NOAA Technical Memorandum NMFS-NWFSC-28

Investigation of Scientific Information on the

Impacts of California Sea Lions and Pacific Harbor Seals on Salmonids and on the Coastal Ecosystems of Washington, Oregon, and California

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EXECUTIVE SUMMARY

In the 1994 Amendments to the Marine Mammal Protection Act (MMPA), Congress directed that a scientific investigation be conducted to "determine whether California sea lions and Pacific harbor seals a) are having a significant negative impact on the recovery of Salmonid fishery stocks which havebeen listed as endangered species or threatened species under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), or which the Secretary finds are approaching such endangered species or threatened species status; or b) are having broader impacts on the coastal ecosystems of Washington, Oregon, and California." This report provides the results of the scientific investigation requested by Congress.

Investigation into the existing scientific information addressing these issues was undertaken by a Working Group established by the National Marine Fisheries Service (NMFS). NMFS determined it did not have the resources nor was there sufficient time to conduct thorough field investigations on the issues identified by Congress within a 1-year time frame, so the investigation focused on a Working Group review of information from past field studies. The Working Group compiled and reviewed all available information on the status and trends of California sea lions (*Zalophus californianus*), Pacific harbor seals (*Phoca vitulina*), and the seven species of Salmonids found in Washington, Oregon. and California. Members of the Working Group also conducted several additional studies to augment existing information.

The status of many Salmonid populations has become precarious in recent years. Six populations of Pacific Salmonids have been listed under the Endangered Species Act (ESA) and 12 populations are proposed for listing as of February 1997. Serious declines in these and many other populations of Salmonids are the result of a complex array of factors over time, including changes in Salmonid riverine habitat, changes in oceanic conditions, overharvest, development of hydroelectric power systems in major riverine migratory routes, and detrimental impacts of hatchery programs. Predation by California sea lions and Pacific harbor seals may now constitute an additional factor in Salmonid population decline and can affect recovery of depressed Salmonid populations in somesituations.

The California sea lion population has been increasing at an annual rate of about 5% per year since the mid-1970s. The number of California sea lions off Washington, Oregon, and California

was estimated at more than 161,000 sea lions in 1994. California sea lions are present year-round in southern California where they breed and pup. Male sea lions migrate northward into Washington, Oregon, and northern California each year from September to May, coinciding with spawning runs of many depressed Salmonid populations. California sea lions are opportunistic feeders, foraging on schooling fish and other prey that form dense aggregations. Their diet is diverse and varies regionally, seasonally, and annually. The proportion of Salmonids found in the California sea lion food habits samples varied by site, season, and year. California sea lions have had a significant negative impact on the recovery of one Salmonid population-winter steelhead that migrate through the Hiram M. Chittenden Locks (Ballard Locks) in Seattle, Washington.

Pacific harbor seals are present in Washington, Oregon, and California year-round; pupping occurs in all three states. Harbor seal populations in the three states have been increasing at a rate ofabout 5-7% annually since the mid-1970s. The estimated abundance by state from 1993-95 was 34,134 seals in Washington, 9,251 in Oregon, and 32,699 in California. Pacific harbor seals are opportunistic feeders, preying on a wide variety of benthic and epibenthic fish and cephalopods. Their diet also varies regionally, seasonally, and annually. The proportion of Salmonids found in Pacific harbor seal food habits samples varied between studies as well as by site, season, and area.

The Working Group found that the presence of California sea lions and Pacific harbor seals in rivers and estuaries concurrent with migrations of depressed Salmonid populations is a concern because pinniped predation can impact small runs of depressed Salmonids. The Working Group could not determine if either pinniped species is having a significant negative impact on any wild Salmonid population, except winter steelhead that migrate through the Ballard Locks, because of the limitations of the available data. Although the Working Group concluded that substantial additional research is needed to fully address this issue, it found that existing information on the seriously depressed status of many Salmonid stocks issufficient to warrant actions to remove pinnipeds in areas of co-occurrence where pinnipeds prey on depressed Salmonid populations. The Working Group identified the elements of a research program to assess impacts of pinniped predation on depressed Salmonids and identified the geographic areas of greatest concern for impacts on Salmonids in each state.

The Working Group found that California sea lions and Pacific harbor seals are interacting with many commercial and recreational fisheries on the West Coast. It also found numerous instances of conflicts at docks and marinas, primarily with California sea lions, that raise human safety concerns. In all three states, reports of pinnipeds removing Salmonids and other fish from fishing gear and damaging gear have increased. Interactions appear to be most severe, in terms of lost catch and gear damage, in Salmonid gillnet, salmon troll, salmon net-pens, and southern California charterboat fisheries. The Working Group reviewed mitigation measures that have been used to reduce or eliminate pinniped predation on Salmonids or minimize interactions with fisheries and found that most nonlethal deterrence measures have limited or short-term effectiveness. Development of new technologies and techniques is needed to effectively deter pinnipeds from fishery conflicts and from marinas where human safety issues arise.

The Working Group could not determine ecosystem-level impacts because of the complexity of ecosystems and the limited knowledge of how they function. The Working Group reviewed existing biomass consumption estimates for California sea lions and Pacific harbor seals and noted problems with the estimates. New estimates of annual food consumption by harbor seals and sea

lions were calculated by the Working Group using a bioenergetics model integrating data on abundance, sex and age structure, and feeding rates. The Working Group estimated a minimum total biomass consumption of about 217,400 metric tons by sea lions and seals in Washington, Oregon, and California and found that it amounted to almost half of what is harvested in commercial fisheries. The Working Group determined it is reasonable to assume that increasing numbers of pinnipeds areconsuming an increasing number of prey composed of a variety of species; however, to what degree the increased presence of pinnipeds and increased biomass consumption affects ecosystems is unknown. Research was identified to determine the coastwide degree of interaction between pinnipeds, fisheries, and other West Coast ecosystem elements.

INTRODUCTION

In recent years, the status of some salmonid populations has become precarious. As of February 1997, 6 populations of Pacific salmonids have been listed under the Endangered Species Act (ESA), and 12 populations are proposed for listing under the ESA. Serious declines in these and many other populations of salmonids are the result of a complex array of factors over time, including changes in salmonid riverine habitat, changes in oceanic conditions, overharvest, development of hydroelectric power systems in major riverine migratory routes, and detrimental impacts of hatchery programs. Predation by California sea lions (*Zalophus californianus)* and Pacific harbor seals (*Phoca vitulina*) may now constitute an additional factor in salmonid population decline and may affect recovery of depressed salmonid populations.

Since passage of the Marine Mammal Protection Act (MMPA) in 1972, populations of California sea lions and Pacific harbor seals (pinnipeds) have increased steadily in Washington, Oregon, and California. These two pinniped populations are healthy and productive, and are not considered to be depressed, threatened, or endangered. Reports of pinniped interactions with salmonid fisheries have increased in recent years, as have reports of scarring of salmonids attributed to pinnipeds. This has raised concern that predation on salmonids by pinnipeds could be increasing and causing significant negative impacts on threatened, endangered, or severely depleted salmonid populations. Increased predation could not only cause further declines in salmonid populations, but could also prevent or slow the recovery of listed salmonid stocks. The proposed National Marine Fisheries Service (NMFS) Recovery Plan for Snake River salmon specifically identifies pinniped predation on salmon as a factor that must be considered for recovery of Snake River chinook salmon that are listed under the ESA (NMFS 1995a).

Because of public concern over salmonid population declines and the role pinnipeds may have, Congress mandated a review of the impacts of increasing pinniped populations on decreasing salmonid populations as well as impacts on the West Coast ecosystems. The 1994 Amendments to the MMPA directed the Secretary of Commerce to conduct a "scientific investigation to determine whether California sea lions and Pacific harbor seals a) are having a significant negative impact on the recovery of salmonid fishery stocks which have been listed as endangered species or threatened species under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), or which the Secretary finds are approaching such endangered species or threatened species status; or b) are having broader impacts on the coastal ecosystems of Washington, Oregon, and California." After completion of the investigation, the NMFS on the behalf of the Secretary is directed to "enter into discussions with the Pacific States Marine Fisheries Commission on behalf of the states of Washington, Oregon, and California, for the purposes of addressing any issues or problems

identified as a result of the scientific investigation, and to develop recommendations to address such issues or problems." These recommendations are then to be submitted, along with this report, to the House of Representatives' Committee on Resources and the Senate's Committee on Commerce, Science, and Transportation.

NMFS determined it did not have the resources nor was there sufficient time to conduct thorough field investigations on the issues identified by Congress within a 1-year timeframe, so the investigation therefore focused on a review of information from past field studies. A review of the existing scientific data on pinniped predation as a potential factor in the decline and recovery of salmonid populations as well as broader ecosystem impacts was undertaken by a Working Group established by NMFS. Working Group members were selected based on their knowledge of salmonids, marine mammals, and the interactions between them. The Working Group established the following objectives for this investigation:

1. Compile information on population size and trends of salmonids, Pacific harbor seals, and California sea lions in Washington, Oregon, and California.
2. Compile and review published literature and unpublished data on Pacific harbor seal and California sea lion food habits.
3. Identify and assess the nature and magnitude of pinniped interactions with salmonids in Washington, Oregon, and California.
4. Identify depressed, threatened, or endangered salmonid stocks or stocks approaching that status in Washington, Oregon, and California and assess whether they are or may be affected by pinniped predation.
5. Identify and assess any broader ecosystem impacts of pinniped populations on coastal and estuarine ecosystems in Washington, Oregon, and California.
6. Identify conflicts with humans that exist now or are likely to arise from growth of pinniped populations.
7. Identify methods that have been used to mitigate conflicts and adverse impacts on fish stocks and coastal ecosystems.
8. Identify additional information needed to assess the nature and effects of pinniped predation on salmonid stocks and coastal ecosystems.

During the investigation of available information, the Working Group found significant gaps in the information needed to evaluate the interactions and impacts of pinnipeds on salmonids. Similar information gaps on potential impacts of pinnipeds on Snake River spring/summer and fall chinook salmon (listed as threatened under the ESA) were also identified by NMFS in the recovery plan for Snake River salmon (NMFS 1995a). To address some of these shortcomings, scientists of the Working Group obtained new information on occurrence of California sea lions in California, reevaluated the occurrence of salmonids in the diet of sea lions and harbor seals, and made new estimates of overall biomass consumption by California sea lions and harbor seals.

The Working Group believed it was important to include information beyond that specified by the Congressional mandate. Consequently, this report includes a review of mitigation methods used to reduce pinniped predation on fish populations, and information on Steller sea lions (Appendix A) because this species also is occasionally involved in interactions.

NOAA Technical Memorandum NMFS

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SALMONIDS--STATUS OF POPULATIONS

There are seven anadromous species of Salmonidae present in Washington, Oregon, and California: chinook salmon (*Oncorhynchus tshawytscha)*, chum salmon (*O. keta*), coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), sockeye salmon (*O. nerka*), steelhead (*O. mykiss*), and sea-run cutthroat trout (*O. clarki*). Each of these species begins its life in fresh water, migrates to salt water to mature, and returns to fresh water to spawn. The exact details of this cycle vary between and within the seven species, but the environmental conditions necessary to complete these cycles are generally similar. These conditions include adequate stream flow, unimpeded access to ocean habitats and upriver spawning habitat, appropriate composition of the river or stream bottom, and complexity of habitat where spawning and fry development take place.

Anadromous salmonids are comprised of populations that originate from specific watersheds as juveniles and generally return to their natal streams to spawn. While the environmental requirements of all salmonids on the Pacific coast are generally quite similar, individual stocks have developed complex adaptations to the specific local conditions of the particular river systems that they inhabit. Ricker (1972) defined a salmonid "stock" as salmon that spawn in a particular river system (or portion of it) at a particular season and that do not interbreed to any substantial degree with any group spawning in a different place, or in the same place at a different season. Because local populations of salmonid stocks possess adaptive genetic differences, salmonids are more appropriately managed and conserved by stock, rather than by species (MacLean and Evans 1981). Populations of salmonids are loosely distinguished based on the season of the year during which they return to their native streams to spawn. Thus, spring-run fish enter the rivers in the spring, summer-run fish in the summer, fall-run fish in the fall, and winter-run fish in the winter (Nickelson et al. 1992).

In recent years, native, naturally spawning salmonid populations have declined as a result of habitat loss and degradation; inadequate riverine passage and flows due to hydropower, agriculture, logging, and other developments; overfishing; negative interactions with other species and hatchery fish; and environmental fluctuations and declines in fresh water (drought) and marine (El Niño) productivity. Nehlsen et al. (1991) evaluated the status of all salmonid stocks for Washington, Oregon, California, and Idaho, and identified 214 native, naturally spawning Pacific salmonid stocks that they classified as facing a high or moderate risk of extinction, or as of special concern. Nehlsen et al. (1991) suggested that 18 of these stocks may already be extinct. Of the 214 stocks they identified, 101 were at high risk of extinction, 58 were at moderate risk of extinction, 54 were of special concern, and one was classified as threatened under the ESA. Thirty-nine of these stocks occur in California, 58 on the Oregon coast, 76 in the Columbia River Basin, and 41 in the Washington coast/Puget Sound area (Nehlsen et al. 1991). Some of these stocks consist of small wild populations for which spawning has not been observed for some time. In other cases, hatchery programs were established to supplement native stocks, and the continued existence of some native stocks is in doubt. Because escapement is estimated as the aggregate of all fish returning to a basin, a decline in a native stock may be masked by returns of hatchery fish. Nehlsen et al. (1991) also reported that 104 of the 214 stocks identified were believed to have a high probability of introgression, or genetic "mingling" of hatchery stock with wild stocks. When native stocks reproduce with non-native stocks, the characteristics of the native population may be altered or lost (Nehlsen et al. 1991, Hindar et al. 1991, Waples 1991a, Hard et al. 1992). This can result in a reduction in fitness of the native stocks and an increased susceptibility to disease.

Recent efforts to preserve salmonids have focused on federal protection under the ESA. Since 1990, the NMFS has received a number of petitions to list populations of Pacific salmonids as threatened or endangered under the ESA; the first to be listed as endangered was the Sacramento River winter chinook salmon. If listed, the ESA requires that recovery plans be developed and implemented.

The ESA allows listing of "distinct population segments" of salmonids, but provides no explicit guidance on how to determine when a population is distinct enough to qualify as an ESA "species." NMFS developed a policy to determine what constitutes a species of wild Pacific salmonid under the ESA. To be considered distinct, a salmonid population must be substantially reproductively isolated and make a substantial contribution to the evolutionary legacy of the biological species (Waples 1991b). A distinct population that meets these criteria is defined as an "Evolutionarily Significant Unit" (ESU). Within an ESU that is listed or proposed for listing, some individual wild populations or stocks may be considered healthy. Conversely, a "not warranted" determination with respect to ESA listing does not necessarily mean that all wild populations within the ESU are healthy. When evaluating the two criteria to determine an ESU, a variety of factors are considered, including genetic and life-history traits of the wild salmonid populations, ecological characteristics of their habitats, and the effects of human factors (e.g., stock transfers) that may have altered native gene pools. After the ESUs are identified, NMFS evaluates the level of risk to determine whether a listing as threatened or endangered under the ESA is warranted. The following is a summary of the ESA listing actions and status reviews on Pacific salmonids.

Endangered

1. Sacramento River winter chinook salmon
2. Snake River sockeye salmon
3. Umpqua River cutthroat trout

Threatened

1. Snake River spring/summer chinook salmon (proposed endangered)
2. Snake River fall chinook salmon (proposed endangered)
3. Central California coho salmon

Proposed for Listing

1. Lower Columbia River steelhead (threatened)
2. Upper Columbia River steelhead (endangered)
3. Snake River Basin steelhead (threatened)
4. Oregon Coast steelhead (threatened)
5. Oregon Coast coho salmon (threatened)
6. Klamath Mountain Province steelhead (threatened)
7. Southern Oregon/Northern California coho salmon (threatened)
8. Northern California steelhead (threatened)
9. . Central California coast steelhead (endangered)

10. South/central California coast steelhead (endangered)
11. . Southern California steelhead (endangered)
12. Central Valley steelhead (endangered)

Candidate Species (under consideration for listing, but not yet proposed for listing)

1. Puget Sound/Strait of Georgia coho salmon
2. Southwest Washington/Lower Columbia River coho salmon
3. Middle Columbia River steelhead

Status Review Completed--Listing Not Warranted

1. West coast pink salmon (odd-year and even-year populations)
2. Olympic Peninsula coho salmon
3. Olympic Peninsula steelhead
4. . Puget Sound steelhead
5. Southwest Washington steelhead
6. Upper Willamette River steelhead

Under Status Review

1. West coast chinook salmon
2. West coast sockeye salmon
3. West coast chum salmon
4. West coast sea-run cutthroat trout

In addition to the federal classification system, each state has a somewhat different system for classifying stock status and uses separate definitions for the categories. The definitions used by the states and the federal government for the various categories of salmonid stocks are listed in Appendix B. Terms used to describe salmonids such as "wild stock," "cultured stock," and "escapement" are described in Appendix C.

Stock Status by State and Region

The Working Group summarized the status of salmonids in Washington, Oregon, and California, using the most recent data available from the states. Appendix D lists the overall status of wild, naturally producing salmonid populations by region, along with numbers of pinnipeds present during salmonid migration. Appendix E shows the status of salmonid populations in greater detail, by river and state. The summary for Washington State relies on the "1992 Washington State Salmon and Steelhead Stock Inventory" (SASSI) report (WDF et al. 1992) and on more recent information provided by the Washington Department of Fish and Wildlife (WDFW). The data on Oregon salmonids is derived from the Oregon Department of Fish and Wildlife's (ODFW) "Status of Anadromous Salmonids in Oregon Coastal Basins," (Nickelson et al. 1992) and from more recent evaluations provided by ODFW. The status of California salmonid stocks relies on a paper, "Petition for a Rule to List Steelhead as Threatened or Endangered under the Endangered Species Act and to Designate Critical Habitat," by the Oregon Natural Resources Council et al. 1995, as well as Moyle and Yoshiyama 1992, Nehlsen et al. 1991, and updated information from the California Department of Fish and Game (CDFG). Classifications by the states and NMFS are different for some stocks. For ease of reference in this report, each state is divided into regions (Figs. 1-4) based on pinniped distribution, natural geographic partitions, and major salmonid river systems.

Washington

Washington is divided into eight regions for analysis of the status of salmonid and pinniped populations: 1) Eastern Bays, 2) Puget Sound, 3) Hood Canal, 4) Strait of Juan de Fuca/San Juan Islands, 5) Washington Coast, 6) Grays Harbor, 7) Willapa Bay, and 8) Columbia River Basin. Figures 1 and 2 show these regions as well as the major rivers and areas referenced in this report. The following paragraphs describe the status of salmonids in each region using Washington's three categories to describe salmonid status: healthy, depressed, and critical (definitions of these terms are in Appendix B). More details on the status and run-timing of these salmonid populations are in Appendices D and E.

Pink salmon--Pink salmon occur in four of the Washington regions (Appendix D). Populations are generally rated as healthy, with four exceptions. In the Strait of Juan de Fuca, the Upper Dungeness River run is classified as depressed, and the Lower Dungeness and Elwha River runs are classified as critical. In Hood Canal, the Dosewallips River run is classified as depressed.

Sockeye salmon--Sockeye salmon occur in four of the Washington regions (Appendix D). The status of Washington Coast sockeye salmon stocks is mixed. The sockeye salmon run is healthy in the Quinault River and depressed in the Ozette River. The Eastern Bays stocks are classified as critical. In Puget Sound, sockeye salmon stocks are depressed. Sockeye salmon runs are healthy in two Washington tributaries of the Upper Columbia River (the Wenatchee and Okanogan Rivers). Sockeye salmon in the Snake River are listed as endangered under the ESA.

Chum salmon--Chum salmon occur in each of the eight Washington regions. The status of Washington Coast chum salmon runs is unknown. Runs are healthy in Grays Harbor and Willapa Bay. The Strait of Juan de Fuca/San Juan Islands fall chum salmon runs are classified as unknown, the summer run as critical. The fall chum salmon runs in Hood Canal are healthy, while most summer runs are critical. Chum salmon are healthy in Puget Sound and the Eastern Bays. Fall chum salmon in the Washington tributaries of the Lower Columbia River are depressed. Chum salmon do not occur above the Lower Columbia River.

Coho salmon--Coho salmon occur in each of the eight Washington regions. Coho salmon status is mixed throughout Washington. Coho salmon in the Puget Sound, Eastern Bays, Hood Canal, Grays Harbor, and Willapa Bay regions are candidate species for listing under the ESA, and the status of runs is mixed with some unknown and others healthy or depressed. In the Strait of Juan de Fuca/San Juan Islands region, the eastern portion of the region (east of Salt Creek) is part of the ESU that is a candidate species for listing under the ESA, and the status of runs is mixed. Coho salmon were extirpated above Bonneville Dam.

Chinook salmon--Chinook salmon occur in each of the eight Washington regions. Their status varies considerably by area and by run within regions. Washington Coast spring and fall chinook salmon runs are classified as healthy, summer runs are mixed, and spring/summer runs are depressed. Other healthy runs include Grays Harbor (spring) and Willapa Bay (fall). Grays Harbor (summer) and Willapa Bay (early fall) chinook runs are depressed. The Strait of Juan de Fuca/San Juan Islands fall runs are depressed. The summer/fall chinook salmon runs in this region are healthy, while spring/summer runs are critical. The Eastern Bays summer runs are mixed, while the spring and fall runs are depressed. The Nooksack River spring chinook salmon run in this region is classified as critical. Hood Canal summer/fall runs are depressed. The Puget Sound summer/fall runs are mixed status. Spring and fall runs in Washington tributaries of the Lower Columbia River and Upper Columbia River (late fall) runs are healthy. Washington has classified the Snake River spring/summer and fall chinook runs as critical, and these are listed as threatened under the ESA.

Steelhead--Steelhead occur in each of the eight Washington regions. The status of winter runs in the Washington Coast and Grays Harbor regions is mixed. Willapa Bay winter runs are healthy. The status of summer runs in the Washington Coast region is unknown, and Grays Harbor summer runs are depressed. The Strait of Juan de Fuca/San Juan Islands summer runs are depressed, while the status of winter runs is mixed. The Eastern Bays winter runs are healthy and summer runs are mixed, except the Deer Creek summer run is critical. The Puget Sound summer and winter steelhead runs are healthy, although the Lake Washington run of winter steelhead is now classified as critical. The status of Hood Canal winter runs is mixed and unknown for summer runs. The summer and winter runs in the Washington tributaries of the Upper and Lower Columbia River are classified as depressed, as is summer steelhead in the Snake River. Lower and Upper Columbia River steelhead have been proposed for listing under the ESA as threatened and endangered respectively.

Sea-run cutthroat trout--Sea-run cutthroat occur in each of the eight Washington regions. Although classification of the runs has not been completed, most are considered depressed or critical due to severe habitat degradation and chronically low returns.

