,** 21-22, 24, 27-28, 196, 220, 293, 299-302, 304, 306, 308-310, 341, 545, 547

Pacific white-sided dolphin, 534

Palaemon macrodactylus, 440

Pandalus danae, 129

Pandalus jordani, 118, 120

Pandalus platyceros, 121, 123, 126

Panope generosa, 449-450
Panulirus interruptus, 98, 100
Paralabrax clathratus, 222-223

Paralabrax maculatofasciatus, 226-227

Paralabrax nebulifer, 198, 224

Paralichthys californicus, 195, 198, 510 Parastichopus californicus, 131, 134 Parastichopus parvimensis, 134

Pelagic stingray, 260

Pelican, 33, 3001, 305, 541-542, 546, 550 Petrale sole, 384, 386-387, 389, 21, 119, 199

Phanerodon atripes, 236 Phanerodon furcatus, 236 Phocoena phocoena, 534 Phocoenoides dalli, 534-535

Physeter catodon, 532

Pile perch, 127, 236-238, 240

Pilot whale, 532-533 Pink abalone, 89, 92, 95 Pink salmon, 405, 407 Pink seaperch, 236

Pinnipeds, 177, 521-525, 527-529 Pismo clam, 87, 135-137, 437, 559 Platichthys stellatus, 199-200 Platyrhinoidis triseriata, 257, 259

Pleuronectes bilineatus, 203
Pleuronectes isolepis, 203
Pleuronectes vetulus, 384
Pleuronichthys coenosus, 203
Pleuronichthys decurrens, 203
Pleuronichthys ritteri, 203
Pleuronichthys verticalis, 203

Porpoises, 220, 301, 308, 395, 521-522, 529-535, 568

Postelsia palmaeformis, 285
Prionace glauca, 342, 344
Protothaca laciniata, 451
Protothaca staminea, 451
Protothaca tenerrima, 451
Psettichthys melanostictus, 203
Pteroplatytrygon violacea, 260

Purple sea urchin, 101, 105-106, 560

Quillback rockfish, 68, 170, 177-178

Rainbow perch, 236 Raja binoculata, 257 Raja inornata, 258 Raja rhina, 258

Rays, 53, 91, 93, 95, 116, 125, 136, 149, 151, 210, 236-237, 253, 256-262, 346, 348, 388, 396, 452, 455, 467, 470-471, 501, 503, 526, 563, 569

Razor clam, 443-444, 559

Red abalone, 89-93, 95-97, 102, 145, 147-148, 494-495, 554

Red rock crab, 112, 114

Red rock shrimp, 187, 127-128, 560 Red sea urchin, 26, 87, 91, 101-106, 560

Redtail surfperch, 150, 236-238

Reef perch, 236

Restricted Access, 19-20, 70, 73-76, 98, 105, 165, 216, 560-561

Reviewers, 20, 583-584 Rex sole, 388-389, 400

Rhacochilus toxotes, 236, 239 Rhacochilus vacca, 236, 238 Rhinobatos productus, 257, 259

Ridgeback prawn, 88, 121, 123-126, 561

Risso s dolphin, 533-534

Rock crabs, 87, 112-113, 115, 136, 501, 561

Rock scallop, 142-143, 561

Rock sole, 203

Roncador stearnsii, 230 Round stingray, 259-260

Rubberlip seaperch, 236, 239-240

**Sablefish,** 27, 76, 119, 291, 359-361, 366, 374, 382, 390-392, 401-402,

Salmo gairdneri, 418

Salmon, 19, 21, 27, 29, 32, 36, 48, 50-57, 59-61, 63, 66, 69, 73-74, 107, 109-110, 122, 162, 176-177, 179, 193, 195, 259, 291, 295, 309, 341, 345-348, 361, 366, 370, 380-381, 394, 405-420, 424-429, 457, 460, 463, 466, 472, 478, 484, 507-509, 521, 523-524, 558-559, 561, 567, 569-572, 584