Oregon

Oregon is divided into six regions for analysis of the status of salmonid and pinniped populations: 1) Columbia River Basin, 2) North Oregon Coast, 3) Tillamook Bay, 4) Umpqua River, 5) Rogue River, and 6) South Oregon Coast. Figure 3 shows these regions and major rivers and areas referenced in the text. The following paragraphs describe the status of salmonids in each region using Oregon's three categories: healthy, special concern, and depressed (definitions of these terms are in Appendix B). More details on the status and run-timing of these salmonid populations are in Appendices D and E.

Pink salmon--Pink salmon occasionally occur in Oregon waters, but there is no evidence of permanent populations.

Sockeye salmon--Sockeye salmon are generally no longer found in Oregon, except those migrating in the Columbia River and a few of unknown origin that return each year to the Deschutes River.

Chum salmon--Chum salmon occur in three of the Oregon regions. In the North Oregon Coast and Tillamook Bay regions, most runs are classified as of special concern. Chum stocks in Nehalem River are in somewhat better condition than others. Chum salmon runs in the Oregon tributaries of the Columbia River no longer exist except as occasional strays.

Coho salmon--Coho salmon occur in each of the six Oregon regions. Coho salmon are classified as depressed in all of the coastal regions, except the Coos and Coquille River populations are healthy. Oregon coastal coho salmon have been proposed for listing as threatened under the ESA. Lower Columbia River coho salmon are classified as depressed.

Chinook salmon--Chinook salmon occur in each of the six Oregon regions. Based on an internal ODFW review in October 1995, conservation concerns have been identified for all North Oregon Coast spring chinook salmon runs, except for the Nehalem River runs which are considered healthy. Fall chinook salmon are typically healthy in northern Oregon, with the exception of the Salmon and Sixes Rivers and Dry Creek, where the runs are classified as of special concern. Fall chinook salmon are depressed in the South Oregon Coast. Both spring and fall chinook salmon in Oregon tributaries of the Columbia River are considered depressed, except the Deschutes River fall run which is healthy. Umpqua River Basin fall chinook and North Umpqua spring chinook salmon are healthy; however, South Umpqua spring chinook are depressed. The Rogue River has a healthy spring chinook salmon run. The fall chinook salmon in the Rogue River Basin are classified as healthy in the middle and upper Rogue River and in the Applegate River, but classified as depressed in the lower Rogue River and the Illinois River (tributary of the Rogue River). Spring/summer and fall chinook salmon in the Snake River have been listed as threatened under the ESA.

Steelhead--Steelhead occur in each of the six Oregon regions. Most winter steelhead populations in Oregon are depressed. The only exceptions are the winter steelhead in the North Umpqua, Coquille, Rogue, and Winchuk Rivers, which are healthy. However, the steelhead in the Illinois River are depressed. Of the summer steelhead populations in Oregon, only those in the North Umpqua River are healthy. All other summer steelhead are considered depressed. Coastal steelhead populations have been proposed for listing as threatened under the ESA.

Sea-run cutthroat trout--Adequate data to determine trends in abundance for most populations of sea-run cutthroat trout are not available. All sea-run cutthroat populations in Oregon are considered depressed. Nehlsen et al. (1991) listed sea-run cutthroat trout stocks in Oregon coastal streams and in small tributaries of the lower Columbia River as being at moderate risk of extinction. They listed Hood River sea-run cutthroat trout as being at high risk of extinction (the definitions of "moderate" and "high" risk of extinction used by Nehlsen et al. (1991) are the same as the definitions used by the State of California as listed in Appendix B). Because populations of sea-run cutthroat trout in Oregon occur near the extreme southern edge of the range of the subspecies, they may be particularly vulnerable to climatic change, habitat loss, or the cumulative effects of these and other disturbances (Nickelson et al. 1992). Umpqua River sea-run cutthroat trout have been listed as endangered under the ESA.

California

California is divided into eight regions for analysis of the status of salmonid and pinniped populations: 1) Smith River, 2) Klamath River, 3) Cape Mendocino, 4) North California Coast, 5) San Francisco Bay, 6) Monterey Bay, 7) Central California Coast, and 8) Southern California Bight. Figure 4 shows these regions and major rivers and areas referenced in this report. The following paragraphs describe the status of salmonids in each region using California's four categories: healthy, special concern, moderate risk of extinction, and high risk of extinction (definitions of these terms are in Appendix B). More details on the status and run-timing of these salmonid populations are in Appendices D and E.

Pink salmon--California is the southern edge of the pink salmon range and they have never been common there (Moyle and Yoshiyama 1992). Today, pink salmon are considered extremely rare in California. Moyle and Yoshiyama (1992) report small numbers of pink salmon in the San Lorenzo River, the Sacramento River and tributaries, Klamath River, Russian River, Garcia River, and Ten Miles River. They hypothesize that these are probably "strays" from the ocean that followed other salmon runs up the river and thus are not distinct "runs." Nehlsen et al. (1991) consider pink salmon runs in the Klamath, Russian, and Sacramento Rivers to be extinct.

Sockeye salmon--Sockeye salmon do not occur in California waters.

Chum salmon--Chum salmon historically occurred in streams from the San Lorenzo River (Monterey Bay) to the Oregon border (Moyle and Yoshiyama 1992). Today, small runs may persist in the South Fork of the Trinity River and the Smith River. However, Moyle and Yoshiyama (1992) report that chum salmon in California are on the "verge of extinction." Nehlsen et al. (1991) report that chum salmon in the Sacramento and Klamath Rivers are extinct.

Coho salmon--Coho salmon are widely distributed in California streams (Appendix D). Historically, there are records of coho salmon in streams as far south as the Big Sur River (Central Coast) and up to the Smith River near the Oregon border (Moyle and Yoshiyama 1992). There have been significant declines in recent years, however. Klamath River coho salmon runs are listed as of special concern by Nehlsen et al. (1991). Runs in coastal streams north of San Francisco (Trinity, Mad, Noyo, and Eel Rivers) are at moderate risk of extinction, while those in the small coastal streams south of San Francisco are at high risk of extinction (Nehlsen et al. 1991). Coho salmon in Malibu Creek are thought to be extinct (Nehlsen et al. 1991). Coho salmon from the Oregon border south to and including the San Lorenzo River have been proposed for listing as threatened under the ESA.

Chinook salmon--Chinook salmon are found in six of the eight California regions (Appendix D). In the Smith River, spring chinook salmon are listed at high risk of extinction, while the fall run is at moderate risk of extinction. The spring chinook salmon in the Klamath-Trinity drainage are depleted and were rated at high risk of extinction by Nehlsen et al. (1991) and ONRC et al. (1995). The status of fall runs in this region is mixed: the Shasta River is at high risk, Redwood Creek and the lower Klamath River tributaries are at moderate risk, and the Scott River is listed as of special concern (Nehlsen et al. 1991, ONRC et al. 1995). In the Cape Mendocino region, the runs in the minor Humboldt Bay tributaries are depleted and are listed as at high risk of extinction (Nehlsen et al. 1991, ONRC et al. 1995). North Coast fall chinook salmon are at high risk of extinction. In the San Francisco Bay region, spring chinook salmon have declined severely and most runs are at high risk of extinction. Currently, spring chinook salmon occur only in Deer and Mill Creeks in the Sacramento drainage. Fall chinook in the San Francisco Bay region are of special concern (Nehlsen et al. 1991, ONRC et al. 1995). Winter chinook salmon in the Sacramento River are listed as endangered under the ESA.

Steelhead--Historically, winter steelhead occurred in California coastal streams from the Oregon border to the United States/Mexico border. Wild populations of winter steelhead in many coastal streams from the Russian River south are either severely depleted or extirpated (Moyle and Yoshiyama 1992, McEwan and Jackson 1996). Summer steelhead in the Smith River region are at high risk of extinction (Nehlsen et al. 1991). In the Klamath River, summer steelhead are at moderate risk, and in Redwood Creek they are at high risk of extinction. In the Cape Mendocino region, summer steelhead in the Eel River are at moderate risk of extinction, while the Mad River runs are listed at high risk of extinction (Nehlsen et al. 1991). Winter steelhead in the San Francisco Bay region are at high risk of extinction. In the Monterey Bay region, winter steelhead are at high risk of extinction in the Carmel and Pajaro Rivers and at moderate risk of extinction in the Salinas River. Winter steelhead in the Central Coast are at high risk of extinction in the Santa Ynez River and of special concern in the Big and Little Sur Rivers. Winter steelhead in the Southern California Bight (Malibu Creek, Santa Clara, and Ventura Rivers) are at high risk of extinction (Nehlsen et al. 1991). In the past 30-40 years, most summer steelhead populations in

California have declined considerably and most are represented by 100 fish or less (Moyle and Yoshiyama 1992). All steelhead populations in California have been proposed for listing under the ESA.

Sea-run cutthroat trout--Sea-run cutthroat trout have undergone a major decline over the last two decades. Nehlsen et al. (1991) report that sea-run cutthroat trout in California coastal streams are at a moderate risk of extinction.

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CALIFORNIA SEA LION: POPULATION SIZE AND TRENDS

The California sea lion population, which occurs from the offshore islands of Mexico north to Vancouver Island, British Columbia, has increased dramatically in this century. In the late 1920s, 1,000-1,500 California sea lions were counted on land in California (Bonnot 1928, Cass 1985). Commercial harvest in the 1800s and early 1900s likely reduced the numbers of California sea lions at the turn of the century. With curtailment of commercial hunting in the early 1940s, the population gradually began to increase. Following passage of the MMPA in 1972, the California sea lion population off the West Coast of the United States has increased steadily at an average annual rate of more than 5% since the mid-1970s (Barlow et al. 1995) as indicated by pup counts (Fig. 5). Although the population is now very large and may be greater than any historical level (Low 1991), there is no evidence that it has reached its optimal sustainable population (OSP) level which is the management goal mandated by the MMPA (NMFS 1992).

In the United States, California sea lions breed primarily on the California Channel Islands of Santa Barbara, San Nicolas, San Miguel, and San Clemente. Large numbers of California sea lions also breed in Baja California, Mexico. California sea lions give birth to a single pup from late May through late June each year and breeding occurs in July. After the breeding season, most subadult and adult males (from both the Baja and the Channel Islands rookeries) migrate northward to central and northern California, Oregon, Washington, and British Columbia (Bartholomew 1967, Mate 1975). The peak of the northward migration occurs in September through October on the Oregon coast, in December in Washington, and in January and February in British Columbia. In the spring, most subadult and adult males migrate south, returning to the breeding rookeries in southern California and western Baja California. The southward migration peaks in Washington in March and April, and in Oregon in April and May (Brown 1988); most sea lions have left the Northwest by June (Gearin et al. 1986, 1988b). Some subadult males, adult males, and juveniles remain at haul-outs in central and northern California during the breeding season (Bartholomew 1967, Huber 1991,NMFS-SWFSC, unpubl. data.). Most of the year-round population in southern California consists of adult females, their pups, and juveniles.

Population abundance estimates are based on pup counts during the breeding season. To estimate total abundance, a correction factor (based on an estimate of the proportion of pups in the population) is applied to the number of pups counted in a given year (Boveng 1988, Lowry et al. 1992). From 1975 to 1994, pup counts of California sea lions in southern California (Fig. 5) increased at an annual rate of 5.2% (Lowry et al. 1992, Barlow et al. 1995, NMFS-SWFSC/AFSC unpubl. data). El Niño events have been shown to decrease the number of births and pup survival, especially the 1983 and 1992 events (DeLong et al. 1991, DeLong et al. 1993, NMFS-SWFSC/AFSC unpubl. data). The California sea lion population off the West Coast of the United States in 1994 was estimated at between 161,066 and 181,355 (Barlow et al. 1995).

Washington

In the last 15 years, counts of California sea lions at Everett, Washington (in Puget Sound) have increased from 108 in 1979 (Everitt et al. 1980) to 1,113 sea lions in 1995 (NMFS 1996a). They are present in Washington waters primarily during the nonbreeding season (September to May) and are concentrated in Puget Sound, particularly near Everett (Fig. 2). Counts of sea lions hauled-out in the Everett area are used as an index of the number of sea lions in the inland waters (Strait of Juan de Fuca/San Juan Islands, Hood Canal, Puget Sound). Preliminary analysis of mark-recapture data collected in 1995 indicates that counts at Everett may represent only 50-55% of the animals in the inland waters (NMFS-AFSC unpubl. data). Counts of sea lions in the inland waters of Washington averaged 300-500 animals from 1986 to 1994, and then peaked in 1995 at more than 1,100. Approximately 200-500 California sea lions have been observed during surveys in the 1990s on the offshore rocks and islands on the outer coast of Washington. The majority of these animals are found in the more northern portion of the coast. Sea lions are now also reported far upstream in rivers such as the Nisqually and Chehalis Rivers. Appendix D lists the population counts for regions in Washington.

Oregon

Peak counts of California sea lions in Oregon have increased from 1,000-2,000 in the late 1970s to 5,000-7,000 in the early 1990s (ODFW unpubl. data). Counts made during the early 1990s for the Oregon regions are in Appendix D. California sea lions are found in greatest abundance on the south coast of Oregon at Rogue Reef and Orford Reef (800-1,000), at Cape Arago and Sea Lion Caves on the central coast (2,000-3,000), and at Cascade Head and the south jetty of the Columbia River on the north coast (2,000-3,000). From October to April, California sea lions are found in the Columbia River (300-500) from Astoria to the Bonneville Dam. They congregate in-river at Astoria at the east mooring basin and near fish processing plants (100-300), near the mouths of the Cowlitz and Lewis Rivers (50-100), and in the Multnomah Channel at the mouth of the Willamette River (10-50). In the Willamette River, small numbers (4-6) are found as far inland as Willamette Falls in Oregon City (see Fig. 3 for location). Increasing numbers of California sea lions are found in a number of coastal bays and rivers, including the Rogue River (10-20), Coos Bay (30-50), Yaquina Bay (50-100), and Tillamook Bay (6-12). Sea lions congregate at the mouths of many rivers primarily during salmonid runs, or during herring or smelt spawning returns.

California

In July and September of 1995, the California Department of Fish and Game (CDFG) conducted statewide aerial surveys to update counts of California sea lions on sites that were last surveyed on a statewide basis in 1980-82 by Bonnell et al. (1983). Summer counts in Bonnell et al. (1983) were 4,378 (1980) to 11,209 (1982), whereas counts in 1995 were 14,300, including 3,000 at the Farallon Islands (1994 estimates by W. Sydeman, Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970. Pers. commun., July 1995). Fall counts in the early 1980s ranged from 10,334 to 24,348; in 1995, the total count was 16,900, including 1,000 at the Farallon Islands (Sydeman, pers. commun.).

Counts at Año Nuevo Island in 1992-94 ranged from 2,313 to 3,400 (mean 2,869) (Ono et al. 1993, NMFS-SWFSC unpubl. data) compared with 1,317 to 3,169 (mean 2,452) in 1980-82 (Bonnell et al. 1983). In the 1995 summer surveys, the largest concentration (6,745) of sea lions in central California was on Año Nuevo Island, comprising 60% of the total mainland count. Generally, the largest haul-out in central/northern California is on the Farallon Islands. Peak abundance usually occurs there during the spring or fall migration, but the highest numbers (6,000-7,000) have occurred during the summer breeding season in El Niño years (Huber 1991). Counts have also been made in the San Francisco Bay area since California sea lions first began hauling-out at Pier 39 in 1990, with peak counts occurring during winter. The highest number was 627 in February 1991 (K. Hanni, California Marine Mammal Center, Marin Headlands, Golden Gate National Recreation Area, Sausalito, CA 94965-2697. Pers. commun., August 1995).

Peak abundance of California sea lions occurs in southern California (south of Morro Bay) during the summer breeding season, when the majority of adults and a lesser proportion of subadults are present. In 1994, at the Channel Island breeding rookeries, the minimum count for the period of peak abundance was 81,300 sea lions (Barlow et al. 1995).

PACIFIC HARBOR SEAL: POPULATION SIZE AND TRENDS

The Pacific harbor seal is distributed along the west coast of North America from Asuncion Island, off Baja California, northward to the Gulf of Alaska. Harbor seals are the most abundant pinniped in Washington and Oregon, and one of the most common pinnipeds in California. They are present year-round and pupping occurs in all three states. They occupy virtually all types of nearshore habitats (offshore rocks; sandy, gravelly, or rocky beaches; and estuarine mud flats) throughout the year and are found in most coastal bays and in many rivers. Populations of harbor seals have increased significantly since the MMPA was passed in 1972, but as with California sea lions, it has not been determined whether they have reached OSP (NMFS 1992).

The timing of harbor seal pupping occurs sequentially along the West Coast of the United States, with pups born earlier in the south and later in the north (Bigg 1973, Bigg and Fisher 1975). In Washington, there is additional variability in the timing of pupping, with considerably later (2 months) pupping in the inland waters (San Juans, Strait of Juan de Fuca, Eastern Bays, and Puget Sound) than on the coast and an extended pupping season from August to January in Hood Canal.

Females reach sexual maturity at 2-5 years of age, give birth for the first time at 3-6 years, and can live as long as 30 years (Bigg 1969). Most males reach sexual maturity at 3-5 years of age and few survive beyond age 20 (Bigg 1969). In many areas, pregnant females segregate into nursery aggregations, away from the main haul-out sites. Pups are weaned at about 4 weeks (Stein 1989), after which there is no further contact between the mother and pup. Once weaning is completed, nursery areas are abandoned and seals return to the main haul-out areas.

Harbor seals do not have extensive annual migrations. Based on studies of tagged seals, they usually remain within a 25-50 km area, although movements of up to 500 km have been recorded.

Washington

There are 319 harbor seal haul-out sites in Washington (Huber 1995). Numbers of harbor seals have increased by 7.7% annually between 1978 (when systematic counts began) and 1993 (Fig. 6). A correction factor was developed to account for harbor seals in the water during surveys in Washington and Oregon (Huber 1995). Using this correction factor (1.53) on the mean count of 22,310 seals (including pups) during the 1993 pupping season, the Washington total abundance in 1993 was estimated as 34,134 seals (Huber 1995). Recent counts (minimum population estimates) of harbor seals for each of the Washington regions are shown in Appendix D.

Some seals move seasonally from one area to another in response to locally abundant prey species such as eulachon in the Columbia River (Beach et al. 1985) or sockeye salmon in the Fraser River (Olesiuk

1993). Most information on harbor seal abundance in Washington is based on surveys conducted during the pupping season which occurs in May/June on the coast and July/August in the inland waters. The major exception is two studies on abundance and movements of harbor seals in the Columbia River and adjacent estuaries (Grays Harbor, Willapa Bay, Tillamook Bay) in 1980-82 and 1991-94 (Beach et al. 1985, Brown et al. 1995). Many of the seals which pup and breed in the coastal estuaries of Washington and Oregon in summer feed in the Columbia River in spring and fall (when salmonids are present) and in winter (when eulachon are abundant).

Oregon

There are 101 harbor seal haul-out sites in Oregon (ODFW unpubl. data). As in Washington, counts of harbor seals have increased in Oregon since systematic counts were initiated in the 1970s, with an annual rate of increase of 7.4% from 1977 to 1993 (Fig. 7). In 1975, approximately 2,500 seals were counted statewide (ODFW unpubl. data); similar statewide counts of harbor seals in 1984-85 were 3,500-3,800 (Brown 1988). In 1993, the mean count of harbor seals in Oregon was 6,046 (ODFW unpubl. data). Most of the abundance information is from counts conducted during the pupping season in May/June, with the exception of the Columbia River as noted above. Using the correction factor (1.53) on initial counts, the Oregon total abundance estimate in 1993 was 9,251 harbor seals. Recent counts (minimum population estimates) of harbor seals for each of the Oregon regions are shown in Appendix D.

California

Since at least the 1960s, the abundance of harbor seals in California has been increasing and they have continued to occupy new haul-out sites. In 1982, there were 427 documented haul-out sites along the mainland coast. Currently, there are more than 860 documented haul-out sites in addition to haul-out sites on all eight of the Channel Islands in the southern California Bight.

The annual rate of increase in the harbor seal population in California was 5.6% from 1979 to 1995 (Fig. 8) based on counts by Hanan (1996). Systematic aerial photographic surveys have been conducted by CDFG specifically to count all harbor seals in California during their early summer molting period, which is considered to be the time of peak abundance onshore (Stewart and Yochem 1994). In 1995, the count of harbor seals in California was 23,336. Using a correction factor of 1.4 suggested by Boveng (1988) to account for seals in the water, the estimated abundance in California in 1995 was 32,699 harbor seals. Recent counts (minimum population estimates) of harbor seals for each of the California regions are shown in Appendix D.

PINNIPED FOOD HABITS STUDIES

This report reviews published information on California sea lion and harbor seal food habits, but because the data were collected for a variety of research programs that each address different research questions, much of the information is insufficient to address pinniped impacts on specific salmonid populations. There also are problems with applying available food habits information to the issue of impacts of pinniped predation on salmonids or other prey species in the ecosystems. There are caveats associated with all methods used to collect food habits data. These problems, described below, must be taken into account in any extrapolations or conclusions drawn from food habits data.

1. Food habits studies which involve the identification of fish by otoliths (fish ear bones) alone will underrepresent cartilaginous fish and fish with fragile or digestible otoliths. Harbor seals and other

small pinnipeds may not always consume the heads (which contain otoliths) of larger fish such as salmonids (Pitcher 1980). For example, Riemer and Brown (1996) recently reanalyzed harbor seal food habits samples collected in the Columbia River in 1980-82 (Beach et al. 1985) using salmonid bones, gill rakers, and teeth, as well as otoliths for prey identification. Using these additional hard parts increased the occurrence of salmonids in all samples for both California sea lions and harbor seals (Appendices F and G). There are uncertainties concerning the appropriateness of relating the occurrence of hard parts from prey species to the actual occurrence of the prey species in the diet because it is not known if identifiable hard parts occur in the same proportion in food habits samples as they do in the actual diet.

2. Studies based on stomach contents of beachcast pinniped carcasses may not be representative of the food habits of healthy animals because beachcast animals are likely to have been sick or injured and may not have fed prior to stranding.
3. Food habits data based on pinnipeds taken incidentally in fisheries may be biased toward the diet of younger animals because they are often more susceptible to entanglement in fishing nets. Prey may be biased toward only those species which occur in or near the nets.
4. Studies which rely on observations of surface feeding by pinnipeds may overestimate the importance of larger prey because they are easier to observe. Smaller prey can be consumed under water. Other problems with interpretation include prey that are eaten too quickly to be identified or are ingested under water. Nonetheless, surface feeding observations are a good technique for quantifying pinniped predation on adult salmonids at sites where salmonid foraging occurs, such as river mouths.
5. Few studies involving shooting pinnipeds for food habits analyses have been conducted recently, so information from these studies is not current. Studies that have used this technique have generally provided direct and quantitative information on prey consumption by pinnipeds (Jobling and Breiby 1986, Jobling 1987).

Another source of information on pinniped feeding behavior is scars/wounds on salmonids that are attributable to predation attempts by pinnipeds. Salmonid scarring data, summarized below under "Salmonid Scarring by Pinnipeds," (see page 32) also have associated caveats that affect the interpretation of scarring data for food habits studies. The Working Group found that the quality of scarring data is inconsistent; differences exist between observers, sites, degree of interest, and diligence in reporting information. Estimates of scarring from fishway windows are biased downwards because only one side of the fish is observed. Scars are easier to observe on salmonids that have just returned to hatcheries. Because the skin darkens as salmonids get closer to spawning, making scars more difficult to detect, it is important to consider when scar data are collected relative to spawning time. In addition, there are non-pinniped sources of scars on salmonids which could be misinterpreted as pinniped marks; training to distinguish the two is not done at most locations nor done consistently.

California Sea Lion Food Habits

California sea lions are opportunistic feeders, preying on a wide variety of fish and squid. Their diet is diverse, varying by location as well as seasonally and annually (Antonelis et al. 1984, Beach et al. 1985, Lowry and Folk 1987, Lowry et al. 1990, 1991, DeLong et al. 1993, Brown et al. 1995). Some of the more common prey within the breeding range in California are Pacific whiting, anchovy, market squid, and shortbelly rockfish (see Appendix H for genus/species of pinniped prey items) (Scheffer and Neff

1948, Fiscus and Baines 1966, Fiscus 1979, Antonelis et al. 1984). North of the breeding range, the diet shifts to those species which are locally and seasonally abundant. Sea lions move into specific areas during the nonbreeding season in response to local abundance of prey.

The results of food habits studies based on analysis of stomach contents, scat samples, and observational studies from Washington to California conducted since 1970 are summarized in Appendix F. The results of available information are discussed below starting from the north in Washington and moving south through California.

Washington

Important prey in Washington are Pacific whiting, herring, squid, spiny dogfish, gadids, and salmonids (Everitt et al. 1981, Gearin et al. 1986, Gearin et al. 1988b). Scat samples from California sea lions have been examined from two sites, Everett and Shilshole Bay, which are located about 20 miles apart in northern Puget Sound. In both areas, Pacific whiting and Pacific herring were the most frequent prey in the scats (Appendix F). Salmonids occurred in about 6% of the samples from Everett and in 25% of the samples from Shilshole Bay, at the entrance of the Lake Washington Ship Canal, and at the Ballard Locks (Gearin et al. 1988b). Sea lions congregate near Everett, apparently in response to a large spawning stock of Pacific whiting in Port Susan (Gearin et al. 1986). At the Ballard Locks, winter steelhead were the most frequently observed prey of sea lions based on surface feeding observations (NMFS 1995). Sea lions were also observed preying on downstream migrating juvenile salmonids (smolts) and on adult coho and sockeye salmon at the Ballard Locks (NMFS 1996a). Throughout Washington, California sea lions feed on steelhead and coho, sockeye, chum, and chinook salmon, both on free-swimming fish and on fish caught in gillnets and on hook-and-line gear (Gearin et al. 1986, Gearin et al. 1988a).

Columbia River

In the Columbia River, food habits studies utilizing beachcast sea lion carcasses (Beach et al. 1985), and studies on incidentally taken sea lions (Brown et al. 1995), indicate that the primary prey species are eulachon, salmonids, lamprey, herring, rockfish, and anchovy (Appendix F). About 13% of the beachcast samples contained salmonids, while 28% of the samples from incidental takes by the salmon gillnet fishery contained salmonids (Appendix F).

In the past decade, California sea lions have occurred seasonally with increasing frequency upriver in the lower Columbia River. Since 1990, California sea lions have been reported 128 miles from the river mouth near Willamette Falls on the Willamette River (a tributary of the Columbia). At least one to three sea lion males have been observed each spring near the fish ladders and smolt chute outfall in the area of Willamette Falls, consuming spring chinook salmon and winter and summer steelhead. In the spring of 1995, California sea lions were observed by ODFW and NMFS feeding on both adult salmonids and smolts. During limited observations (7 hours) over a 2-day period, one large California sea lion was observed to kill and consume an average of one salmonid per hour (ODFW unpubl. data). In 1996, at least five California sea lions were observed at Willamette Falls from April 2 through May 4. During limited observations in 1996 (155 hours), these sea lions were seen consuming 42 chinook salmon, 27 steelhead, and 20 unidentified salmonids (a total of 89 salmonids or about 0.6 salmonids/hour) (ODFW unpubl. data). ODFW and NMFS have implemented an observation/deterrence program at Willamette Falls to document the nature and extent of sea lion effects on salmonids at this site and to assess the effectiveness of various deterrence measures.

Oregon

In addition to the Columbia River area, food habits studies of California sea lions in Oregon have occurred at Cascade Head and the Rogue River (Appendix F). At Cascade Head, chub mackerel, Pacific herring, salmonids, unidentified skates, cephalopods, spiny dogfish shark, lamprey, Pacific whiting, sand lance, rockfish, and northern anchovy were the primary prey (Appendix F). Salmonid remains occurred in 29% of 82 sea lion scat samples taken in February 1994 and 8% of 32 samples collected in October 1994 (Riemer and Brown 1996).

California sea lion predation on salmonids in the lower Rogue River has been reported in several studies. Surface feeding observations have described lamprey (Jameson and Kenyon 1977) or salmonids (Roffe and Mate 1984, ODFW unpubl. data) as the most frequently identified prey. However, in 35 gastrointestinal tracts collected from California sea lions by Roffe and Mate (1984) in the same area, lamprey was the principal prey, occurring in 93% of the samples while steelhead occurred in 54% and chinook salmon in 11%. Spring chinook salmon return to the Rogue River primarily from late March to the end of May each year. In 1995, both Steller sea lions and California sea lions began appearing in increasing numbers in the mouth of the river in late April. From April to early June 1996, ODFW observed sea lions consume 9 chinook, 1 steelhead, 3 unidentified salmonids, and 3 Pacific lamprey in 55 hours of observation (ODFW unpubl. data).

California

California sea lion food habits have been studied at the Klamath River in northern California, at the Russian River, Pier 39 (San Francisco), the Farallon and Año Nuevo Islands in central California, and at the Channel Islands in southern California (Appendix F). At the Klamath River, Bowlby (1981) used direct observation of foraging behavior, examination of gastrointestinal tracts of beachcast sea lion carcasses, and scat analysis. Bowlby (1981) found lamprey was the main prey, with chinook salmon and steelhead occurring in 1-8% of samples depending on method of analysis (Appendix F). In spring 1978, Bowlby (1981) made 1,126 observations of sea lions foraging at the surface. Sea lions caught lamprey 96% of the time and salmonids less than 1% of the time. The major prey in gastrointestinal samples was lamprey. Scat analysis supported his conclusion that lamprey was the most frequent prey, followed by Pacific whiting and cephalopods (Appendix F).

Hanson (1993) studied the foraging ecology of California sea lions at the mouth of the Russian River in 1989-90. California sea lions were present during winter, spring, and early summer months, with a peak in abundance in the late winter and early spring. Pinniped abundance corresponded with peak salmonid returns. Hanson (1993) noted a 0.52 fish/hour catch rate for California sea lions when adult salmonids were in the river.

In central California, at the Farallon Islands, California sea lions consumed Pacific whiting and rockfish primarily (Appendix F). At Año Nuevo Island, California sea lions consumed Pacific whiting, shortbelly rockfish, and market squid (Appendix F) (NMFS-SWFSC/AFSC unpubl. data). No salmonid otoliths were found in the central California scat samples; however, other fish bones in the samples were not examined or identified. Scats collected at Pier 39 in San Francisco Bay indicate seasonal variability in the sea lion diet. Pacific herring was the most common prey during fall and winter, while spiny dogfish and a small number of salmonid smolts were also eaten (Appendix F) (California Marine Mammal Center, unpubl. data).

In southern California at the Channel Islands, based only on otolith and beak identification, the most commonly consumed prey were market squid, Pacific whiting, shortbelly rockfish, jack mackerel, chub mackerel, and northern anchovy (Appendix F) (NMFS-SWFSC/AFSC unpubl. data). Salmonid otoliths were found in only 2 out of the 9,513 scat samples examined during 12 years of sea lion food habits studies at the Channel Islands (Appendix F).

Pacific Harbor Seal Food Habits

Harbor seals are opportunistic feeders, preying on a wide variety of cephalopods and benthic and epibenthic fish. Their diet varies as they take advantage of food that is seasonally and locally abundant. Food habits studies based on analysis of stomach contents, scat samples, or feeding observations in Washington, Oregon, and California since 1970 are summarized in Appendix G. These recent studies as well as some earlier studies are discussed below, starting from the north in Washington and moving south through California.

Washington

Harbor seal food habits in Washington were described in earlier years by Scheffer (1928), Scheffer and Sperry (1931), and Scheffer and Slipp (1944). Those studies indicated that Pacific whiting, tomcod, and walleye pollock were important prey, as well as flatfishes, Pacific herring, shiner perch, plainfin midshipman, and sculpins. More recent studies indicate that these species are still the most frequent prey of harbor seals in Puget Sound, the Strait of Juan de Fuca, and Hood Canal (Appendix G). At Gedney Island (near Everett) in northern Puget Sound, Pacific whiting dominate scat samples. In the coastal estuaries of Grays Harbor and Willapa Bay, northern anchovy, flatfish, crustaceans, smelt, and sculpin are the most frequent prey (Beach et al. 1985).

In most studies conducted before 1980, only otoliths were used to identify prey. Because harbor seals do not often eat the heads (where otoliths are found) of large fish such as salmonids, evidence of salmonid predation by harbor seals in the early studies was probably underestimated. However, even in early studies, predation on pink salmon in the fall, steelhead in the winter, and chinook salmon in the spring was reported in Puget Sound (Everitt et al. 1981, NMFS-AFSC unpubl. data).

In a reanalysis of samples collected in the period 1980-82, using bones and teeth as well as otoliths, the percentage of samples containing salmonid remains increased from 5% to 28% in Willapa Bay and from 4% to 10% in Grays Harbor (Riemer and Brown 1996). The data set containing the largest percentage of salmonid remains (50%) was from seals caught incidentally in salmon gillnet fishery in Grays Harbor (Appendix G). In addition to adult salmonid remains, smolt remains were also observed in scat samples from Grays Harbor (Brown et al. 1995) and Puget Sound (NMFS-AFSC unpubl. data).

Columbia River

Food habits of harbor seals in the Columbia River have been reported in a number of studies conducted since the early 1980s (Appendix G). A variety of prey species including anchovy, herring, lamprey, starry flounder, and other flatfish, sculpin, gadids, smelt, and salmonids are taken by seals in this area (Beach et al. 1985, Brown et al. 1989, Brown et al. 1995, Riemer and Brown 1996). The prey item most frequently taken by harbor seals in the Columbia River in winter is eulachon, and the highest counts of seals in the river coincide with the winter spawning of eulachon. Brown et al. (1989) examined gastrointestinal tracts of harbor seals killed incidentally in winter salmon gillnet fisheries from 1986 to 1988 and found eulachon in 100% of the samples and estimated that 97% of the prey eaten during the sampling period was eulachon. No salmon remains were identified in the Brown et al. (1989) samples even though most were collected during salmon fisheries. The seals clearly targeted on the much more abundant eulachon, but three other factors also may have influenced the probability of finding salmon remains in the gastrointestinal tracts of the seals sampled. First, fish species identifications were based only on otoliths and presence of salmonid flesh, and therefore other salmonid bones would have been missed. Second, the samples were collected during a gillnet fishery that occurs early in the spring chinook migration, before peak numbers of spring chinook occur inriver. Third, the samples were collected primarily from young seals that may be too small to successfully forage on the large chinook salmon migrating upriver. Nonetheless, when the eulachon run is over, the 2,000-3,000 harbor seals in the river will switch to other abundant prey species which then would include salmonids.

The occurrence of salmonids in harbor seal food habits studies in the Columbia River has varied from none to up to 60% occurence in some samples. Salmonids were identified in only 3 of 436 scat samples collected in the early 1980s by Beach et al. (1985): 1 with sockeye salmon remains (April 1982) and two with steelhead remains (April and August 1981). These scat samples were reanalyzed for salmonid remains using new identification techniques by Riemer and Brown (1996), and the occurrence of samples with salmonid remains increased from 3 to 28, with frequencies of occurrence in the total sample increasing from <1% to 6% (Appendix G). Beach et al. (1985) also found salmonid remains in 12% of 50 harbor seal gastrointestinal tracts collected from beachcast seal carcasses. These samples were collected throughout the year, but the largest numbers of samples were obtained from February through May. In 1991 to 1994, Brown et al. (1995) found salmonid remains in 13% of 61 harbor seal gastrointestinal tracts collected in the Columbia River. Salmonids were most frequently found in samples collected in the spring (33% of samples in April and May) and fall (60% of samples in September and October). Similarly, salmonids were identified in 19% of 67 scat samples collected in the spring (April 1995) and 39% of 36 scat samples collected in the fall (September and October) of 1994 (Riemer and Brown 1996). No salmonid remains were found by Riemer and Brown (1996) in 51 harbor seal scat samples collected in the winter (February and March) of 1992-93, similar to the lack of salmonid remains in samples collected in the winters of 1986-88 (Brown et al. 1989). Preliminary results of recent food habits studies show salmonid remains (primarily juveniles) in about 20% of 186 harbor seal scats collected in March through May of 1996 (NMFS-AFSC unpubl. data). In summary, salmonids appear to be targeted as prey by harbor seals primarily in the spring and fall, possibly because they are abundant and available in the river at that time in contrast to the winter when eulachon are much more abundant.

Oregon

As in other areas, harbor seals in Oregon feed on a wide variety of prey species (Appendix G), including anchovy, smelt, herring, flatfish, cottids, gadids, sculpins, rockfish, sand lance, salmonids, and cephalopods (Beach et al. 1985, Brown and Mate 1983, Harvey 1987, Graybill 1981, Roffe and Mate 1984, Brown et al. 1995, Riemer and Brown 1996). In these studies, salmonids were reported as occurring in 1-30% of samples (scats or gastrointestinal tracts) or direct surface-feeding observations.

Beach et al. (1985) examined 38 harbor seal scats collected in September and October in Tillamook Bay on the north Oregon coast. While other prey species were more common, one sample contained remains from a minimum of 19 small steelhead. Salmonid remains were identified in only 1 of 150 harbor seal scat samples collected in Netarts Bay, just south of Tillamook Bay, by Brown and Mate (1983). However, the majority of these samples were not collected during times when salmonids were known to occur there. Based on direct feeding observations, Brown and Mate (1983) estimated that harbor seals consumed 6.1%, 7.2%, and 1.5% of the 1978, 1979, and 1980 chum salmon runs, respectively, in Whiskey Creek (a tributary of Netarts Bay). The number of seals feeding in the area was similar each year, but the impact of their predation was greatest when the annual chum salmon return was low. For example, in 1979, seals took more than 7% of just over 550 returning salmon, while in 1980 the estimated consumption of nearly twice as many fish represented less than 2% of a return of more than 5,000 salmon.

In Coos Bay, Graybill (1981) found salmonid otoliths (steelhead and coho) in only 3 of 297 harbor seal scat samples (1%) collected primarily during May through September. Little evidence of smolts was noted even though two salmon-ranching (aquaculture) operations had released thousands of salmonid smolts into Coos Bay during the period of scat collection. It must be noted, however, that Graybill (1981) identified salmonids only from otoliths, and that the new prey identification techniques used by Riemer and Brown (1996) were not used to revise the occurrence of salmonids from these samples.

In the Rogue River, Roffe and Mate (1984) estimated from gastrointestinal tract examinations that steelhead comprised 5% and chinook salmon comprised 6% of the harbor seal diet in the late 1970s. However, based on numbers of seals present at that time, they concluded that salmonid consumption had a negligible impact on fish stocks in the Rogue River. More recently, ODFW found that Pacific lamprey, rex sole, rockfish, and Pacific tomcod occurred most frequently in scat samples (ODFW unpubl. data). However, salmonid remains (both adults and juveniles) were found in 13% of the scat samples. Harbor seal abundance peaked in March and April, but the occurrence of salmonids in scat samples was greatest in October (43%) and April to May (10-20%). During 55 hours of observations by ODFW from April to June 1996, harbor seals consumed 2 unidentified salmonids, 1 jack chinook, and 19 Pacific lamprey (ODFW unpubl. data).

California

Along the California coast, pinnipeds have been observed preying on adult salmonids and smolts at river mouths, estuaries, and the open ocean (Briggs and Davis 1972, Jones 1981, Herder 1983, Miller et al. 1983, Hart 1987, Hanson 1993, Stanley and Shaffer 1995, CDFG unpubl. data). In northern California, harbor seals have been observed consuming migrating salmonids (Stanley and Shaffer 1995, Hart 1987, Herder 1983, Miller et al. 1983).

Scats collected from the Klamath River contained remains of salmonids, lamprey, smelt, and flatfish (Herder 1983). In the lower Klamath River, substantial predation on released, tagged chinook salmon, coho salmon, and steelhead by harbor seals was observed each year between 1976 and 1990 in conjunction with seining operations conducted by CDFG to monitor upstream salmonid migrations during August, September, and early October. Because these salmonids had been held, handled, and tagged, they were likely more vulnerable to predation. In 1980-81 and 1984-88, studies were conducted to evaluate the feeding activity of harbor seals during these seining and tagging operations. The estimated percentage of seined/tagged fish taken by seals was relatively constant, ranging from about 3% to 8% (Hart 1987, Stanley and Shaffer 1995). Hart (1987) observed that a majority of the fish were consumed by as few as 12 seals.

Hanson (1993) observed the foraging behavior of harbor seals at the mouth of the Russian River in 1989-90. Harbor seals were present year-round; however, peak abundance corresponded with peak salmonid returns. Hanson (1993) also analyzed harbor seal scats and found that seals utilized a wide variety of prey, including flatfish, octopus, Pacific whiting, hagfish, and plainfin midshipman which were present during all seasons, while salmonids, smelt, lamprey, and rockfish occurred on a seasonal basis (Appendix G). Salmonid remains (primarily unidentified smolts) were most numerous during the winter (December to February) when they occurred in 20% of the scats. They were also found in 4% of the scats collected in the fall and 3% of the scats in the spring. Hanson (1993) observed harbor seals successfully capturing adult salmonids in shallow waters at catch rates of 0.27 fish/hour.

In central California, harbor seal scats contained shrimp, octopus, northern anchovy, plainfin midshipman, white croaker, and staghorn sculpin in San Francisco Bay (Appendix G). In the Monterey Bay area, based on otoliths and beaks only, harbor seals consume rockfish, octopus, spotted cusk-eel, white croaker, market squid, flatfish, staghorn sculpin, and plainfin midshipman (Appendix G). In Elkhorn Slough, Harvey et al. (1995) did not detect any evidence of salmonids in harbor seal scats even though steelhead may occasionally enter Elkhorn Slough.

In the Channel Islands off southern California, the most common prey were rockfish, octopus, spotted cusk-eel, and plainfin midshipman, based on otoliths and beaks only (Appendix G). On the southern California mainland, octopus and plainfin midshipman were the most commonly consumed food. Seals also consumed market squid, rockfish, flatfish, Pacific whiting, and spotted cusk-eel, based on otoliths and beaks (Appendix G).

Salmonid Scarring by Pinnipeds

Scars attributed to predation attempts by sea lions and harbor seals have been observed on adult salmonids at fish ladders and hatcheries, and in sport fish landings in Oregon and Washington since the early 1980s (Scordino 1993). These marks consist of descalings in the form of two overlapping arches caused by seal or sea lion canine teeth, two to three parallel scratches caused by seal claws, or puncture wounds caused by pinniped bites. The first quantification of scarring was at Bonneville Dam, where counters looked at one side of the salmonids as the fish moved rapidly past the fish-ladder windows. In 1980, fish counters observed 328,612 salmonids from four species in the fish ladder window and documented that at least 0.4% of the salmonids observed had evidence of pinniped-caused scars (Scordino 1993).

In 1990, an increased incidence of pinniped scarring (increasing from negligible numbers up to 19% of salmon examined) was noted by biologists handling Snake River spring chinook at Lower Granite Dam, raising concerns about impacts of pinnipeds on listed salmonids (Scordino 1993). From 1990 to 1993, steelhead and spring/summer chinook handled at the Lower Granite Dam were examined for evidence of attempted pinniped predation. Most predation scars are tooth marks and claw rakes that result in minor descaling of the fish and probably do not affect survival. However, some of the more severe bites and puncture wounds on fish may result in mortality. Scars were found on 7.8% of the steelhead and on 16.4% of the spring/summer chinook; this included the more severe puncture wounds on 2.1% of the steelhead and 5.7% of the chinook (Harmon et al. 1994). In 1994, Huber et al. (1995) handled steelhead and spring chinook at the Bonneville Dam and several hatcheries on the Columbia and Snake Rivers. They found 24% of the steelhead with pinniped marks (including 10% with bite wounds) and 16% of the spring chinook with pinniped marks (including 4% with bite wounds).

In more recent studies on pinniped scarring on spring/summer chinook salmon and steelhead in the Columbia and Snake Rivers, pinniped canine marks and claw rakes were found on 12% of the spring/summer chinook salmon (Huber et al. 1995a, Harmon et al. 1994). Many of the tooth marks and claw rakes examined consisted of minor descaling of the fish that probably did not affect their survival; however, up to 6% of the spring chinook salmon had more severe bites and marks that could have resulted in mortality (Harmon et al. 1994, Huber et al. 1995a). Harmon et al. (1994) hypothesized that pinniped-induced stress from scarring and injuries may also result in lowered spawning success and that considerable salmonid mortality, both direct and indirect, may result from confrontations with, and injuries from, pinnipeds.

Huber et al. (1995a) determined that most of the predation marks on spring/summer chinook salmon in the Columbia River were caused by harbor seals, but 10% were clearly inflicted by California sea lions. It is not clear if the preponderance of marks attributable to harbor seals is the consequence of more harbor seals feeding on the salmonids, or of harbor seals being less successful than sea lions at capturing and consuming chinook salmon. More data are needed on harbor seal predation on free-swimming adult salmonids before accurate estimates of losses can be generated.

In Oregon, there are few river systems where pinniped scarring has not been observed or reported. At most of these locations, seals and/or sea lions have been observed foraging in stretches of the river in the few miles just below hatcheries (e.g., Nehalem River, Tillamook Bay, Salmon River), and in some cases directly at the base of fish ladders, weirs, or fishways (e.g., Willamette River, Netarts Bay, Yaquina Bay, Coos Bay). In general, ODFW has noted the highest observed scarring rates occur on winter steelhead (6-53%), followed by coho (11-20%). Chinook salmon have the lowest frequency of predator scars (8-14%). Scarring rates for winter steelhead observed at various hatcheries in Oregon are shown in Table 1. Fewer data exist for scarring rates on coho and chinook, but frequencies at Alsea River and Salmon River have been reported from 8% to 14% of returning adult fish.