Salmon culture, 507-508 Salmon shark, 345-347 Salmonids: overview, 405 Sand basses, 224-227 Sand crab, 138-139, 562 Sand sole, 203 Sanddabs, 149, 201-203 Sarda chiliensis, 215, 218

Sardine, 21-22, 24, 27-28, 70, 129, 151, 196, 220, 234, 291, 293-294, 299-304, 306, 308-310, 312-313, 319, 335, 337, 341, 348, 544-545, 547, 550,

Sardinops sagax, 293, 299-300, 302

Saxidomus giganteus, 447 Saxidomus nuttalli, 447

Scomber japonicus, 293, 306, 308

Scorpaena guttata, 160

Scorpaenichthys marmoratus, 157-158

Scorpionfish, 53-54, 63, 68, 149-150, 160-161, 265-266, 272, 562

Sea cumbers, 131

Sea otter, 87, 89, 91-92, 96, 101-102, 113, 136-137, 279, 282, 437, 450, 498, 522, 536-540, 553, 556, 559

Sea palm, 273, 285

Seabirds, 37, 47, 150, 193, 199, 291, 308, 521, 541-550

Sebastes auriculatus, 170 Sebastes carnatus, 185 Sebastes caurinus, 173 Sebastes chrysomelas, 185

Sebastes dalli, 179

Sebastes entomelas, 370-371

Sebastes flavidus, 372 Sebastes goodei, 366 Sebastes jordani, 380-381 Sebastes levis, 363

Sebastes maliger, 177-178 Sebastes melanops, 162

Sebastes melanostomus, 368-369

Sebastes miniatus, 189
Sebastes mystinus, 165
Sebastes nebulosus, 185
Sebastes paucispinis, 361
Sebastes pinniger, 175

Sebastes rastrelliger, 172, 185, 188

Sebastes rufus, 378-379 Sebastes serranoides, 168-169 Sebastes serriceps, 185, 188

Sebastolobus alascanus, 377

Sebastolobus altivelis, 374, 377 Semicossyphus pulcher, 155-156

Seriola lalandi, 212

Sevengill shark, 253, 255, 470-471

Sharpnose seaperch, 236

Sheep crab, 88, 115-117, 145, 147-148, 562

Shiner perch, 460, 498, 193, 236 Shortbelly rockfish, 176, 341, 380-381

Shortfin mako shark, 336-339 Shortfinned pilot whale, 532-533 Shortspine thornyhead, 374, 376 Shovelnose guitarfish, 257, 259-260

Sicyonia ingentis, 123-126 Siliqua patula, 443-444 Silver surfperch, 236, 239

Silversides, 53, 63, 206, 243-246, 265-266, 477, 563

Sixgill shark, 470-471

**Skates and rays, 149, 151, 257-262, 563, 569 Skipjack tuna, 216, 315, 328-330, 333, 563** 

Slender sole, 203

Sockeye salmon, 27, 405, 407 Soupfin shark, 150, 255-256

Spartina, 483

Speckled sanddab, 201-202 Sperm whale, 522, 532 Sphyraena argentea, 219, 221

Spiny lobster, 21, 79, 87-88, 98-100, 280, 556, 563

Spirinchus starksi, 476

**Spirinchus thaleichthys,** 476, 479 **Spot prawn,** 75, 121-126, 563 **Spotfin croaker,** 138, 229-231, 563

Spotfin surfperch, 236, 239

Spotted sand bass, 149, 222, 226-227, 564

Squatina californica, 248, 251

Squid, 19, 21, 27, 48, 52, 55-57, 59-61, 70, 74-75, 87, 151, 158, 174, 190, 196, 202, 206-207, 210, 212, 215, 217, 220, 224, 235, 243, 250, 291, 293-298, 306-307, 309-310, 319, 323, 326, 333, 335, 337, 341-343, 361, 366, 521, 523-524, 526, 531-533, 538, 547, 568, 571-572, 583