Table 1. Pinniped-caused scarring observed on winter steelhead in Oregon hatcheries (ODFW unpubl. data).

Location	**Timeframe**	**Incidence of Scarring**
Nehalem River Hatchery	1985 to 1992*	31-53%
Alsea and Fall Creek Hatcheries (Alsea River)	1989 to 1992	19-27%
Salmon River Hatchery	1984 to 1986	38-40%
Big Creek Hatchery (lower Columbia River)	1992 to 1993	22-43%
Klaskanine Hatchery (lower Columbia River)	1992 to 1993	20-52%
Cedar Creek Hatchery	1989 to 1992	10-43%
Trask River Hatchery (Tillamook Bay)	1989-90	35%
Bandon Hatchery	winter 1990-91	26%
Elk River Hatchery	winter 1990-91	21%
Marion Forks Hatchery (Willamette River)	winter 1990-91	10%
South Santiam (Willamette River)	winter 1990-91	12%
Rock Creek Hatchery	winter 1990-91	45%

* Exception is a lower rate of 6.4% in 1990-91

In California, Miller et al. (1983) reported that at an ocean-farming operation at Davenport, about 15% of the adult salmon and steelhead that entered the return structure had been bitten by harbor seals. During two spawning seasons from 1994 to 1996 in Scott Creek, pinniped tooth and claw marks have been found on 28-40% of the captured coho salmon and 31-50% of the captured winter steelhead (Monterey Bay Salmon and Trout Project, unpubl. data; D. Streig and M. McCaslin, Monterey Bay Salmon and Trout Project, 825 Big Creek Road, Davenport, CA 95017. Pers. commun., February 1997). On the San Lorenzo River, 15% of the returning winter steelhead had pinniped bite and claw marks in the 1991-92 season. The proportion of pinniped-scarred steelhead increased to 47% and 54% in the 1994 and 1995 seasons (Monterey Bay Salmon and Trout Project, unpubl. data; Streig and McCaslin, pers. commun., February 1997). The higher rate of pinniped scarring in steelhead may be a consequence of steelhead traveling close to the shoreline in the upper 2 meters of the water column, where they are more vulnerable to capture by pinnipeds than coho which occur in more open areas. In Scott Creek, coho salmon may be more susceptible to predation by harbor seals than other areas because they linger in the lagoons before they make their upstream migration to spawn (Streig, pers. commun., September 1995). Precocious male steelhead (those that return to fresh water to spawn after less than 1 year in the ocean) returning to Scott Creek do not exhibit any tooth or claw marks. These males are smaller (less than 22 inches) than adult steelhead and thus, harbor seals may be more efficient in capturing and killing (rather than scarring) these smaller steelhead (Streig, pers. commun., September 1995).

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AREAS OF CONCERN: PINNIPED AND SALMONID CO-OCCURRENCE

There are many areas in all three states where California sea lions and Pacific harbor seals haul-out within foraging range of rivers with depressed salmonid runs. In most of these areas little or no information is available on whether seal or sea lion predation is a problem. However, because many salmonid runs are depressed, even limited predation may slow the recovery of these runs. The Working Group identified areas where there is potential for pinniped predation to affect depressed salmonid populations, and areas where research is needed to assess the magnitude of the impacts and determine whether mitigation efforts are warranted. The areas where depressed stocks are vulnerable to predation are listed in each region from north to south.

Washington

Strait of Juan de Fuca/San Juan Islands

Harbor seals are present year-round. California sea lions are present in the fall, winter, and spring. Salmonid stocks in this area are vulnerable to predation as adults from summer to winter, and as juveniles from April to June. All fall chinook salmon in this area are classified by the state as depressed or critical stocks, and adults are vulnerable to predation. Numerous coho salmon and several winter steelhead runs are depressed in this area, and both adults and juveniles are vulnerable to predation. Juvenile spring chinook salmon and steelhead, especially at Discovery and Sequim Bays, also are vulnerable to impacts from pinniped predation. Summer chum and coho salmon returning to Discovery Bay are critical stocks and are vulnerable to being impacted by pinniped predation. In addition, Dungeness and Elwha River pink salmon are critical stocks and may be impacted by pinniped predation.

Eastern Bays (Bellingham Bay, Skagit Bay)

Harbor seals are present year-round. Because of their low abundance, California sea lions are not a threat to salmonids in this area. Juvenile salmonids of all critical and depressed stocks are at least partially vulnerable to harbor seal predation during outmigration. The April-to-June timeframe is of most concern because both juveniles and adult salmonids from critical stocks are present. Numerous coho salmon stocks in this area are depressed, and adults and juveniles are vulnerable to predation. Nooksack River spring chinook salmon, Baker River sockeye salmon, and Deer Creek summer steelhead are classified by the State as critical stocks and may be impacted by pinniped predation.

Puget Sound

Harbor seals are present year-round. California sea lions are present in the fall, winter, and spring. Pinnipeds have been observed upriver in several rivers draining into Puget Sound. There is overall concern in the Puget Sound area for predation on spring-, fall-, and winter-run adult salmonids and on juvenile spring chinook salmon and steelhead. More than 1,000 California sea lions, which occur seasonally near the mouth of the Snohomish River, have been observed 8-10 miles upriver and prey on free-swimming salmonids in the estuary. As many as 300 harbor seals haul-out on log booms near the mouth of the Snohomish River in fall and winter and have been reported 15-20 miles upriver. Pinnipeds are known to depredate catch in the fall coho and chum salmon gillnet fisheries and the steelhead set-net fishery in the Snohomish River area. In the Nisqually River, both seals and sea lions are common at the mouth; sea lions have been observed preying on free-swimming salmonids and have been observed as far as 40 miles upriver near the dam at McKenna. California sea lions frequently interact with tribal coho salmon and steelhead gillnet fisheries at the mouth of the Green River (Duwamish Waterway), have been observed preying on free-swimming salmonids inriver, and have been observed as far as 20 miles upriver in the Green River. Both seals and sea lions prey on adult salmonids and smolts below and above the Ballard Locks facility, and sea lions have been observed preying on steelhead in Lake Washington up to the mouth of the Cedar River. California sea lions have been documented to have consumed 65% of the winter steelhead migrating through the Ballard Locks, and have also been observed foraging on the fall coho salmon run, the early portion of the sockeye run, and downstream migrating smolts in the spring. White River spring chinook salmon are designated as critical and may be impacted by predation. Numerous coho stocks in Puget Sound are depressed, and both adults and juveniles are vulnerable to predation.

Hood Canal

Harbor seals are present year-round. California sea lion abundance is low, but a few occur in the area in the fall, winter, and spring. Most salmonid stocks of concern migrate as subyearlings and therefore are not vulnerable to predation as juveniles. However, steelhead and coho salmon migrate as yearlings and are sufficiently large to be pinniped prey. Pinniped predation on adult salmonids from summer to winter is of concern. Quilcene, Dosewallips, Duckabush, Hamma Hamma, Dewatto, Tahuya, and Union River summer chum salmon (classified by State as critical stocks) may be impacted by pinniped predation.

Washington Outer Coast

Harbor seals are present year-round. California sea lions are present in the fall, winter, and spring. A California sea lion was observed preying on free-swimming coho near Tatoosh Island in September 1995. Sea lions also depredate catch in coastal salmon troll fisheries. Harbor seals have been observed upriver in the Sooes River. Of most concern is potential harbor seal predation on spawning adults and outmigrating juveniles from May to July. Queets and Quinault River spring and summer chinook salmon and Lake Ozette sockeye salmon are classified by the State as depressed and may be impacted by pinniped predation.

Grays Harbor

Harbor seals are present year-round. California sea lions occur infrequently, but have been observed far upriver in the Chehalis River. There is a potential for harbor seal predation on adult and juvenile salmonids from May to July and December to February. Harbor seals commonly depredate catch in the salmonid gillnet fisheries in Grays Harbor and in the Chehalis and Humptullips Rivers. Satsop River summer chinook salmon and winter steelhead populations are classified by the State as depressed and may be impacted by pinniped predation.

Willapa Bay

Harbor seals are present year-round and commonly depredate catch in the summer and fall salmon gillnet fisheries in Willapa Bay. There is concern for predation on adult salmonids in August and September. North River early fall chinook salmon are classified by the State as depressed and may be impacted by pinniped predation.

Columbia River

Harbor seals are present year-round, with peak numbers exceeding 3,000 from mid-December through mid-March. California sea lions (300-500) are present in fall, winter, and spring. The large and increasing number of pinnipeds raises concern over impacts of pinnipeds on Snake River spring/summer chinook and fall chinook salmon, which are declining and listed as threatened under the ESA. Harbor seals regularly occur more than 50 miles upriver. California sea lions occur as far as the Bonneville Dam (about 145 miles upriver) and into the Willamette River up to Willamette Falls (128 miles from the Pacific Ocean). Pinniped scarring on numbers of ESA-listed spring chinook salmon at Lower Granite Dam raises a greater concern about the level of pinniped impact on ESA-listed species. The large numbers of both harbor seals and California sea lions in the mouth of the Columbia River from late fall to early spring raises concerns for impacts on adult winter steelhead and spring chinook migrating upriver, as well as on juvenile salmonids from all stocks migrating downstream from March to June. California sea lions have been observed consuming adult salmonids far upriver near the fish ladder system at Willamette Falls since 1990. Steelhead and spring chinook passing through the Willamette fishway are depressed stocks and especially vulnerable to predation at this site. Harbor seal numbers in the Lower Columbia River begin increasing during the fall chinook migration upstream, raising concerns for impacts of pinniped predation on these populations also.

Oregon

North Oregon Coast

Harbor seals are present year-round. California sea lions are present from fall through spring. All Oregon coastal coho salmon and steelhead have been proposed for listing under the ESA and are vulnerable to impact by pinniped predation at all sites where they co-occur with pinnipeds during migration. Pinniped scars have been documented on both coho and steelhead in most rivers. Groups of California sea lions have been regularly observed foraging for winter steelhead in the mouth of the Nehalem River estuary for the past 4-6 years. Between 1985 and 1992, the occurrence of pinniped scars on returning adult winter steelhead in the Nehalem River has averaged from 30% to 50%. Harbor seal abundance in the Siletz River has increased over the past 10 years, while counts of spawning adult coho salmon have declined. In the lower Alsea River, sea-run cutthroat are currently at very low numbers and no longer support a viable sport fishery. This raises concerns about the impacts of pinniped predation in the lower river because the Alsea Bay estuary has a large year-round population of harbor seals in Oregon (300-600 seals). Counts of spawning adult coho salmon have declined significantly in recent years even though high-quality spawning habitat is still available. Between 1982 and 1992, pinniped scarring rates on coho salmon in the Alsea River were reported at 11%, while 19-27% of returning winter steelhead had pinniped-caused scars.

Tillamook Bay

One of the largest aggregations of harbor seals in Oregon (500-800 seals) resides year-round in Tillamook Bay. These seals regularly interact with salmonid sport fisheries in this region. California sea lions are frequently observed foraging for salmonids in the mouth of the bay. Pinniped scars have been observed on 35% of the winter steelhead returning to the hatchery on the Trask River. Counts of spawning coho salmon have declined in recent years. Coho salmon and steelhead in this region have been proposed for listing under the ESA and are vulnerable to impacts by pinniped predation.

Umpqua River

Year-round abundance of harbor seals (600-1,000 seals) in the Umpqua estuary is second in Oregon only to the Columbia River. Umpqua River sea-run cutthroat trout are declining and have been listed as endangered under the ESA. Although information is lacking, there is great concern about this endangered population being impacted by pinniped predation, especially since pinniped scarring has been observed on Umpqua River cutthroat. Coho salmon and steelhead in the Umpqua River have been proposed for listing under the ESA and are vulnerable to impacts by pinniped predation during migration through the estuary and lower river areas.

Rogue River

The diversity and abundance of pinnipeds (harbor seals, California sea lions, and Steller sea lions) that forage in the mouth of the Rogue River may be greater than at any other coastal river. Coho salmon and steelhead in this region have been proposed for listing under the ESA and are likely vulnerable to being impacted by pinniped predation. Lower Rogue River and Illinois River fall chinook stocks are depressed and also may be vulnerable to being impacted by pinniped predation. Consumption of returning adult salmonids by pinnipeds at the mouth of the Rogue River has been reported at rates of several fish per hour during peak fish runs. Predation during fall months is of greatest concern because of the poor conditions of the salmonid runs at that time.

South Oregon Coast

Harbor seals are present year-round. California sea lions are present from fall through spring. This region has a number of small coastal rivers and streams that have low or precluded flow during some years when coho salmon and steelhead are attempting to migrate. All Oregon coastal coho salmon and steelhead have been proposed for listing under the ESA and can be impacted by pinniped predation.

California

Smith River

Harbor seals are present year-round, with peak haul-out abundance in the summer. California sea lions are present in the fall through spring. Coho salmon and steelhead have been proposed for listing as threatened under the ESA and are vulnerable to impacts from pinniped predation. Spring chinook (classified by State as at high risk of extinction) and fall chinook and cutthroat trout (classified by State as at moderate risk of extinction) also may be vulnerable to impacts from pinniped predation.

Klamath River

Harbor seals are present year-round, with a peak of about 400 seals in the summer. California sea lions are present in the fall and spring. Both harbor seals and sea lions have been documented feeding on salmonids in this area since the 1960s. Coho salmon and steelhead have been proposed for listing as threatened under the ESA and are vulnerable to being impacted by pinniped predation. Klamath River spring chinook are classified by the State as having high risk of extinction, and impacts of pinniped predation are of concern. Impacts of pinniped predation on fall chinook in the Klamath, Shasta, Salmon, and Trinity Rivers are also of concern as these populations have been classified by the State as having a moderate risk of extinction.

Cape Mendocino

Harbor seals are present year-round. California sea lions are present in the fall and spring. Harbor seals haul-out in large numbers (600-1,050 seals) at the mouth of the Eel River. More than 1,200 sea lions have been counted in the vicinity of Trinidad Head. Coho salmon and steelhead have been proposed for listing as threatened under the ESA and may be vulnerable to impact by pinniped predation. Mad River fall chinook (classified by State as at moderate risk of extinction) and Eel River fall chinook (classified by State as at moderate to high risk of extinction) also are vulnerable to impacts from pinniped predation.

North Coast

Harbor seals are present year-round. California sea lions are present in the fall and spring. Harbor seals and sea lions have been documented feeding on salmonids in the Russian River. Coho salmon and steelhead have been proposed for listing as threatened under the ESA and may be vulnerable to impact by pinniped predation. Mattole and Russian River fall chinook (classified by State as at high risk of extinction) also may be vulnerable to pinniped predation impacts.

San Francisco Bay/Central Valley

Harbor seals are present year-round. California sea lions are present year-round just offshore at the Farallon Islands. The San Francisco Bay/Central Valley area has many river systems and creeks, and both sea lions and harbor seals have been found well within the inland deltas and river systems. Central California coho salmon, which have been listed as threatened under the ESA, and all steelhead populations, which have been proposed for listing as endangered under the ESA, are vulnerable to being impacted by pinniped predation. Sacramento River winter chinook have been listed as endangered under the ESA. Papermill Creek, San Leandro River, Alameda Creek, and Sacramento River winter steelhead have been classified by the State as having a high risk of extinction and are of special concern for pinniped predation impacts. Other stocks classified by the State as having a moderate risk of extinction are Sacramento River spring/summer chinook, Yuba River spring chinook, and Deer Creek and Mill Creek spring chinook.

Monterey Bay Area

Harbor seals are present year-round. California sea lions are present year-round at Año Nuevo Island, peaking in the fall, with numbers well over 6,000 individuals. Central California coho salmon in the San Lorenzo River and other rivers to the north are listed as threatened under the ESA and are vulnerable to impacts from pinniped predation. Steelhead have been proposed for listing as endangered under the ESA, and impacts of pinniped predation also are of concern.

Central Coast

Harbor seals are present year-round. California sea lions are present in the summer and fall. Steelhead in this region have been proposed for listing as endangered under the ESA and there is concern about potential pinniped predation.

Southern California Bight

Harbor seals are present year-round. California sea lions are present year-round in large numbers at the Channel Islands, with peak population (81,300 sea lions) during the summer. Most historic salmonid runs are extinct in this area. Southern California steelhead have been proposed for listing as endangered under the ESA. There are no known harbor seal or sea lion haul-out sites in the southern California rivers, and pinniped predation therefore is probably not a concern. However, the presence of only a few migrant pinnipeds in one of the rivers with steelhead could impact the steelhead populations.

DISCUSSION OF PINNIPED IMPACTS ON SALMONIDS

Salmonid life-history patterns determine the availability of salmonids to pinniped predation. Adult salmonids are most vulnerable to pinniped predation during the spawning migration through estuaries and river mouths, especially where salmonids concentrate or passage may be constricted. Predation on juvenile salmonids is affected by their size during the outmigration. Chum and pink salmon migrate to sea as fry soon after hatching, when they are too small to be pinniped prey. Pink salmon, however, may summer in nearshore ocean areas where they are vulnerable to pinniped predation. Spring chinook salmon, coho salmon, sockeye salmon, and steelhead migrate to the ocean as yearlings or older, at a size where they are vulnerable to pinniped predation. Most fall and summer chinook salmon migrate downstream as sub-yearlings when they may also be too small to be prey of pinnipeds. However, some of the early-timed summer chinook salmon migrate downstream as yearlings when they are large enough to be vulnerable to predation. Sea-run cutthroat migrate to the coastal estuaries at a variety of ages, from subyearlings to 2-year-olds, and spend most of their adult life close to shore where they could be continuously vulnerable to pinniped predation.

Chinook, chum, coho, pink, and sockeye salmon and steelhead have all been documented as prey of pinnipeds in Washington, Oregon, or California. Sea-run cutthroat have not been specifically identified in any food habits studies, but pinniped-scarred cutthroat have been observed in the Umpqua River (Beach et al. 1985) and they are likely prey of pinnipeds in estuaries. Some studies reported "trout," which may be steelhead or cutthroat. The studies show varying rates of occurrence of salmonids as prey of pinnipeds depending upon location, season, prey availability, and methods used for collecting food habits data in each particular study (Appendices F and G).

The most widely known and intensely studied pinniped/salmonid conflict is California sea lion predation on winter steelhead at the Ballard Locks in Seattle, Washington. Although California sea lions first began appearing in the Ballard Locks area on a somewhat regular basis in 1980, their predation on steelhead was not viewed as a resource conflict until 1985, when a significant decline in the wild winter steelhead spawning escapement was noted (Gearin et al. 1996). Subsequent scientific studies documented that sea lions were removing significant numbers of adult steelhead that were returning to the Lake Washington system to spawn (Scordino and Pfeifer 1993). As shown in Table 2, the number of wild steelhead consumed by sea lions between 1986 and 1992 was 42-65% of the total run (NMFS 1995b). In spite of intense sea lion deterrence and mitigation efforts from 1985 to 1995, a small number of sea lions returned to the Ballard Locks area each season and preyed on steelhead (Scordino and Pfeifer 1993). NMFS and WDFW have attempted all feasible, nonlethal approaches to reduce sea lion predation without success (NMFS 1995b). The winter steelhead population declined significantly and recent spawning escapements have been less than 150 fish, which is within the range considered to be near the threshold level below which the ability of the population to recover may be impaired (NMFS 1996a). Because of the precarious status of the steelhead population and the impact that sea lions were having on the status and recovery of this salmonid population, NMFS authorized WDFW in 1995 to lethally remove the "problem" sea lions at the Ballard Locks that could not be deterred by nonlethal means (NMFS 1995b).

Table 2. Lake Washington winter steelhead escapement and consumption by California sea lions.

	Run Estimate						
Run year	**Pre-season**	**Post-season**	**Steelhead escapement**	**Escapement goal**	**Percent of goal**	**Steelhead consumed**	**Percent of escapement**
1982-83	--	--	2,575	1,600	161	--	--
1983-84	--	2,166	1,250	1,600	78	--	--
1984-85	--	2,527	474	1,600	30	(1500)	59*
1985-86	--	2,261	1,816	1,600	114	329	15
1986-87	2,965	2,997	1,172	1,600	73	1,254	42
1987-88	2,635	2,274	858	1,600	54	1,178	52
1988-89	1,655	1,973	686	1,600	43	1,287	65
1989-90	2,093	1,806	714	1,600	45	1,065	59
1990-91	2,355	1,520	621	1,600	39	899	59
1991-92	1,442	--	599	1,600	37	--	--
1992-93	1,611	--	184	1,600	12	--	--
1993-94	1,159	76	70	1,600	4	6	8
1994-95	60-371	137	126	1,600	8	11	8

* Predation not monitored, based on estimate.

The observations of steelhead predation by California sea lions at the Ballard Locks show a significant proportion (65%) of an entire salmonid run can be consumed by sea lions (Scordino and Pfeifer 1993) and clearly demonstrates that the combination of high local-predator abundance during salmonid migrations, restricted passage, and depressed fish stocks can result in significant impacts on local salmonid populations (NMFS 1995b). There are only a few areas on the West Coast, other than the Ballard Locks, where studies have documented the influence of pinniped predation on local salmonid populations. In the Puntledge River estuary, British Columbia, Bigg et al. (1990) observed Pacific harbor seals surface feeding on salmonids and documented predation rates of up to 46% of the returning adult fall chinook. In Netarts Bay, Brown and Mate (1983) found that the number of seals feeding in the area was similar in each year of their study; however, the impact of the predation was greatest when the chum salmon return was low. In 1979, the seals took more than 7% of about 550 returning chum salmon, while in 1980, the estimated consumption of nearly twice as many fish represented less than 2% of the return of more than 5,000 salmon. In the Rogue River, Roffe and Mate (1984) estimated that in the late 1960s, sea lions and seals removed less than 1% of the spring chinook and about 6% of the summer steelhead returns to the Rogue River, which was equal to about half of the annual sport catch during that time.

Co-occurrence of Salmonids and Pinnipeds

California sea lions and harbor seals are present in most areas where salmonid runs occur in Washington, Oregon, and California. In most places, little information is available on year-to-year changes in the seasonal abundance and daily distribution of pinnipeds near or in salmonid rivers. More information exists on the seasonal abundance of salmonids in rivers and estuaries, but, because cohort sizes of salmonids can vary dramatically, estimates from one year or season applied to another year or season may over- or underrepresent the importance of salmonids in the pinniped diet. Consequently, there is little appropriate long-term information on the effect of pinniped predation on salmonids. However, data from the Ballard Locks (Gearin et al. 1988a) and the Puntledge River estuary in British Columbia (Bigg et al. 1990) indicate that where salmonid populations are depressed and particularly where fish passage is restricted by man-made structures (e.g., dams), narrow channels, or shallow water, pinniped predation can have a detrimental effect on salmonid populations. At the Ballard Locks, California sea lions consumed as much as 65% of the wild steelhead run in Lake Washington (see Table 2). At the Puntledge River estuary, harbor seals consumed up to 46% of returning adult fall chinook. As expected, the greatest effect of pinniped predation occurs when salmonid populations have already been reduced to low numbers.

Much of the predation at the Ballard Locks was by a few California sea lions that repeatedly foraged on salmonids in spite of deterrence efforts by NMFS and WDFW. The observations at the Ballard Locks indicate the ability of individual animals to consume large numbers of salmonids. One sea lion in 1986 was observed over the course of a 7-day period to kill at least 84 steelhead in 56 hours of observations, for a combined rate of 12 steelhead killed per 8 hours per day (Gearin et al. 1986). The highest predation rates observed were 4 steelhead kills in 23 minutes during 1 day for this animal. On the same day, this sea lion killed 12 steelhead in 4.75 hours. These observations indicate the potential predation levels of California sea lions when prey is abundant and where foraging ability is enhanced by narrow feeding channels. Individual sea lion behavior was also observed during the coho salmon runs through the Ballard Locks. In 1996, a single California sea lion was observed to kill 136 coho salmon in 62 hours (2.1 coho per hour) (NMFS 1996a). The highest predation rates observed for this animal were 18 coho salmon over 4.4 hours (4.1 fish per hour). The maximum number of coho observed killed by this sea lion during any one day was 19 coho salmon in 6.9 hours (2.7 fish per hour). Similarly, one sea lion was observed killing 5 spring chinook in 3 hours in the area of the Willamette Falls fishway (ODFW unpubl. data). Another observation at the Falls was one sea lion taking 7 spring chinook in 7 hours (1 per hour). Although these observations cannot be applied to other areas nor extrapolated over time, they clearly show the potential for individual California sea lions to consume large numbers of salmonids.

In most cases where pinnipeds and salmonid smolt co-occur, it is assumed that the pinnipeds are feeding on smolt. However, because the smolt are consumed under water, it is unknown to what extent the seals and sea lions exploit that resource. At the Ballard Locks, California sea lions were observed actively foraging during the peak of smolt outmigration, and although the observers were confident that the sea lions were eating smolt, they could not quantify numbers of smolt consumed (NMFS 1996a). One recent study in Canada quantifies harbor seal predation on smolt. In the lower Puntledge River in British Columbia, harbor seals forage on chum salmon fry and coho salmon smolts at night by using the lights from bridges to silhouette the fish and aid in their capture. During the peak of predation, consumption was estimated at 140,000 chum salmon fry and 13,000 coho salmon smolt per night (P. Olesiuk, Canada Department of Fisheries and Oceans, Science Branch, Pacific Biologic Station, Nanaimo, BC V9R 5K6. Pers. commun., 1996). As is true in most areas where individual pinnipeds can be identified, most predation (53-57%) was attributable to a small number (10) of recognizable seals. Total consumption was estimated at 3.1 million chum salmon fry (7-31% of the 1995 production) and 138,000 coho salmon smolt (15% of the 1995 production) between April and June (P. Olesiuk, Canada Department of Fisheries and Oceans, Science Branch, Pacific Biologic Station, Nanaimo, BC V9R 5K6. Pers. commun., 1996).

The Working Group considered California sea lion and Pacific harbor seal foraging on salmonids in the open ocean. In a review of marine mammal-salmonid interactions in the Pacific Northwest, Fiscus (1979) suggested that mammal predation on free-swimming salmonids in the open ocean probably has a minimal impact, and consumption rates on healthy and abundant fish stocks in these situations is relatively low. Studies from the 1970s on northern fur seals offshore of Washington, however, found that salmonids (mostly immature pink, coho, and chinook salmon) were present in 20% of the samples examined (Fiscus 1980). Antonelis and Perez (1984) estimated that 11.6% of the prey consumed by northern fur seals off Washington and Oregon annually was salmonids, and they estimated an annual consumption of 3,897metric tons (t) of salmonids. Although the Working Group found no comparable information on California sea lions or Pacific harbor seals, it did note that a California sea lion had been observed taking a coho salmon in coastal waters off Washington. Nonetheless, pinniped predation on small populations of depressed or listed salmonids, whether inriver or in the open ocean, is important in assessing the impacts of predation on recovery of salmonid populations.

In many of the small coastal rivers and streams in southern Oregon and northern California, the Working Group found there is a unique situation that makes returning adult coho salmon and winter steelhead more vulnerable to pinniped predation than larger systems. In low rainfall years or when rain arrives late in the winter season, small coastal rivers do not flow with sufficient volume to open the beach crest and flow into the sea. Low-tide periods also create or confound this condition in small, low-flowing rivers and streams. During such periods, adult fish arrive and accumulate in nearshore waters just offshore of the closed-off river mouth. The adult salmonids are then exposed to days or weeks of pinniped predation at these sites until sufficient rainfall occurs or higher tides allow access to the river or stream. During successive years of drought, the situation is exacerbated because the river mouths are open only intermittently during the salmonid spawning season. Downstream migrating smolt also become more vulnerable to pinniped and bird predation in these conditions, as the fish congregate in the lagoons formed near the river mouth until it opens up to the sea.

In understanding the effects of pinniped predation on salmonids, the Working Group noted that it is important to keep in mind that not all pinnipeds at a haul-out near a salmonid run are actively feeding on salmonids. Herder (1983) found that although there were up to 200 harbor seals in the Klamath River area, only 9 seals were responsible for depredation on gillnets each day. At the Ballard Locks, only 3% of the 248 sea lions marked in the nearby Shilshole Bay entered the Ballard Locks area in 1995 to feed on steelhead (NMFS 1996a). This indicates that removing pinnipeds from nearby areas may not be an effective solution to the problem of pinniped predation in local areas.

Estimates of Salmonid Mortality Due to Predation

In all but a few sites, information on direct mortality--how many pinnipeds (and whether they are seals or sea lions) are feeding on how many salmonids (which species of salmonid and whether they are adults or juveniles)--is unknown. In reviewing past data on pinniped food habits, seasonal pinniped and salmonid abundance and distribution, and salmonid mortality due to pinniped predation, the Working Group identified deficiencies that limited the use of such data in quantifying pinniped consumption of salmonids. In addition, information is lacking on changes in abundance or distribution of other salmonid predators (e.g., mackerel) which may affect salmonid populations and thus confound the effects caused by pinnipeds.

Most food habits studies were not designed to estimate overall consumption or species-specific consumption rates, and results from such studies cannot be extrapolated to estimate salmonid consumption. Some studies were conducted at a time of year when salmonids were not present; consequently, salmonid importance in the annual diet is underestimated. Smolt predation was not represented or was underrepresented in most food habits studies because the otoliths of juvenile salmonids are fragile and quickly digested; therefore, they may not be identified in stomachs or scats. The occurrence of salmonids was also underrepresented in earlier food habits studies because only otoliths were used to identify prey species. Several studies using bones, teeth, gill rakers, and otoliths to identify prey species have noted that using only otoliths will underrepresent salmonids in the diet (Gearin et al. 1988b, Riemer and Brown 1996). At this point, even though the use of other hard parts besides otoliths provides better detection of salmonids in scats, it is not possible to identify what species of salmonid was consumed.

Many of the pinniped food habits studies were conducted 10-20 years ago when salmonids, other fish, and pinniped population levels were quite different. Results from older studies may not be applicable to current conditions of increased abundance of pinnipeds and decreased abundance of many salmonid stocks. The year-to-year variation in salmonid abundance is an important factor in assessing impacts of pinnipeds. A constant number of pinnipeds consuming a constant number of salmonids will have a much greater effect on small or declining salmonid populations.

Data were also lacking for an estimate of indirect mortality due to wounds inflicted by pinnipeds in unsuccessful predation attempts. The Working Group found that scarring data cannot be used to estimate salmonid mortality or actual rates of predation. However, pinniped scarring data does serve as an indicator of trends of exposure of salmonids to pinniped predation. Where time series of annual pinniped scarring rates can be compiled, they may be a valid indicator of changes in exposure of adult salmonids to pinniped predation in specific rivers and estuaries.

Salmonid Consumption Estimates

The Working Group did not attempt to estimate salmonid consumption by pinnipeds because they found the data available at present were inadequate. However, they did review recent estimates of salmonid consumption by California sea lions and harbor seals in Oregon made by Kaczynski and Palmisano (1992), as well as estimates of Snake River salmon consumption by harbor seals made by Chapman et al. (1991) and Park (1993). The Working Group found similar technical and analytical weaknesses in all three reports.

Annual consumption of salmonids by California sea lions in Oregon was estimated by Kaczynski and Palmisano (1992) at 142.9 t (35,800 fish) based on the following assumptions: 1) a daily maintenance diet of about 6.8 kg for an adult male sea lion, 2) salmon comprises about 10% of the total biomass that sea lions consume, and 3) up to 2,000 sea lions are present for 3 months during migration and 200 sea lions overwinter in Oregon.

Harbor seal annual consumption of salmonids in Oregon was estimated by Kaczynski and Palmisano (1992) at 816 t (204,500 fish) based on the following assumptions: 1) a daily maintenance diet of 2.7 kg per day for a 54-kg harbor seal, 2) salmon comprises 10.8% of the biomass that harbor seals consume, and 3) harbor seal abundance in Oregon was 10,000 in 1992. Chapman et al. (1991) and Park (1993) estimated harbor seal consumption of Snake River spring chinook using the same assumptions of average size, daily food intake, and percentage of salmon in the diet as Kaczynski and Palmisano (1992). Chapman et al. (1991) calculated that 2,100 seals in the Columbia River (over the 100 days when adult Snake River spring chinook are migrating) consumed 15,700 salmon (of which they assumed 3,000 were Snake River chinook). Park (1993) estimated harbor seals in the Columbia River consumed 22,558 salmon (of which 4,500 were assumed to be Snake River chinook) based on 3,000 seals present during the spring chinook run.

ODFW (1992) reviewed the Kaczynski and Palmisano (1992) report and concluded that they failed to stratify analyses by location, species, and life histories of both salmonids and pinnipeds; inaccurately interpreted or reported scientific studies; and failed to analyze data using valid and sufficiently rigorous methods. The Working Group found that Kaczynski and Palmisano (1992) extrapolated their estimates from one or two site- and season-specific food habits studies to the entire state and failed to differentiate between species of salmonids.

The Working Group found that Chapman et al. (1991) and Park (1993) made many of the same assumptions as Kaczynski and Palmisano (1992) in using data on another species from another area to estimate predation on adult spring chinook in the Columbia River. The Working Group noted that spring chinook had not been identified in the scats or stomach contents of harbor seals in the Columbia River (Beach et al. 1985, Brown et al. 1989) and, consequently, a predation rate cannot be estimated. Although there is pinniped scarring on adult spring chinook as a result of predation attempts by seals and sea lions, the Working Group found that it is unknown to what extent harbor seals are successful in predating adult spring chinook in the Columbia River and what proportion of the salmonids that may be taken by seals or sea lions are from the Snake River.

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DISCUSSION OF ECOSYSTEM IMPACTS

Determining the impact of pinnipeds on the U.S. West Coast ecosystems is a complex assessment involving separating the effects of other predators (including commercial, sport, and tribal fishers), predator and prey population dynamics, disease, and changes in environment. Because California sea lions and harbor seals are opportunistic predators, their food habits change dramatically over areas, seasons, and years in response to changes in abundance and availability of their prey. These ecological interactions are complicated, and at this time there is insufficient information to evaluate whether pinniped predation influences prey populations in most situations. Consumption estimates require information on predators, including an age/sex structured model of seasonal distribution; energetic requirements based on mass and reproductive condition; annual, seasonal, and geographic variation in the percent (by weight) of prey in diet; and average energy density of prey. Statistical models to quantify the impact of pinnipeds on prey have been proposed for the interactions of Cape fur seals and hake in the Benguela Current, gray seals and cod in the North Atlantic, and harp seals and cod and capelin in eastern Canada. The problems encountered in these studies which cause bias in consumption estimates include variation in annual and seasonal proportion of prey in diet and changes in energetic costs. It is also difficult to assess the impact of predation on prey dynamics without understanding the interaction of other predators and other sources of natural mortality. Because of these constraints, the Working Group limited consideration of potential ecosystem impacts to annual biomass consumption estimates for harbor seals and sea lions, socioeconomic implications of pinniped interactions with commercial and sport fisheries, and pinniped interactions with other human activities.

To derive overall annual consumption estimates, the Working Group made the following assumptions: the currently available pinniped population structure and abundance estimates are accurate, average size of different age and sex groups within the population are known, allometric scaling of energy requirements (i.e., consumption rates for large animals are lower than for small animals) from Innis et al. (1987) and Olesiuk (1993) are adequate to estimate biomass consumption, and available data on prey are representative. No assumptions were made regarding caloric density of prey, although it may have important effects on prey selection.

Estimates of Biomass Consumption by California Sea Lions

Estimates of annual biomass consumption for California sea lions along the U.S. West Coast are sketchy. Coastwide consumption calculations for sea lions are complicated because different age classes are present on different parts of the coast for varying amounts of time during the year. Adult and subadult males migrate from southern California northward into Oregon, Washington, and British Columbia for 9-10 months of the year, while adult females, juveniles, and pups remain in southern California waters year-round. Additional complexities are differing energy requirements depending on size and reproductive condition and inadequate year-round abundance data for sea lions north of southern California. The Working Group therefore could not calculate a coastwide estimate of annual consumption by California sea lions, but instead estimated biomass consumption for areas where limited data were available. A minimum biomass consumption estimate for California sea lions is 147,191 t coastwide based on the sum of the areas shown in Table 3.

Table 3. Regional abundance and annual estimated biomass consumption of California sea lions in Washington, Oregon, and California in 1994.

Region	**Abundance**	**Total annual consumption (in metric tons)**
Puget Sound, WA	24-444/month	830
Washington Coast	?	?
Lower Columbia River	29-290/month	390
Oregon Coast	52-3695/month	5,287
Northern CA Coast	?	?
Central CA Coast	?	?
Southern CA Bight	90,135	140,684
Minimum coastwide total	**--**	**147,191**

For Puget Sound, the Working Group adopted the National Marine Mammal Laboratory (NMML 1996) estimate of biomass consumption, which used monthly mean population counts of sea lions and a consumption rate based on the average weight of sea lions present and seasonal energetic requirements. NMML (1996) estimated the average biomass consumed each year by California sea lions in Puget Sound between 1986 and 1994 was 830 t (Table 3). Because of an increased number of sea lions present in Puget Sound in 1995, NMML (1996) calculated a separate estimate of annual food consumption by California sea lions in Puget Sound of 2,064 t for 1995. The differences in these estimates for Puget Sound demonstrate the variability in these types of estimates based on annual or seasonal changes in pinniped abundance.

For the Lower Columbia River, the Working Group estimated an annual biomass consumption of 390 t for the sea lions that haul-out seasonally in this area (Table 3). The calculation was based on the average abundance of sea lions between January and June 1991-93.

For the Oregon coast, the Working Group estimated that California sea lions have consumed 5,287 t annually over the past 10 years (Table 3). This estimate was developed using coastwide abundance surveys conducted from 1985 to 1994 (ODFW unpubl. data). The mean of annual peak counts from September of each year was applied to a seasonal abundance profile prepared from monthly surveys conducted in 1984-85. Individual animal weights were estimated to average 180 kg for the months of August through December and 278 kg for the months of January through June, incorporating male weight increases during the winter foraging period (NMFS-AFSC unpubl. data). Monthly consumption estimates were totaled over the 11-month period (August-June) when California sea lions are present in Oregon coastal waters.

In California, complete seasonal sea lion abundance data are available only for the southern part of the state. The Working Group estimated that the annual biomass consumed by California sea lions in the southern California Bight is 140,684 t (Table 3) based on females, weaned pups, juveniles, and subadult males (adult males were excluded because they do not feed during the short time they are on the rookeries). Consumption rates of lactating females were increased by a factor of 1.6 based on estimates of the increased energetic cost of lactation (Perez and Mooney 1986, Oftedal et al. 1987, Costa and

Gentry 1986). Other assumptions included 1) the number of females equals the number of pups (36,184 pups in 1994 (Barlow et al. 1995)) divided by 0.70 (based on natality rates of 70%), 2) lactation period is 6 months following birth (a conservative estimate as some do not wean until as late as 11 months of age), and 3) average mass of females is 95 kg (based upon weights of 17 females captured at San Miguel Island between 1993 and 1995).

Estimates of Biomass Consumption by Harbor Seals

Few estimates of harbor seal annual consumption exist in the literature. Harvey (1987) addressed the question of total consumption of fish and of particular prey species by harbor seals in Oregon based on relative abundance of prey species eaten by harbor seals from studies by Graybill (1981), Brown and Mate (1983), Roffe and Mate (1983), and Beach et al. (1985). Based on size (weight) data from live capture of harbor seals in Oregon, daily dietary requirements from Innis et al. (1987), and an estimated harbor seal population in Oregon in 1980 of about 5,000 animals, Harvey (1987) estimated that the total annual biomass consumed by harbor seals was 5,667 t. Harvey (1987) estimated that salmonids comprised less than 1% of the fish consumed, but accounted for 11% (613 t) of the total biomass.

The Working Group estimated annual food consumption by harbor seals using a bioenergetics model integrating data on abundance, sex and age structure, and feeding rates. To derive the consumption estimates, the Working Group assumed the harbor seal population has a stable age distribution and divided it into four age/sex categories: juvenile (0-1 year), subadult (1-4 year), adult female (5+ year), and adult male (5+ year). The proportion of each of these groups in the population was estimated to be 26% juvenile, 17% subadult, 31% adult female, and 26% adult male based on life tables (Bigg 1969, Pitcher and Calkins 1979). Mean weights for each age/sex category were calculated from 627 harbor seals captured in Washington, Oregon, and California (WDFW and ODFW unpubl. data). Population abundance data were from Huber et al. (1993) for Oregon, from Huber (1995) for Washington, and from Hanan (1996) for California. The correction factor for population counts was 1.53 for Washington and Oregon (Huber 1995) and 1.4 for California (Boveng 1988). The Working Group modified the consumption rate equations of Innis et al. (1987) to account for free-ranging seals as proposed by Olesiuk (1993). Table 4 shows the biomass consumption for harbor seals by area in each state. The coastwide estimated total is 70,174 t of biomass consumed annually with 31,495 t in Washington, 8,535 t in Oregon, and 30,142 t in California (Table 4).

Table 4. Total abundance and estimates of annual biomass consumption of harbor seals in Washington and Oregon for 1993, and California for 1995.

	Population Abundance		**Annual Prey Biomass**
Region	**Counts**	**Estimated Total**	**Consumption (metric tons)**
Washington			
Grays Harbor and Willapa Bay	8,143	12,459	11,495
Washington Coast	3,554	5,422	5,003
Strait of Juan de Fuca and San Juan Islands	6,505	9,953	9,183

Eastern Bays	2,274	3,479	3,209
Puget Sound	1,168	1,787	1,649
Hood Canal	677	1,036	956
Washington Total	22,321	34,136	31,495
Oregon			
Columbia River, Tillamook Bay, and North OR Coast (north of Yaquina Bay)	2,728	4,174	3,851
North OR Coast (south of Yaquina), Umpqua River, Rogue River, and South OR Coast	3,318	5,077	4,684
Oregon Total	6,046	9,251	8,535
California			
Smith River	769	1,077	994
Klamath River	438	613	565
Cape Mendocino	2,239	3,132	2,890
North Coast	5,258	7,361	6,792
San Francisco Bay	4,907	6,870	6,339
Monterey Bay	2,845	3,983	3,675
Central Coast	3,060	4,285	3,953
Southern CA Bight (mainland)	808	1,131	1,043
Southern CA Bight (Channel Islands)	3,012	4,217	3,891
California Total	23,336	32,699	30,142

The Working Group did not attempt to extrapolate these overall biomass consumption estimates to individual species. However, the Working Group noted that Brown et al. (1989) estimated harbor seal consumption of eulachon, which is the primary prey of harbor seals in the Columbia River during the winter when eulachon are present in large numbers. Brown et al. (1989) examined stomachs of harbor seals killed incidentally in the winter salmon gillnet fishery from 1986 to 1988 and found 97% of the prey eaten during the sampling period was eulachon. Using the age and weight distribution of harbor seals in this area, Brown et al. (1989) estimated that 2,100 harbor seals would consume 335 t of eulachon during January and February in the Columbia River; the pinniped consumption is about 26% of the commercial catch of eulachon in 1988 in the Columbia River and tributaries (WDFW and ODFW 1996). Although Brown et al. (1989) had to make certain assumptions in developing their estimate of prey consumption by seals, the more restrictive time and area of the study and the clear dominance of eulachon in the diet during winter months probably reduces the error in their estimate.

Overall Biomass Consumption by Pinnipeds

Based on the consumption estimates above for harbor seals (70,174 t) and California sea lions (minimum 147,191 t), a minimum total of about 217,000 t is consumed by these two pinniped populations annually. This compares to a total of about 460,100 t harvested in the commercial fisheries off Washington, Oregon, and California in 1995 (NMFS 1996b). These consumption estimates indicate the large quantity of prey removed from the coastal marine food web by California sea lions and harbor seals. Caveats about interpretation remain. Because food habits of pinnipeds vary seasonally and by location, assuming that the consumption patterns derived from studies in a specific area are representative of all areas during all seasons is incorrect. Extrapolating the impact of predation on individual fish species to a larger area is of questionable value because of the errors and biases introduced by too many assumptions.

The Working Group found very few studies that addressed comparative food habits data from both California sea lions and Pacific harbor seals from the same area, same season, and same years. At Everett in northern Puget Sound, Pacific whiting and Pacific herring were the most frequently found prey in samples from both California sea lions and harbor seals (NMML 1996). Both pinnipeds also preyed on market squid (NMML 1996). The major differences between the diets of the two predators appear to be the absence of dogfish in the harbor seal diet and the higher prevalence of salmonids in the diet of sea lions. Salmonid remains occurred in only 2% of harbor seal scats but were found in 15% of sea lion scats. The harbor seal scats contained remains only from adult salmonids, while the sea lion samples contained remains of adult salmonids, jacks, and smolt in nearly equal numbers (NMML 1996). Hanson (1993) found that California sea lions and harbor seals differed in their ability to capture free-swimming salmonids. California sea lions had much better success rates in catching adult salmonids at the mouth of the Russian River (capture rate of 0.52 fish/hour for sea lions compared to 0.27 fish/hour for seals).