Starry flounder, 149, 199-200, 203, 385, 435, 441, 449 Steelhead, 32, 67, 405-406, 411, 415, 417-427, 507-509, 523, 561, 564 Steelhead rainbow trout, 418-425

Steller sea lion, 524

Stereolepis gigas, 510

**Striped bass,** 53-54, 63, 69, 437, 439, 441, 455, 460-464, 467, 469, 477, 480

Striped marlin, 308, 334-335, 564

Striped seaperch, 193, 236, 239-240

Strongylocentrotus franciscanus, 101, 104-106

Strongylocentrotus purpuratus, 105-106

Submerged Aquatic Plants, 487-492

Surf smelt, 79, 151, 472-474, 476, 478, 564

Surfperches, 27, 149, 151, 236-240, 253, 435, 455

Swordfish, 27, 48, 57, 59-61, 67, 315, 322-324, 328, 331-332, 334, 336, 339, 341-343, 350, 352, 356, 363, 396, 471, 564, 574

Symphurus atricauda, 203

Tapes philippinarum, 451

Thaleichthys pacificus, 477

Thornback, 257, 259-260

Thornyheads, 359-360, 374-377, 382, 390

Thresher shark, 248, 315, 336-337, 339-341

Thunnus alalunga, 317, 321

Thunnus albacares, 331, 333

Thunnus orientalis, 325

Tivela stultorum, 135, 137

Topsmelt, 472, 220, 243-244, 246, 253, 563

Trachurus symmetricus, 293, 309, 311

Treefish, 68, 149, 185-188, 272

Tresus capax, 445-446

Tresus nuttalli, 445

Triakis semifasciata, 252, 254

True smelts, 27, 243, 246, 455, 472-480

Turban snail, 140-141, 145, 147-148

Umbrina roncador, 232

Urolophus halleri, 259

Vermilion rockfish, 26, 189-190, 363

Wakasagi, 472-476, 479, 565

Walleye surfperch, 236, 239-240

Washington clam, 447-448, 565

Water Quality, 20, 29-45, 87, 227, 416, 419, 437, 452, 481, 483, 486, 493, 497, 500-502, 505, 507, 510, 517-518, 558

Wavy turban snail, 140-141, 145, 147-148

Whales, 291, 301, 335, 346, 395, 471, 521-522, 529-535, 537, 567-568

White abalone, 19, 89, 93-95, 97, 494

White croaker, 56, 150, 196, 234-235, 264, 266, 268-272, 341, 441, 565

White seabass, 56, 79, 119-120, 127, 149-151, 206-209, 212, 308, 493, 510-512

White shark, 151, 253, 255, 345-347, 470, 532

White sturgeon, 441, 455, 465-469

Widow rockfish, 19, 171, 359, 363, 370-372,

Xiphias gladius, 322, 324

Yellow rock crab, 112

Yellowfin croaker, 138, 232-233, 565

Yellowfin tuna, 27, 215-216, 315, 328, 331-333, 563, 565

Yellowtail, 127, 67, 79, 149-150, 163, 166, 168, 212-214, 264, 266-268, 272, 301, 308, 326, 359, 363, 372-373, 398-399, 565

Yellowtail rockfish, 163, 168, 359, 372-373

Zalembius rosaceus, 236

Zalophus californianus, 523-524

Zostera marina, 481, 487, 490

The University of California in accordance with applicable Federal and Caste law and University of California	color
he University of California, in accordance with applicable Federal and State law and University policy, does not discriminate on the basis of race, actional origin, religion, sex, disability, age, medical condition (cancer-related), ancestry, marital status, citizenship, sexual orientation, or status	
fietnam-era veteran or special disabled veteran. The University also prohibits sexual harassment. This nondiscrimination policy covers admission, and treatment in University programs and activities.	access,
ind treatment in University programs and activities.	