Pacific whiting in Puget Sound is an example of a principal prey of both sea lions and harbor seals in the same area. Schmitt et al. (1994) reported declines in all groundfish stocks (including Pacific whiting) in Puget Sound between 1983 and 1993. Pacific whiting aggregate and spawn near Everett (in the Port Susan area) during the winter at the same time that California sea lion males are present. In a recent review, Schmitt et al. (1995) generated estimates of prey consumption by California sea lions in Puget Sound based upon food habits data collected from 1986 through 1988. Pacific whiting was the principal prey species, occurring in 67% of the samples (NMML 1996). The prey samples were analyzed to estimate the total mass of each prey species consumed in the diet, so that a proportion of the biomass consumed could be assigned to each species. Schmitt et al. (1995) estimated that male sea lions consumed 286-573 t of Pacific whiting per year, based on a consumption rate of 5-10% of body mass each day. Gearin et al. (1995) revised this estimate using consumption rates based on allometric relationships of mass to consumption (Innis et al. 1987), arriving at a consumption estimate of 266 t of Pacific whiting. This consumption estimate equates to 5.5% of the average spawning biomass of 4,862 t of Pacific whiting in the Port Susan area. Schmitt et al. (1995) speculated that this level of predation, combined with a commercial harvest utilization rate in excess of 20% of the estimated spawning stock and significant but as yet unquantified levels of harbor seal predation, may have contributed to the decline of the Pacific whiting stock. Due to low abundance, the commercial fishery was closed in 1988. It is unknown whether sea lion and seal predation may now be restricting the recovery of the Pacific whiting stock in Puget Sound or if sea lions in Puget Sound continue to utilize Pacific whiting as winter food to the same extent that they did in the late 1980s.

Pinniped Interactions with Commercial Fisheries

Harbor seals and California sea lions interact with almost all commercial fisheries on the West Coast.

Because pinniped mortalities due to entanglement in fishing gear do not appear to have had any negative effects on the increase in seal or sea lion populations, the principal concerns are damage to catch and gear and potential indirect impacts on the fish stocks. The loss in catch and gear is most severe in salmonid gillnet and salmon troll fisheries (NMFS 1992). Fish caught in gear are removed or damaged by pinnipeds, causing direct loss of income to the fishers. Bait is taken out of traps and off hooks, making the gear ineffective. Fishing gear is damaged, making it "unfishable," especially in the case of California sea lions tearing through salmonid gillnets.

West Coast Salmon Troll Fishery

Miller et al. (1983) conducted a comprehensive study of marine mammal-fishery interactions in California waters in 1979-80 and reported that the commercial-salmon troll fishery had the highest rate of salmon depredation by pinnipeds, with an estimated loss of 12,459 legal-sized salmon (about 1% of the catch) to California sea lions in 1980. Beeson and Hanan (1996) reported a much greater incidence of California sea lion predation in the 1995 commercial-salmon troll fisheries; an estimated 86,700 salmon (legal- and sub-legal-sized salmon) were removed from troll gear during the fishery, which caught an estimated 734,800 (legal- and sub-legal-sized) salmon off California. Beeson and Hanan (1996) determined that this predation is about 12% of what the troll fishery caught, and estimated the commercial value of the sea lion removals at $1.73 million. Increased losses of troll-caught salmon to sea lions have also been reported off the Oregon coast.

Washington Salmonid Gillnet Fisheries

Harbor seals and California sea lions interact with salmonid gillnet fisheries throughout Puget Sound (NMFS 1992). Tribal biologists have noted considerable loss of catch to pinnipeds in the Green River, Duwamish River, and lower Nisqually River. Pinnipeds have damaged up to 12% of yearly catches from the tribal set-net fishery in the Neah Bay area (Gearin et al. 1989). California sea lions interact with tribal set-net fisheries for coho and steelhead in the Lake Washington Ship Canal, and substantial losses of steelhead from gillnets have been observed (Gearin et al. 1988a, 1988b, Pfeifer et al. 1989).

Columbia River/Grays Harbor/Willapa Bay Salmon Gillnet Fisheries

Damage to salmon in the gillnet fisheries in the Columbia River, Grays Harbor, and Willapa Bay was recorded during observer programs in 1980-82 and 1991-93. In the Columbia River, the incidence of damage was comparable between the two studies except for a high damage rate in winter 1993, which may have been due to a record-low catch (Scordino 1993). In Grays Harbor, approximately 7-23% of chinook salmon caught each season had been damaged by pinnipeds. In Willapa Bay, the range was about 4-14% per season. The variation in rates is attributable to the annual variation in catch; as the catch decreases, the proportion of damaged fish increases.

California Tribal Salmon Gillnet Fishery

In the Klamath River in 1981 and 1982, Herder (1983) monitored the tribal-subsistence salmon gillnet fishery and estimated a depredation rate on salmonids of 13.2% due to harbor seals. Harbor seals were found to consume 3.6% and 7.9% of the chinook salmon, coho salmon, and steelhead released from a seining-tagging operation in 1981 and 1982 respectively. Herder (1983) found that even though the nearby harbor seal population was 150-200 animals, only 7 harbor seals per day were responsible for the salmonid gillnet fishery depredation. All depredation during more than 700 hours of gillnet fishing observations were by harbor seals; no California sea lions were observed taking salmonids from the nets even though salmonids were present in California sea lion scat samples from this area.

California Set-Net and Drift Gillnet Fisheries for Halibut, Seabass, and Swordfish/Sharks

In 1980, Miller et al. (1983) reported the highest pinniped depredation rate in the California gillnet fisheries occurred in the California halibut and white seabass set-net fisheries off southern California, where pinnipeds depredated 10% of the catch. In contrast, the white croaker, Pacific bonito, and flying fish gillnet fisheries experienced a depredation rate of less than 2%. Data collected in 1995 by CDFG show nearly the same situation of sea lions and harbor seals primarily depredating catch in the California halibut, white seabass, and barracuda gillnet fisheries (Beeson and Hanan 1996). There are also reports of pinniped depredation in gillnet fisheries that target mackerel, Pacific bonito, rockfish, shark, and swordfish.

From July 1990 to July 1994, NMFS observers monitored 60,967 set-net sets (mostly targeting on California halibut). Pinniped depredation was reported in 19% of the observed sets. During the 1993-94 white seabass season, fisher logbooks indicated 20% of the fishing days had "fish lost to pinnipeds" (Beeson and Hanan 1996). In the 1994-95 season, there was a reported loss in this fishery in 12% of the fishing days. Commercial fishers report that pinnipeds can damage 10-30% of the catch daily, a monetary loss of approximately $50-75 per day, or $3,000-4,000 for a season (Beeson and Hanan 1996). Because of the implementation of restrictions on the use of set-nets in California waters, fishing effort in the halibut set-net fishery has declined substantially over the past 5 years, from more than 7,000 days of effort and more than 200 boats in 1990 to less than 2,000 days of effort and 40 boats in 1994 (Beeson and Hanan 1996). According to commercial gillnet fishers, depredation rates and gear damage have increased over the past 5 years for boats that remain in the fishery. Many fishers have reported to CDFG that they are being "put out of business" by continual pinniped depredations and related loss of income. Commercial fishers also report that pinniped depredation is more intense during El Niño periods.

Miller et al. (1983) found that sea lions depredated more than 1% of the swordfish catch in the shark-swordfish gillnet fishery in 1981. From July 1990 to July 1994, NMFS observers in this fishery documented that 250 (2.5%) of the total observed drift gillnet sets (9,892 sets) sustained pinniped depredation. In addition to depredation of catch, sea lions and harbor seals damage gillnet gear. Miller et al. (1983) estimated the total value of fish removed by pinnipeds and gear loss in California gillnet fisheries was $121,000 in 1980. Today, fishers claim that individual gear damage and catch loss in gillnet fisheries range from $1,000 to $20,000 annually.

In addition to commercial gillnets, sea lions also depredated CDFG gillnets used for a striped bass tagging study in the Bay-Delta (Dave Kohlhorst, CDFG, 1416 9th St., Sacramento, CA 95814. Pers. commun., April 1996). Sea lions removed 100 striped bass from the gillnets over a 10-day period, as far as 60 miles inland from the San Francisco Bay Bridge.

California Herring Gillnet Fishery

Pacific herring are fished during the winter spawning season (November to March) in San Francisco Bay, Tomales Bay, Humboldt Bay, and Crescent City. Both California sea lions and Pacific harbor seals interact and depredate catch in this fishery. Miller et al. (1983) reported that foraging activities by sea lions and harbor seals in San Francisco Bay usually involved only one to four animals per net. Total depredation of catch was less than 1% for both the 1979-80 and 1980-81 seasons. In recent years, according to one Humboldt Bay herring fisher, depredation has increased because of increased numbers of both harbor seals and sea lions. Sea lions are the main cause of gear damage (Beeson and Hanan 1996).

Puget Sound Salmon Net-Pen Facilities

NMFS has received many reports of both harbor seals and California sea lions damaging salmonids in net-pens. Although pinnipeds normally cannot access whole fish through the net-pen webbing, they can bite and kill fish through the webbing and then consume the parts of the fish. In some instances, net-pens have been ripped open by California sea lions, allowing salmon in the pen to escape. The extent of predation problems in this fishery depends upon the type of pens used and the size of fish in the pen. Net-pens made of flexible materials allow predation by pinnipeds, while solid net-pens prevent pinnipeds from catching the fish (P. Dorn, Suquamish Tribe, P.O. Box 498, Suquamish, WA 98392. Pers. commun., July 1995). Net-pens that contain larger fish are reportedly more likely to be the target of pinniped predation (M. Huff, Port Gamble S'Klallam Tribe, 31974 Little Boston Road, Kingston, WA 98346. Pers. commun., July 1995). One net-pen facility in Puget Sound recorded 71,449 salmon damaged by California sea lions from October 1995 to June 1996 (R. Safford, Global Aqua, 9507 NE South Beach Drive, Bainbridge Island, WA 98110. Pers. commun., February 1997). In spite of an investment of more than $200,000 in predator nets, California sea lions were still finding access to the net-pens. The salmon lost to sea lions during this period accounted for 4-5% of production at harvest, with a value of $1.67 million based on a weight of 3.6-4.5 kg per salmon at production and a sales price of about $5.72/kg. The facility reports that it is incurring additional costs of $60,000-$70,000 per year due to the sea lions for divers to repair nets and remove killed fish from pens, and firecrackers used in attempt to deter sea lions from pens (S. McKnight, Global Aqua, 9507 NE South Beach Drive, Bainbridge Island, WA 98110. Pers. commun., February 1997).

Tillapaugh et al. (1991) reported that seal attacks on salmonid farms in British Columbia annually cost fish farmers an estimated $4 million (Canadian) in lost revenues due to fish kill and escapes. In addition, from 1989 to the summer of 1991, B.C. fish farmers spent an estimated $2 million in direct costs for anti-seal nets and technology (Tillapaugh et al. 1991). Rueggeberg and Booth (1989) also surveyed salmonid farmers in British Columbia to estimate the impact of pinnipeds on the net-pen fishery. About 25% of the farmers surveyed reported losing fish to harbor seal and sea lion predation, totaling 61,000 salmonids. They also reported losing approximately 44,000 fish to holes in net-pens created by harbor seals, sea lions, or river otters. If this is representative of the entire industry, Rueggeberg and Booth (1989) estimate that the fishery lost 101,700 fish per year to harbor seal and sea lion predation and 61,600 fish to net damage by pinnipeds or river otters, or approximately 1% of total production.

California Live Bait Operations

California sea lions have been known to haul-out on bait barges, where they prey on the bait, scare the bait, and block the operator's access to the barge. One bait barge operator reported losing 50% of the bait overnight to sea lions (Beeson and Hannan 1996). Some bait-pen operators have installed chain-link fences on top of the barges and nets around the outside of the pens to keep sea lions from accessing the barge or the pens.

California Round-Haul Fisheries

California sea lions and harbor seals interact with the round-haul herring fishery and the purse seine fisheries for squid, sardine, and mackerel by foraging in the nets and frightening fish out of the net

(Miller et al. 1983). Round-haul nets currently cost about $30,000 each, and sea lions have been observed "chewing" portions of the net. In the round-haul herring fishery, only sea lions were involved in depredations (Miller et al.1983).

Trap Fisheries

Lobster, crab, and live-fish trap fishers report that California sea lions frequently destroy their traps. Miller et al. (1983) did not report any pinniped interaction or depredation in the trap fisheries. However, sea lions are now reported to open traps to remove the bait (sea lions do not prey on the trapped lobsters or crab) and destroy the traps (Beeson and Hanan 1996). These interactions are most prominent in the San Diego area, although there are also reports from Ventura and Santa Barbara fishers. California sea lions also have been reported to remove bait and damage Dungeness crab pots in Puget Sound in recent years.

Other Commercial Fisheries

Other commercial fisheries with pinniped interactions and depredations include the non-salmon hook-and-line and trawl fisheries. Miller et al. (1983) reported that 517 kg of rockfish, about 1% of the total catch, were depredated by sea lions in the southern California hook-and-line fishery. There is little current information on sea lions depredating hook-and-line fisheries. One fisher described sea lions depredating mackerel used to bait a shark set-line, while another mentioned sea lions depredating mackerel caught for the fresh-fish market (Beeson and Hannan 1996). Miller et al. (1983) reported sea lions removing fish in the cod end of trawl nets, although no current data exist. In Elkhorn Slough, Oxman (1995) found that harbor seals competed with commercial fisheries for four species: white croaker, sanddab, lingcod, and English sole.

Pinniped Interactions with Sport and Charterboat Fisheries

Interactions between pinnipeds and sport fishers have been reported coastwide. In Washington and Oregon, both harbor seals and sea lions are known to remove salmonids from sport hook-and-line gear (NMFS 1992). In the Columbia River, most of the interactions occur during the spring chinook fisheries in the lower mainstem, at the mouths of tributaries, and in the Willamette River when California sea lions are most abundant. There is little documentation of the extent of this interaction and no estimates of economic losses attributable to pinnipeds. However, in recent years, state fisheries agencies have received increased reports of pinnipeds removing salmonids from fishing gear in coastal waters, inshore bays and estuaries, and inriver fisheries. Sport fishers in some areas have reported that if California sea lions are within 100 m of a fish when hooked, a sea lion will take the fish before it can be landed (Chuck Tracy, WDFW, Columbia River Anadromous Fisheries Division, 16118 NE 219th St., P.O. Box 999, Battleground, WA 98604. Pers. commun., October 1995). In the spring of 1994, interviews of sport anglers by Huber et al. (1995a) in the Lewis River (tributary of the Columbia River) indicated that fishers experienced frequent predation of hooked fish by California sea lions, although only a small number of sea lions were present.

In many bays in Oregon, successful sport crabbing from boats or docks, using crab rings or pots, has been severely impacted or eliminated because California sea lions steal crab bait and destroy gear. Harbor seals also occasionally steal bait from crab rings.

Interactions between sport fisheries and pinnipeds have been documented extensively in California, where pinniped depredation of salmonids caught by sport fishers occurs both in rivers and in the ocean.

Pinniped feeding rates on hooked salmonids in the Klamath River in the 1960s, 1970s, and 1980s were less than 1% (Herder 1983). In the ocean fisheries in the Monterey Bay area in 1969, sea lions removed about 4% of the fish caught by commercial and sport fishing vessels (Briggs and Davis 1972). The overall loss rate for ocean sport anglers was less than 1% in 1980, but large numbers of juvenile California sea lions removed as much as 17% of the hooked salmonids in Monterey Bay between February and April (Miller et al. 1983).

Studies conducted by CDFG show increased rates of predation by pinnipeds on salmonids caught in the charterboat and private skiff fishery in 1994 and 1995 (Beeson and Hanan 1996). In 1995, ocean salmonid sport landings were greatest in Monterey and San Francisco. Monterey also had the highest depredation rates (number of sea lion takes relative to total angler landings) during March (21%), April (27%), and September (19%), coinciding with the male sea lion spring and fall migrations. In the Monterey area during April, sea lions took an estimated 11,900 salmonids from angler lines, 43% of the total number of salmonids taken in the Monterey sport fishery for the 1995 season (charterboat and private skiff combined). Statewide, anglers landed an estimated 498,600 salmonids, while an estimated total of 27,900 salmonids were lost to sea lions (5.3% of total hooked).

In southern California, sport fishing is a $536-million business (Thompson and Crooke 1991). Since at least 1979, more pinniped interactions in the non-salmonid sport fishery occurred in southern California, especially near San Diego, than any other area (Miller et al. 1983, Hanan et al. 1989). Sea lions directly affect charterboat fishing by consuming bait and chum and depredating hooked fish. Miller et al. (1983) found that fewer fish were caught by charterboats when a sea lion was present. Consequently, when sea lions are present, skippers frequently move the boats to other fishing areas, resulting in additional fuel costs and loss of fishing time.

Sea lion interactions with charterboat fisheries and depredation of catch occur throughout the year in southern California (Beeson and Hanan 1996). For the first seven months of 1995, 14% of all non-salmonid trips were depredated by sea lions (1,414 depredated trips out of 10,042 total trips). A depredated trip was defined as a charterboat trip with at least one fish reported taken by sea lions. In comparison, in central/northern California, less than 2% of the non-salmonid trips were depredated by sea lions (55 depredated trips out of 2,939 total trips). The majority of depredations involved California barracuda in nearshore coastal waters in the Los Angeles and San Diego areas.

In 1979 and 1980, Miller et al. (1983) reported that there were no pinniped interactions with charterboat trips in California north of Avila (San Luis Obispo County), and depredation was rare except in the San Diego area. In 1980, the total annual loss from depredation by California sea lions in southern California was estimated at 15,141 non-salmonids that had a fresh-fish market value of $28,100; Pacific bonito comprised 78% of this loss. Beeson and Hanan (1996) analyzed the charterboat fishing logs, statewide, for January through July 1995, and found that 26,138 non-salmonids were taken by pinnipeds. Of this total, 97% were taken in southern California and had a fresh-fish market value exceeding $145,200; California barracuda comprised 59% of this loss.

In 1994, the San Diego charterboat fleet experienced sea lion depredations throughout the year, ranging from 7% in February to a high of 38% in April (number of depredated trips relative to the total number of trips). The highest percentage of depredated trips occurred in March through May. California barracuda were taken most often by sea lions, although rockfish, mackerel, kelp, and barred sand bass were also taken (Beeson and Hanan 1996).

Hanan et al. (1989) found interaction and depredation rates for charterboat fisheries in the San Diego area decreased in spring and early summer, and increased in mid-summer. They attributed this seasonal trend to sea lions congregating in the Channel Islands for the breeding season. Hanan et al. (1989) found that the interaction and depredation rates declined following an El Niño event, and suggested that the reason was a reduced number of available fish.

Contamination of Shellfish Beds

Another potential impact of expanding pinniped populations on the coastal ecosystems is contamination of shellfish beds. In the 1980s, high concentrations of fecal coliform at the Dosewallips River in Hood Canal, Washington, resulted in the closure of commercially and recreationally harvested shellfish beds to protect the health of the public. The contamination was determined to be caused by the feces of large numbers of harbor seals that used the area as a haul-out (Calambokidis et al. 1989, Calambokidis and McLaughlin 1988). To alleviate the contamination problem, a fence was built to prevent seals from hauling-out near shellfish beds, and a raft was built in deeper water as an alternative haul-out site for the seals. At present, the Dosewallips shellfish beds are partially open to commercial and recreational use (K. Anderson, Puget Sound Water Quality Action Team, P.O. Box 40900, Olympia, WA 98504-0900. Pers. commun., July 1995). The partial closure remaining at Dosewallips River is due to contamination from both agriculture and seals.

The Working Group found that only 1 site of the 77 commercial shellfish beds in Washington was closed because of high coliform counts caused by seals. In Quilcene Bay, Henderson Inlet, Belfair State Park, Port Gamble Bay, and other Hood Canal areas, human and domestic animal sewage appears to be a more widespread cause of contamination than harbor seals (Anderson, pers. commun., July 1995). Nevertheless, oyster growers in Grays Harbor, Willapa Bay, and Hood Canal have expressed concern that fecal coliform contamination from increasing pinniped populations may cause future shellfish closures in Washington. Similar pinniped contamination concerns have been raised at commercial oyster aquaculture sites in Tillamook and Yaquina Bays in Oregon, but no studies have addressed the concern.

Pinnipeds in Harbors and Human Safety

Since passage of the MMPA, seals and sea lions have been afforded protection from disturbance, harassment, and killing, thereby allowing them to occupy areas from which they would have been removed in the past. The result has been direct conflict between pinniped and human use at public and private beaches, public marinas, and private docks, and involves landowners, vessel operators, and beachgoers.

Pinniped interactions with humans also have expanded into the freshwater environment as pinniped occurrence in bays and upriver has increased. California sea lions have been observed more than 145 miles up the Columbia River at the Bonneville Dam and have interacted with sport fishers throughout the river. In the Willamette River, California sea lions haul-out on docks in the Portland, Oregon metropolitan area and prey on spring chinook and steelhead at the fishway at the Willamette Falls. Reports of California sea lions occurring far inland from the ocean are increasing in other areas such as the Nisqually River and Chehalis River in Washington and up the San Francisco Bay Delta as far inland as Antioch.

The Working Group found that the most frequently reported pinniped conflicts with humans are encounters on docks, marinas, and public beaches. In California, reports of problems with sea lions and harbor seals have been received from harbors in Humboldt Bay, Noyo River, San Francisco Bay, Santa Cruz, Monterey Bay, Redondo Beach, and San Diego. In Washington and Oregon, problems with California sea lions are commonly reported in harbors in Puget Sound, Washington, and in Astoria and Yaquina Bay, Oregon. Most problems reported are caused by California sea lions hauling-out on docks and boats. California sea lions have prevented owners from accessing their boats, boats have been fouled, and the weight of animals has damaged docks and small boats. Some small boats reportedly have sunk from the weight of the animals. Fishers at Cape Arago in Oregon frequently report California sea lions jumping onto their vessels and stealing bait. Sea lions also have been reported to have bitten people carrying fish and taken fish laid out on docks. The number of California sea lions hauled-out on Pier 39 in San Francisco increased from 6 to nearly 500 between 1990 and 1994, with a high of 627 in 1991. The City of San Francisco finally "gave up" the pier to the sea lions, as animals reacted aggressively when humans attempted to remove them, and it is now a tourist attraction.

Another indirect effect of increasing pinniped populations on human safety is the possibility of an increase in the number of large sharks that prey on pinnipeds . Although there have been a number of media reports that increased attacks on humans by the great white shark (*Carcharodon carcharias*) are related to an increase in the shark populations caused by increased numbers of pinnipeds in coastal areas, the Working Group found little scientific information on this issue. McCosker and Lea (1996) report that the majority of shark attacks on humans have occurred at or near the surface, near shore, and in the vicinity of pinniped colonies and/or river mouths. Recent information on changes in shark abundance and distribution resulting from the increased populations of pinnipeds comes from studies by Pyle et al. (1996) at the Farallon Islands. At the Farallon Islands, increased attacks on pinnipeds between 1987 and 1993 are attributed to increased numbers of white sharks in the area; prior to that, increased numbers of attacks were attributed to increased populations of elephant seals and sea lions (Pyle et al. 1996).

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DISCUSSION OF MITIGATION MEASURES FOR PINNIPED CONFLICTS

Most information on the effectiveness of mitigating measures for pinniped/fisheries interactions is the result of NMFS and state efforts to control California sea lion predation on depressed salmonid runs (i.e., at the Ballard Locks), and have been undertaken under the authority of section 109(h)(1)(C) of the MMPA which authorizes nonlethal removal of nuisance animals. Up until 1995, commercial fishers were permitted to injure or kill a marine mammal that was causing immediate damage to their catch or gear so long as other nonlethal efforts had been attempted without success. Since the reauthorization of the MMPA in 1994, fishers and members of the public are permitted to use only nonlethal deterrence methods to prevent pinnipeds from damaging property.

Measures that have been tried or considered for reducing or eliminating pinniped predation on salmonids or minimizing interactions with fisheries are harassment, aversive conditioning, exclusion from selected areas, removal of offending pinnipeds, and pinniped population control.

Harassment Methods

Methods to directly deter pinnipeds from fish predation or fishing gear include noise stimuli and tactile and vessel harassment. Deterrence efforts involving noise stimuli (underwater firecrackers, cracker shells, acoustic devices, and predator sounds) are based on the assumption that noise can be used to startle, warn, scare, or cause physical distress to pinnipeds, moving them out of areas where fish are vulnerable to predation or away from fishing gear. Vessel chase and tactile harassment have also been attempted as a means of deterrence.

Firecrackers

Underwater firecrackers (called "seal bombs") have been used to disperse pinnipeds. Underwater firecrackers have been effective on a short-term basis in many situations, but over the long-term with repeated use, sea lions and seals learn to ignore or avoid the noise (Gearin et al. 1986, Pfeifer et al. 1989, Geiger and Jeffries 1986). At the Ballard Locks, although firecrackers were effective in reducing predation rates of California sea lions in the first season of use, they became relatively ineffective in subsequent years because the animals appeared to have learned to ignore or tolerate the noise (Pfeifer et al. 1989). They also learned to evade close exposure to firecrackers by diving and surfacing in unpredictable patterns (NMFS 1995b). Similar tolerance/avoidance of firecrackers has been observed in fisheries interaction situations with harbor seals (Geiger and Jeffries 1986).

Cracker Shells

Cracker shells are shotgun shells containing an explosive projectile designed to explode about 50-75 yards from the point of discharge. Although the noise may startle pinnipeds and cause them to temporarily flee, there is usually no physical discomfort to the animals involved since the explosion is in the air or on the water surface. Cracker shells have been used in fishery interaction situations with harbor seals with limited effectiveness because the seals have learned to avoid or ignore the noise (Beach et al. 1985).

Acoustic Harassment Devices (AHDs)

The AHD produces a high-amplitude, pulsed but irregular "white noise" under water in the 12-17 kHz range that is intended to cause physical discomfort and to irritate pinnipeds, thereby repelling them from the area of the sound (Mate and Greenlaw 1981). A complete description of the AHD and the areas that it has been used is presented in a workshop report, "Acoustical Deterrents in Marine Mammal Conflicts with Fisheries" (Mate and Harvey 1987). AHDs have been shown to be initially effective in some situations, but their effectiveness diminishes quickly as pinnipeds learn to tolerate the noise. AHDs were used on harbor seals in the Klamath River in an attempt to deter seals from preying on salmon released from seines, but were not effective in reducing harbor seal predation. The AHD also was used on California sea lions at the Ballard Locks facility, but was ineffective in deterring most sea lions (NMFS 1995b). Several researchers have reported that the use of AHDs on commercial fishing gear resulted in the devices appearing to act as a "dinner bell," thereby attracting pinnipeds to fishing gear (Geiger and Jeffries 1986, Jefferson and Curry 1994).

Acoustic Deterrent Devices (ADDs)

The ADDs are a modification of the AHDs, developed for use in deterring seals and sea lions from commercial salmonid net-pen and salmonid ranch facilities. The ADDs have omni-directional and unidirectional arrays which produce periodic sound emissions centered at 10 kHz and at higher decibel levels than the AHDs (Norberg and Bain 1994). At the Ballard Locks, an acoustic ensonified zone has been established under water in the area below the spillway dam and fish ladder to control the presence of California sea lions and reduce their predation on returning winter steelhead. The ADDs appear to be effective in deterring new sea lions from the Ballard Locks area, but have limited effectiveness on California sea lions that repeatedly forage at this site (NMFS 1996a).

Predator Sounds

The effectiveness of predator vocalizations to frighten sea lions has not been consistent (Shaughnessy et al. 1981, Fish and Vania 1971). Pinnipeds sometimes have shown immediate avoidance responses to the projection of killer whale sound recordings, but generally they have habituated quickly (Anderson and Hawkins 1978, Shaughnessy et al. 1981). In one study, sea lions were actually attracted to a researcher's broadcast of predator vocalizations in the Baja California area (NMFS 1995b).

Vessel Chase

Chasing or hazing California sea lions with a vessel proved to be ineffective at the Ballard Locks, as animals learned to avoid the vessel or swim under it (Pfeifer et al. 1989). Both commercial and sport fishermen have also used their vessels in an attempt to chase seals and sea lions from their operation, but such efforts are usually unsuccessful.

Tactile Harassment

Tactile harassment involves shooting pinnipeds with nonlethal projectiles such as rubber bullets or blunt-tipped arrows. Tactile harassment has been used successfully by instilling an avoidance reaction in other wildlife species (e.g., grizzly bears and polar bears) in some situations. Blunt-tipped arrows were tested by WDFW on California sea lions at the Ballard Locks with no significant change in predation rates (Pfeifer et al. 1989). Rubber projectiles discharged from a shotgun were tested by ODFW on California sea lions at Willamette Falls with limited success.

Aversive Conditioning

Aversive conditioning is the application of an unpleasant or painful stimulus to train animals to avoid a specific behavior. This technique has been used with coyotes to condition them not to eat sheep (Forthman-Quick et al. 1985).

Taste Aversion

Taste aversion is a form of aversive conditioning that involves putting an emetic agent (e.g., lithium chloride) into a prey species to induce vomiting when the prey is consumed. This technique has been used successfully on a prey-specific basis with captive California sea lions. Using lithium chloride-treated fish, Kuljis (1986) conditioned captive sea lions to avoid one of three prey species without affecting the sea lions' desire to eat the other two species. Taste aversion using lithium chloride was attempted on California sea lions at the Ballard Locks, but the effort was not successful (Gearin et al. 1988a). A variation on this method is to dart (inject) lithium chloride directly into a pinniped when it consumes a fish or enters an area. The same theory applies: if the pinniped associates becoming sick with entering an area or consuming fish in that area, it would develop an aversion. This approach has not been field tested.

Exclusion from Selected Areas

Efforts to exclude pinnipeds from certain areas have included installation of physical barriers. Other approaches that have been considered, but not implemented, to prevent access to specific areas or haul-outs near "problem areas," are the use of scarecrow or alarm devices on haul-outs, or use of predator models (e.g., killer whale model). The assumption is that if pinnipeds are excluded from a haul-out site, they will leave the area to haul-out elsewhere.

Physical Barriers

Physical barriers have been used to prevent sea lion access to a prime forage area in front of the entrance of the fish ladder at the Ballard Locks, and have been used to prevent harbor seals from entering a channel in the Dosewallips River where harbor seal presence was causing high coliform counts in shellfish beds. The barrier at the Ballard Locks (a large-mesh net strung under water) was ineffective because fish passage may have been hampered by the barrier, and sea lions were observed foraging on steelhead at the face of the barrier. The barrier at the Dosewallips River was effective in excluding harbor seals from a haul-out site and resulted in lowered coliform counts at the shellfish beds. Fences also have been used successfully to prevent sea lions from hauling-out on marine buoys and docks in Shilshole Bay. At the Willamette Falls fishway, a metal barrier consisting of vertical metal bars was placed in the opening of the fish ladder to prevent sea lions from entering but still allow salmon to pass.

Predator Models

Although media reports on the use of a killer whale model indicated that it was effective in repelling seals from net-pens in Scotland, use of the same predator model at net-pens in Maine had no effect in repelling harbor or gray seals (NMFS 1995b). Observations of pinniped behavior in the presence of predators and during field testing has shown that these methods are very short term or ineffective. Sea lions have been shown in varying experimental regimes to quickly become nonresponsive to activities that do not result in infliction of pain (NMFS 1995b).

Scarecrows/Alarms on Haul-outs

Harassing seals from haul-out areas in rivers/estuaries during salmonid runs might be accomplished by placing scarecrow or harassment devices (sirens or loud noise/explosions that dispense noise periodically) on haul-outs. This method has not been tested. It would be effective only if the pinnipeds relocated to areas far away from the river mouth or estuary. Unfortunately, California sea lions and harbor seals do not necessarily have to haul-out at any particular time or place, and may remain in the water during the salmonid run.

Nonlethal Removal of Offending Individual Pinnipeds

Capture and Relocation

Capture and relocation efforts with California sea lions at the Ballard Locks indicate that transporting captured sea lions relatively short distances (from Ballard to the outer Washington coast) are not effective, as the sea lions quickly return. Longer distance relocation from Ballard to the southern California breeding area was a possible, albeit costly, means of delaying sea lion return to Puget Sound for at least 30 days, thereby providing a window of safe passage for migrating salmonids that season (NMFS 1995b). Unfortunately, not all predatory animals can be easily captured, especially those of greatest concern that had been captured/removed previously and had returned to forage at the Ballard Locks (NMFS 1996a). Harbor seals also have been captured and relocated relatively short distances (Ballard Locks to Hood Canal), but the seals also soon returned to the problem area.

Capture and Placement in Captivity

California sea lions have been captured at the Ballard Locks, placed in temporary captivity, and released after the steelhead run. Temporary holding was found to be ineffective in the long term because the sea lion returned the following season and could not be recaptured before it had preyed on salmonids (NMFS 1996a). Sea lions from the Ballard Locks also have been captured and placed in captivity permanently. Although permanent captivity does eliminate the "problem" sea lions without having to kill them, the method is limited by costs and the availability of facilities that can hold sea lions permanently.

Effectiveness of Nonlethal Measures

Past efforts by NMFS and WDFW at the Ballard Locks have been unsuccessful in finding an effective, long-term, nonlethal approach to eliminating or reducing pinniped predation on salmonids (NMFS 1996a). Some nonlethal deterrence measures appear to be effective initially or effective on "new" animals, but become ineffective over time or when used on "new" animals in the presence of "repeat" animals that do not react to deterrence. In situations where nonlethal measures are successful on "new" pinnipeds, lethal removal of the experienced/habitual predators combined with nonlethal deterrence of "new" animals may be an effective means of controlling pinniped predation on salmonids (NMFS 1996a). Further research on the development of new technologies and techniques is needed.

Lethal Removal of Offending Individual Pinnipeds

Lethally removing individual "problem" pinnipeds has been considered in many areas as a solution to problems that involve small numbers of pinnipeds. The lethal removal of all problem animals may not be necessary if limited shooting serves as a deterrent to other animals (NMFS and WDW 1989). The seal control technique used by the Fish Commission of Oregon from 1959 to 1970 involved working downstream in the Columbia River from a boat, shooting at every seal encountered. According to the seal hunter and many gillnetters, the seals became conditioned to the sound of his boat and would flee downstream (NMFS and WDW 1989). Beach et al. (1985) concluded that if this reaction could be replicated, the scaring of seals could prove to be more important for reducing fisheries interactions than killing the seals.

Lethal removal of selected, known individual California sea lions by State authorities was authorized at the Ballard Locks in 1995 under the authority of Section 120 of the MMPA. A number of conditions were placed on the authorization to ensure that only the "problem" animals would be lethally removed and only as a last resort (NMFS 1995b). For example, the lethal authorization required that nonlethal deterrence efforts be in place (use of ADDs) and, in the first year of the authorization, lethal removal could be used only if temporary holding facilities were unavailable or temporary holding was not feasible or practical. To date, no sea lions have been lethally removed. In 1996, three sea lions that were candidates for lethal removal were instead captured and placed in captivity permanently.

Pinniped Population Control

Several programs were instituted in the past to control the population of pinnipeds, but only a few have been monitored to document the effects. A culling program was instituted in 1977 with the goal of reducing the gray seal population of Orkney and Outer Hebrides from 50,000 to 35,000 by 1982 (Harwood and Greenwood 1985). Originally, the plan was to kill pups annually and adult females in alternate years, but because of public concern, only pups were hunted. The cull had little apparent effect as the gray seal population had increased to 65,000 by 1987 (Harwood et al. 1991). Between 1956 and 1968, at least 300,000 northern fur seal adult females were culled from the Pribilof Islands population. The purpose of the culling was to reduce density and thereby lower the age of first reproduction in an attempt to increase pup production. The expected result was to maintain a constant number of subadult males available for the commercial harvest, with lower total population numbers. While the culling was unsuccessful in increasing pup production, it did reduce population numbers (York and Hartley 1981). Beginning in the 1920s and 1930s, state-financed bounty programs in Washington and Oregon selectively killed large numbers of seals and sea lions to reduce the number of predators on commercially important fish species (Newby 1973, Pearson and Verts 1970). Exact numbers of seals and sea lions killed are unknown, but the programs were apparently successful in controlling pinniped populations in both states. The programs ended by 1960 in Washington and by 1970 in Oregon.

A contention of those in favor of pinniped population control is that reducing the number of seals and sea lions will increase the number of fish available to commercial fishers. Butterworth (1992) states that there is no scientific evidence that this contention is true. In fact, he suggests that reduction of pinniped numbers may increase the population of other predators of commercial fish, thus reducing the population of the commercial fish because predatory fish are greater consumers of fish than marine mammals or sea birds. For example, South African Cape fur seals feed on both anchovy and squid, and if the fur seal population were reduced, the squid population which also consumes anchovies would increase and cause a reduction in anchovies available to the fishery (Butterworth et al. 1988). In another example, because Pacific harbor seals and California sea lions are predators of lamprey, decreasing the seal and sea lion population could increase the lamprey population. Lampreys are parasites which can affect both growth and survival of salmonids; consequently, pinnipeds may benefit certain salmonid populations by limiting the lamprey population (Jameson and Kenyon 1977). DeMaster and Sisson (1992) note that the recruitment rate of most fish stocks is quite variable and that this has a much greater effect on determining stock abundance than predation.

CONCLUSIONS

The California sea lion and Pacific harbor seal populations in Washington, Oregon, and California are healthy, robust, and increasing. In contrast, most salmonid populations on the West Coast have declined significantly or are currently declining at significant rates. The Working Group found that concerns over the negative impacts of predation, particularly by pinniped populations that co-occur with depressed salmonid populations, are justified based on intense studies in some situations, such as California sea lion predation on winter steelhead at the Ballard Locks where California sea lions have had a significant negative impact on the recovery of a small salmonid population. However, for most sites of co-occurrence of pinniped and salmonid populations, the Working Group found there is insufficient information to determine whether the pinnipeds are currently having a significant impact on the salmonid populations. Of particular concern are areas where pinnipeds may be impacting salmonid populations that are listed or proposed for listing under the ESA. In spite of the lack of much directed research on pinniped impacts on salmonids, the Working Group found that existing information is sufficient to determine that pinnipeds can affect the recovery of depressed salmonid populations in areas of co-occurrence.

The Working Group found that much of the information from past studies on pinniped-salmonid interactions was inadequate to estimate consumption and impacts on most salmonid populations. Studies of food habits of seals and sea lions show that the occurrence of salmonids varies among food habits samples, depending on when and where the studies were conducted, what kind of samples were taken, and how the samples were analyzed. One of the major problems with interpreting the existing food habits data is that few of the studies were designed to directly assess impacts of predation on specific salmonid populations. It is clear, however, that where salmonid populations are at low levels, and particularly where salmonid passage is restricted by man-made structures, such as at the Ballard Locks, pinniped predation can affect salmonid stocks. Even in areas without man-made passage constrictions, pinniped predation on small salmon runs can be substantial, such as harbor seal predation on 46% of the fall chinook run in the Puntledge River estuary in British Columbia. The predation issue that has received the most attention concerns adult salmonids returning to spawn. Nonetheless, reducing predation on juvenile salmonids, which is more difficult to observe and quantify, may be just as important a factor in reversing declining trends in some salmonid stocks. The Working Group concluded that additional research is needed to fully address the issue of impacts of pinnipeds on salmonid populations.

The Working Group identified three categories of concern for pinniped-salmonid interactions on the West Coast.

1. Areas where there are known impacts from pinniped predation on one or more salmonid populations.

   The Ballard Locks is the only area where adequate research has been conducted to determine that pinniped predation has had a significant impact on the recovery of a salmonid population. There has been insufficient research to place any other specific rivers, creeks, or estuary systems in this category.

2. Areas where there is potential for impacts on salmonids and where studies are needed to quantify the level of impact on one or more salmonid populations.

   Various rivers in Puget Sound, Lower Columbia River, Willamette River, Nehalem River, Tillamook Bay, Siletz Bay, Alsea Bay, Umpqua River, Rogue River, Klamath River, Russian River, San Lorenzo River, and Scott Creek fall under this category.

3. Areas with depressed or significantly declining salmonid stocks where there is insufficient information to determine whether there could be impacts on salmonid populations.

Hood Canal, Strait of Juan de Fuca, Eastern Bays in Washington, coastal rivers/bays in Oregon, Smith River, Mad River, Eel River, Noyo River, Pajaro River, Carmel River, Salinas River, Big Sur River, Little Sur River, Santa Ynez River, and San Francisco Bay/Central Valley in California fall under this category.

The Working Group could not determine to what degree the increased presence of pinnipeds and increased biomass consumption affects ecosystems because of the complexity of ecosystems and the limited knowledge of how they function. However, it is reasonable to assume that increasing numbers of pinnipeds are consuming an increasing number of prey composed of a variety of species. The Working Group estimated total biomass consumption along the coasts of Washington, Oregon, and California (minimum of about 217,400 t) and found that it amounted to almost half of what is harvested in commercial fisheries. The Working Group found no direct evidence of pinniped-related declines in non-salmonid fish stocks, but there is concern about pinniped removal of significant amounts of fishery resources. For example, Pacific whiting in Puget Sound, eulachon in the Columbia River, and anchovy in southern California are non-salmonid populations that also have declined and are the principal prey of pinnipeds in the area, raising concerns that pinniped predation may impact recovery of these fish stocks.

The Working Group concluded that the increased number of pinnipeds coastwide has brought new problems and issues that must be addressed. The Working Group found that California sea lions and Pacific harbor seals are interacting with many commercial and recreational fisheries on the West Coast. There are also numerous instances of conflicts, primarily with California sea lions, at docks and marinas that raise human safety concerns. In all three states, reports of pinnipeds removing salmonids and other fish from fishing gear and damaging gear have increased. There are no recent, comprehensive assessments of the full degree of human interactions with pinnipeds on the West Coast nor coastwide estimates of economic losses due to pinniped conflicts with commercial and recreational fisheries. Mitigation measures that have been used to reduce or eliminate pinniped predation on salmonids or minimize interactions with fisheries have limited or short-term effectiveness. Development of new technologies and techniques is needed to effectively deter pinnipeds from fishery conflicts and from marinas where human safety issues arise. In particular, resource managers and the public must find solutions that conserve all species in the ecosystems, especially those that are severely depressed or listed under the ESA, while allowing optimum yield for healthy living marine resources.

RESEARCH NEEDS

Conservation of salmonid populations is a critical issue on the West Coast. To assess impacts of California sea lions and harbor seals on depressed salmonid stocks and other fish stocks and take appropriate action with pinnipeds where necessary to conserve salmonids, an extensive field research and management program must be designed to specifically address this problem. Research programs should include the following elements:

1. Conduct coastwide survey efforts to determine seasonal distribution and abundance of California sea lions and harbor seals in areas where salmonids are present. The surveys must cover the periods of both smolt and adult migration in each area and should also determine what proportion

of the pinniped population present is involved in salmonid predation. This information would identify all areas where there is potential for substantial predation and focus future research on those areas.

2. Conduct pinniped food habits and mitigation studies in areas identified as having a significant level of co-occurrence of salmonids and pinnipeds. Food habits studies should occur during the salmonid runs. Sampling methods and methods of prey identification must ensure that salmonid remains are identified and consumption levels can be quantified. Studies may involve collection of pinnipeds to quantify salmonid consumption levels. Research should focus on sites where the effects of predation can be determined.
3. Develop methods to identify salmonid hard parts according to species. At present, vertebrae can be used to easily distinguish salmonids from other fish, and some preliminary work has been done to separate steelhead smolt from other salmonids. Further research needs to be done to identify diagnostic characteristics of hard parts for each salmonid species for both adults and juveniles.
4. Determine adult salmonid mortality due to wounds inflicted by pinnipeds during spawning migration. The correlation between scarring and predation is unknown, nor is it known if wounded salmonids have a higher mortality rate or a lower reproductive capacity than non-wounded salmonids.
5. Develop a working model for pinniped consumption estimates. The model should take into account annual and seasonal changes in abundance of predators (fish and marine birds as well as marine mammals) and prey, and annual and seasonal changes in caloric density of prey species. Other sources of natural mortality on prey should be included in the model.
6. Conduct foraging behavior studies of subadult and adult male California sea lions with instrumented animals to document migratory rates, time spent foraging or on land, and foraging areas (geographically and in the water column). This information can be used to estimate consumption of salmonids and other prey species by California sea lions throughout the migration area.
7. Determine if pinniped predation is affecting the recovery of non-salmonid fish stocks (e.g., Pacific whiting in Puget Sound and eulachon in the Columbia River).

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APPENDIX A. INFORMATION ON STELLER SEA LIONS

The Steller sea lion (*Eumetopias jubatus*) is not considered in the main part of this report because the focus of the investigation, as stipulated in Section 120(f) of the MMPA, is Pacific harbor seals and California sea lions. However, since the term "sea lion" could apply to either Steller or California sea lions on the West Coast, this Appendix was prepared to provide the reader with relevant background information on Steller sea lions (also called northern sea lions).

The Steller sea lion is listed as threatened under the ESA throughout its range. NMFS recently proposed to reclassify the Steller sea lion population segment west of long. 144 W as endangered and maintain the remainder of the U.S. population as threatened (4 October, 1995 Federal Register Notice, 60 FR 51968). NMFS is proposing this change in classification because the western population segment, which declined by 70% between 1960 and 1989 (when the species was listed), has declined further with population decreases of 21% from 1990 to 1994. Although the eastern population has shown a stable to increasing trend for the last 15 years, NMFS is proposing to retain this population as threatened because the large decline in the overall population threatens the continued existence of the entire species.

Washington

Steller sea lions occur year-round but do not breed in Washington. The peak abundance is approximately 1,500 sea lions and appears to be stable, although not all surveys from 1988 to 1994 have been analyzed. Peak numbers occur in late summer, fall, and winter (Gearin and Scordino 1995). Steller sea lions haul-out at Split and Willoughby Rocks on the south Washington coast and at Carroll Island, Cape Alava, and Tatoosh Island on the north Washington coast. In 1992 and 1993, nursing pups were observed at Carroll Island and Cape Alava. These pups may have been born in Washington or may have migrated with their mothers from rookeries in British Columbia or Oregon.

Oregon

Steller sea lions are found year-round and have breeding rookeries at several sites. At least 10 haul-out sites are used on a regular basis, with reproductive activities occurring primarily at three sites. Recent counts of Steller sea lions in Oregon (3,000-3,500) have increased from counts made in the late 1970s (2,000-2,500). Annual peak counts occur during the June and July reproductive season. Winter counts range from 1,000 to 1,500 statewide. In 1994, 2,696 adults and juveniles and 423 pups were counted at the 2 major south coast rookeries (Rogue Reef and Orford Reef). Since pup counts from aerial surveys are generally 20-25% below comparable ground counts, true pup production in Oregon is estimated at 550-600 pups per year. An additional small number of pups (4-6) are born each year at Three Arch Rocks on the north coast. Steller sea lions marked as newborn pups on Rogue Reef have been resighted at various ages (6 months-5 years) at haul-out areas from northern California through Washington, British Columbia, southeast Alaska, and the eastern and central Gulf of Alaska.

California

Steller sea lions are found along the coast from Monterey Bay north and are known to breed at Año Nuevo Island, the Farallon Islands, and St. George Reef (off Crescent City). They were once found as far south as San Miguel Island, but no longer occur there. Steller sea lions have been declining by 85% or more since the 1960s (LeBoeuf et al. 1991, Westlake et al. in press). They were counted during the July breeding season at Año Nuevo Island in 1993, when approximately 450 Steller sea lions were recorded. From 1990-95, Steller sea lions at St. George Reef have numbered from 400-700 animals, with just over 100 pups born per year (ODFW unpubl. data). Overall, numbers of Steller sea lions in California have decreased. Current counts for other seasonal haul-out areas in California are not available.

Steller Sea Lion Food Habits

Food habits studies on Steller sea lions are shown below in Table A-1. In the Columbia River, Beach et al. (1985) identified prey of Steller sea lions as Pacific whiting, rockfish, eulachon, anchovy, herring, staghorn sculpin, and lamprey. In the Rogue River, surface feeding observations of Steller sea lions by Jameson and Kenyon (1977) and Roffe and Mate (1984) indicated lamprey and a small proportion (2%) of salmonids were primary prey. More recent observations of Steller sea lions foraging in the mouth of the Rogue River appear to indicate that salmonid consumption has increased (ODFW and

NMFS-AFSC unpubl. data). Steller sea lion scat samples collected from the south Oregon coast from 1986 to 1993 contained primarily Pacific whiting (84%) and lamprey (39%), with salmonids identified in 19% of the samples (Riemer and Brown 1996).

Table A-1. Summary of food habits studies of Steller sea lions in Oregon.

Area	Year	Sampling time period	n	Prey	Percent of samples*	Methods	Source
Columbia River	1980-81	year-round	9	Pacific whiting rockfish eulachon anchovy Pacific herring staghorn sculpin lamprey	33 22 11 11 11 11 11	gastrointestinal tracts from beachcast specimens - otoliths	Beach et al. 1985
Rogue River	1973-76	March - July		lamprey salmonids	87 2	observations (14.5 hours)	Jameson and Kenyon 1977
	1976-78	March - Aug		lamprey salmonids	27 2	observations	Roffe and Mate 1984
Rogue Reef and Orford Reef	1986-93	June - July		Pacific whiting lamprey salmonids	83 38 15	scats - otoliths and bones	ODFW data

* Percent of sample (scat, stomach, etc.) examined that contained the identified prey. This is not the percentage of that prey in the total diet. (n = number of samples)

APPENDIX B. DEFINITIONS OF STOCK STATUS CLASSIFICATIONS

Washington (from WDF et al. 1992)

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Critical Stock: A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

Oregon (from Oregon Department of Fish and Wildlife)

Healthy Stock: A population is classified as healthy if the available spawning habitat has generally been fully seeded and abundance trends have remained stable or increased over the last 20 years.

Special Concern: A population is classified as special concern if either the population is probably composed of 300 or fewer spawners, or a substantial risk exists for interbreeding between the population and stray hatchery fish at a level in excess of standards established by the Oregon Wild Fish Management Policy.

Depressed Stock: A population is classified as depressed if any one of the following have occurred: available spawning habitat has generally not been fully seeded, abundance trends have declined over the last 20 years, or abundance trends in recent years have been generally below 20-year averages.

California (from Nehlsen et al. 1991)

Special Concern: Populations for which: 1) relatively minor disturbances could threaten them, especially if a specific threat is known, 2) insufficient information on population trend exists, but available information suggests depletion, 3) there are relatively large ongoing releases of non-native fish, and the potential for interbreeding with the native population exists, and 4) the population is not presently at risk, but requires attention because of a unique character.

Moderate Risk of Extinction: Populations whose spawning escapements appear to be stable after previously declining more than natural variation would account for, but are above 200. Approximately one adult per spawner is returning to spawn.

High Risk of Extinction: Populations whose spawning escapements are declining. Fewer than one adult fish returns to spawn from each parent spawner. Populations having recent (within the past 1-5 years) escapements under 200, in the absence of evidence that they were historically small, also were placed in this category.

Endangered Species Act Classifications

Threatened: The term "threatened species" is defined as any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Endangered: The ESA defines the term "endangered species" as any species which is in danger of extinction throughout all or a significant portion of its range.

NMFS considers a variety of information in evaluating the level of risk faced by salmonids of an evolutionarily significant unit. Important considerations include 1) absolute numbers of fish and their spatial and temporal distribution, 2) current abundance in relation to historical abundance and carrying capacity of the habitat, 3) trends in abundance, based on indices such as dam or redd counts or on estimates of spawner-recruit ratios, 4) natural and human influences factors that cause variability in survival and abundance, 5) possible threats to genetic integrity (e.g., selective fisheries and interactions between hatchery and natural fish), and 6) recent events (e.g., a drought or a change in management) that have predictable short-term consequences for abundance of the ESU. Additional risk factors, such as disease prevalence or changes in life history traits, may also be considered in evaluating risk to populations.

APPENDIX C. DEFINITIONS OF TERMS USED TO DESCRIBE SALMONIDS

(Definitions reprinted from WDF et al. 1992)

Anadromous Fish: Species that hatch in fresh water and spend some portion of their life cycle there, migrate downstream to the ocean, mature in salt water, and return to fresh water to spawn.

Cultured Stock: A stock that depends upon spawning, incubation, hatching, or rearing in a hatchery or other artificial production facility.

Escapement: Adult fish that have survived all fisheries and will contribute to the spawning population.

Evolutionarily Significant Unit (ESU): A population (or group of populations) that 1) is reproductively isolated from other conspecific population units, and 2) represents an important component in the evolutionary legacy of the biological species.

Mixed Stock: A stock whose individuals originated from commingled native and non-native parents, and/or by mating between native and non-native fish (hybridization); or a previously native stock that has undergone substantial genetic alteration (Note: the term "mixed stock" has a different definition when used in describing commercial and sport fisheries).

Native Stock: An indigenous stock of fish that has not been substantially impacted by genetic interactions with non-native stocks or by other factors, and is still present in all or part of its original range. In limited cases, a native stock may also exist outside of its original habitat (e.g., captive broodstock programs).

Non-native Stock: A stock that has become established outside of its original range.

Salmonid: Any member of the family Salmonidae, which includes all species of salmon, trout, and char. This report addresses only Pacific salmon (chinook, chum, coho, pink, and sockeye) and steelhead and cutthroat trout in Washington, Oregon, and California.

Stock: The fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat, regardless of parentage (includes native).

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Appendix D Status of Wild Salmonid Populations by Region, Timing of the Outmigration of Smolts in the Estuaries, and Species and Numbers of Pinnipeds Present During Adult Salmonid Return Migration

Species	Run	Months of freshwater entry (peaks in caps)	State Status Designation[1]	Comments	Juvenile outmigrant months in estuary (peaks in caps)[2]	Pinnipeds present[3]	No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs
EASTERN BAYS, WASHINGTON							
Chinook	Spring	Apr-June	Mixed	See Appendix E for detail.	Apr, May, JUNE, July, Aug	HS; CSL; SSL	2,100 HS; all year; AUG; 38 haul-outs <5 CSL <5 SSL
	Summer	June-Aug	Depressed	Upper MS[4] and tribs. of Skagit: Healthy	Apr, May, JUNE, July, Aug	HS; SSL	
	Fall	Aug-Oct	Mixed	See Appendix E for detail.	Apr, May, JUNE, JULY, Aug	HS; CSL; SSL	
Chum	Fall	Nov-Jan	Healthy	Some runs Unknown; see Appendix E for detail.	Mar, APR, May	HS; CSL; SSL	
Coho	Fall	SEP, OCT, Nov, Dec	Mixed	See Appendix E for detail.	MAY, June	HS; CSL; SSL	
Pink	Summer	JULY, AUG, Sep, Oct	Healthy	Primarily odd year, except Snohomish River; Nooksack: Unknown	APR, MAY, June	HS; SSL	
Sockeye	Summer	Mid June-Aug	Critical		MAY, June	HS; SSL	
Steelhead	Summer	June-Oct	Mixed	Deer Creek: Critical; see Appendix E for detail.	Apr, MAY, June	HS; SSL	
	Winter	Oct-Apr	Mixed	See Appendix E for detail.	Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Fall	JULY, AUG, Sep	Unknown		Apr, MAY, June	HS; SSL	
PUGET SOUND, WASHINGON							
Chinook	Spring	Apr-June	Critical	White River	Apr, May, JUNE, JULY, Aug	HS; CSL; SSL	1,100 HS; all year; SEP; 17 haul-outs 1,200 CSL; Fall, Winter, Spring; FALL, SPRING; 35 haul-outs 20-50 SSL; all year; 10 haul-outs
	Sum/fall	June-Oct	Mixed	See Appendix E for detail.	Mar, Apr, May, JUNE, July	HS; SSL	
	Fall	Aug-Oct	Unknown		Mar, Apr, May, JUNE, July	HS; CSL; SSL	
Chum	Summer	Late Sep-Nov	Healthy		MAR, APR, May	HS; SSL	
	Fall	Nov-Jan	Healthy	Some runs Unknown; see Appendix E for detail.	Mar, APR, May	HS; CSL; SSL	
	Winter	Late Nov-March	Healthy		Mar, APR, May	HS; CSL; SSL	
Coho	Fall	Sep, OCT, Nov, Dec	Healthy	Some runs Depressed; see Appendix E for detail.	MAY, June	HS; CSL; SSL	
Pink	Summer	July, AUG, Sep	Healthy		APR, MAY, June	HS; SSL	
Sockeye	Summer	Mid June-Aug	Depressed	Lake Washington	MAY, June	HS; SSL	
Steelhead	Summer	Unknown	Healthy	Introduced, non-native	Apr, MAY, June	HS; SSL	

	Winter	Dec-May	Mixed	Lake Washington: Critical; see Appendix E for detail.	Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Fall	JULY, AUG, Sep	Unknown		Apr, MAY, June	HS; SSL	
HOOD CANAL, WASHINGTON							
Chinook	Sum/fall	June-Oct	Depressed	Skokomish: Healthy	Apr, May, JUNE, July, Aug	HS; SSL	1,200 HS; all year; OCT; 13 haul-outs 10-50 CSL; Fall, Winter, Spring; 2 haul-outs <10 SSL; in water
Chum	Summer	Late Sep-Nov	Critical	Rebounding; Union: Healthy	MAR, APR, May	HS; SSL	
	Fall	Nov-Jan	Healthy	Purdy and Weaver Cks: Unknown	Mar, APR, May	HS; CSL; SSL	
Coho	Fall	Mid Sep, OCT, mid Nov	Depressed	Some runs Healthy; see Appendix E for detail.	MAY, June	HS; CSL; SSL	
Pink	Summer	July, AUG, SEP, Oct	Healthy	Dosewallips Depressed	APR, MAY, June	HS; SSL	
Steelhead	Summer	Unknown	Unknown	Unresolved by state and tribes	Apr, MAY, June	HS; SSL	
	Winter	Dec-Mar	Mixed	Unresolved by state and tribes; see Appendix E for detail.	Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Fall	JULY, AUG, Sep	Depressed		Apr, MAY, June	HS; SSL	
Species	**Run**	**Months of freshwater entry (peaks in caps)**	**State Status Designation[1]**	**Comments**	**Juvenile outmigrant months in estuary (peaks in caps)[2]**	**Pinnipeds present[3]**	**No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs**
STRAIT OF JUAN de FUCA/SAN JUAN ISLANDS, WASHINGTON							
Chinook	Sp/sum	Apr-Aug	Critical		Apr, May, JUNE, July, Aug	HS; SSL	5,000 HS; all year; AUG; 167 haul-outs 50-100 CSL; fall, winter, SPRING; 2-3 haul-outs 50-100 SSL; all year; 2-3 haul-outs
	Sum/fall	June-Oct	Healthy		Apr, May, JUNE, July, Aug	HS; SSL	
	Fall	Aug-Oct	Depressed		Mar, Apr, May, JUNE, July	HS; CSL; SSL	
Chum	Summer	Late Sep-Nov	Critical		Mar, APR, May	HS; SSL	
	Fall	Nov-Jan	Unknown	East and West Twin, Pysht, Deep Creek: Healthy	Mar, APR, May	HS; CSL; SSL	
Coho	Fall	Mid Sep, OCT, mid Nov	Mixed	See Appendix E for detail.	MAY, June	HS; CSL; SSL	
Pink	Summer	Elwha: Aug, SEP early run: JULY-Aug late: Aug, SEPT, Oct	Critical	Elwha R. stock thought to be extinct; Dungeness R. 2 distinct runs: early and late summer; see Appendix E for detail.	APR, MAY, June	HS; SSL	
Steelhead	Summer	Unknown	Depressed		Apr, MAY, June	HS; SSL	
	Winter	Dec-Mar	Mixed	See Appendix E for detail.	Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Fall	JULY, AUG, Sep	Unknown		Apr, MAY, June	HS; SSL	

Species	Run	Months of freshwater entry (peaks in caps)	State Status Designation[1]	Comments	Juvenile outmigrant months in estuary (peaks in caps)[2]	Pinnipeds present[3]	No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs
WASHINGTON COAST							
Chinook	Spring	Apr-June	Healthy		Apr, May, JUNE, July	HS; CSL; SSL	2,900 HS; all year; JUNE; 48 haul-outs 200-500 CSL; fall, winter, spring; FALL, SPRING; 6 haul-outs 500-1,000 SSL; all year; SEP-APR; 11 haul-outs
	Sp/sum	Apr-Aug	Depressed	MS, NF, SF Hoh, Mt. Tom Creek, large tribs.: Healthy	Apr, May, JUNE, July	HS; SSL	
	Summer	June-Aug	Unknown	Sol Duc, Beaver, and Bear Creeks (Sol Duc): Healthy	Apr, May, JUNE, July	HS; SSL	
	Fall	Aug-Oct	Healthy	Raft, Moclips, Copalis: Unknown	May, JUNE, JULY, Aug	HS; CSL; SSL	
Chum	Fall	Nov-Jan	Unknown	Upper & Lower MS Quinault, major tribs.: Healthy	Mar, APR, May	HS; CSL; SSL	
Coho	Summer	Early Aug-mid Sep	Healthy	Sol Duc only summer coho in WA	MAY, June	HS; SSL	
	Fall	Sep, OCT, NOV, Dec	Unknown	Some runs Healthy; see Appendix E for detail.	MAY, June	HS; CSL; SSL	
Sockeye	Jan-Sep	Apr-July	Mixed	See Appendix E for detail.	MAY, June	HS; CSL; SSL	
Steelhead	Summer	May-Oct	Unknown	Upper MS Queets: Healthy	Apr, MAY, June	HS; SSL	
	Winter	Nov-Apr	Mixed	See Appendix E for detail.	Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Fall	JULY, AUG, Sep	Unknown		Apr, MAY, June	HS; SSL	
GRAYS HARBOR, WASHINGTON							
Chinook	Spring	Apr-June	Healthy		Apr, May, JUNE, July	HS	5,200 HS; all year; JUNE; 22 haul-outs
	Summer	June-Aug	Depressed		Apr, May, JUNE, July	HS	
	Fall	Aug-Oct	Healthy	MS, NF Johns, Elk: Unknown	May, JUNE, JULY, Aug	HS	
Chum	Fall	Nov-Jan	Healthy		Mar, APR, May	HS	
Coho	Fall	OCT, Nov, Dec	Healthy		MAY, June	HS	
Steelhead	Summer	May-OCT	Unknown		Apr, MAY, June	HS	
	Winter	Dec-May	Mixed	See Appendix E for detail.	Apr, MAY, June	HS	
Cutthroat	Fall	JULY, AUG, Sep	Unknown		Apr, MAY, June	HS	
Species	**Run**	**Months of freshwater entry (peaks in caps)**	**State Status Designation[1]**	**Comments**	**Juvenile outmigrant months in estuary (peaks in caps)[2]**	**Pinnipeds present[3]**	**No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs**
WILLAPA BAY, WASHINGTON							
Chinook	Early fall	Mid Aug-Sep	Depressed		May, JUNE, JULY, Aug	HS	3,800 HS; all year; JUNE;

	Fall	Aug-Oct	Healthy		May, JUNE, JULY, Aug	HS	13 haul-outs
Chum	Fall	Nov-Jan	Healthy		Feb, MAR, APR, May	HS	
Coho	Fall	Oct, NOV, Dec	Unknown		MAY, June	HS	
Steelhead	Winter	Dec-May	Healthy	Some runs Unknown; see Appendix E for detail.	Apr, MAY, June	HS	
Cutthroat	Fall	JULY, AUG, Sep	Depressed		Apr, MAY, June	HS	
LOWER COLUMBIA RIVER (Washington Tributaries below Bonneville Dam)							
Chinook	Spring	Apr-June	Healthy		Apr, MAY, June, Oct	HS; CSL; SSL	Columbia River totals= 1,000-3,000 HS; all year; WINTER; 12 haul-outs 300 CSL; Fall-spring; SPRING; 3 haul-outs 260 SSL; all year; 1 haul-out
	Fall	Aug-Oct	Healthy	SF Toutle (Cowlitz), Green (Toutle): Depressed	May, JUNE, JULY, Aug	HS; CSL; SSL	
Chum	Fall	Nov-Jan	Depressed	Hardy Creek: Healthy	Mar, APR, May	HS; CSL; SSL	
Coho	Fall	Aug, Sep, OCT, NOV, Dec	Depressed		MAY, June	HS; CSL; SSL	
Steelhead	Summer	May-Nov	Depressed	EF Lewis, MS, WF Washougal and tribs.: Unknown	Mar, Apr, MAY, June	HS; SSL	
	Winter	Dec-Apr	Mixed	See Appendix E for detail.	Mar, Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Fall	JULY, AUG, Sep	Depressed		Apr, MAY, June	HS; SSL	
LOWER COLUMBIA RIVER (Oregon Tributaries below Bonneville Dam)							
Chinook	Spring	Apr-June	Depressed		Apr, MAY, June, Oct	HS; CSL; SSL	Columbia River totals= 1,000-3,000 HS; all year; WINTER; 12 haul-outs 300 CSL; Fall-spring; SPRING; 3 haul-outs 260 SSL; all year; 1 haul-out
	Fall	Aug-Oct	Depressed		May, JUNE, JULY, Aug	HS; CSL; SSL	
Chum	Fall		Extirpated		Mar, APR, May	HS; CSL; SSL	
Coho	Fall	Sep, OCT, Nov, Dec	Depressed	Clackamas Healthy	MAY, June	HS; CSL; SSL	
Steelhead	Winter	Late Feb-mid June	Depressed		Mar, Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Fall	JULY, AUG, Sep	Depressed		Apr, MAY, June	HS; SSL	

Species	Run	Months of freshwater entry (peaks in caps)	State Status Designation[1]	Comments	Juvenile outmigrant months in estuary (peaks in caps)[2]	Pinnipeds present[3]	No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs
COLUMBIA RIVER (Above Bonneville Dam; Washington tributaries and main stem except Snake River)							
Chinook	Spring	Apr-June	Depressed		Apr, MAY, June		No pinnipeds inhabit above the Bonneville Dam.
	Summer	June-Aug	Depressed	Wenatchee: Healthy	May, JUNE, JULY, Aug		
	Early fall	Aug-Sep	Depressed	Klickitat: Healthy	May, JUNE, JULY, Aug		
	Late fall	Sep-Oct	Healthy		May, JUNE, JULY, Aug		
Coho	Fall		Extirpated				
Sockeye	Summer	Mid June, JULY, mid Aug	Healthy		MAY, June		
Steelhead	Summer	Late Aug-May	Depressed		Apr, MAY, JUNE		
	Winter	Unknown	Depressed	Wind, Klickitat, tribs.: Unknown	Apr, MAY, June		

COLUMBIA RIVER (Above Bonneville Dam; Oregon tributaries and main stem except Snake River)							
Chinook	Spring	Mar, APR, June	Depressed	Hood, Umatilla, and Walla Walla Rivers: Extirpated	Apr, MAY, June		No pinnipeds inhabit above the Bonneville Dam.
	Late fall (Bright)	Aug, SEP, Oct	Depressed	Healthy in Deschutes	June, JULY, AUG, Sep		
Coho	Fall		Extirpated				
Steelhead	Summer	July, AUG, SEP- Nov	Depressed		Apr, MAY, JUNE		
	Winter	Nov-MAR, Apr	Depressed		Apr, MAY, June		
SNAKE RIVER							
Chinook	Sp/sum	Apr, MAY, JUNE-Aug	Critical	ESA: Threatened	Apr, MAY, June		No pinnipeds inhabit above the Bonneville Dam.
	Fall	Aug, SEP, Oct	Critical	ESA: Threatened	May, JUNE, JULY, Aug		
Sockeye	Summer	Mid July-mid Sep	Critical	ESA: Endangered	MAY, June		
Steelhead	Summer	June-AUG, SEP, Nov	Depressed		Apr, MAY, June		
Species	**Run**	**Months of freshwater entry (peaks in caps)**	**State Status Designation[1]**	**Comments**	**Juvenile outmigrant months in estuary (peaks in caps)[2]**	**Pinnipeds present[3]**	**No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs**
NORTH OREGON COAST (Columbia River to Cape Blanco except Umpqua River)							
Chinook	Spring	Apr, MAY, June	Mixed	See Appendix E for detail.	June-Nov; JULY-AUG	HS; CSL; SSL	3,500 HS; all year; SUMMER; 35 haul-outs 4,880 CSL; late summer to late spring; FALL; 4 haul-outs; multiple in-water resting areas 1,100 SSL; all year; SPRING-SUMMER; 5 haul-outs
	Fall	Aug, SEP- NOV, Dec	Healthy	Some runs Unknown; see Appendix E for detail.	June-Nov; JULY-AUG	HS; CSL; SSL	
Chum	Fall	NOV-Jan	Special Concern		Mar, APRIL, May	HS; CSL; SSL	
Coho	Fall/w	OCT, NOV, Dec	Depressed	Coquille and Coos Rivers Healthy	Mar, Apr, MAY, June	HS; CSL; SSL	
Steelhead	Summer	May-Sep	Depressed		Apr, MAY, June	HS; SSL	
	Winter	Oct-Mar	Depressed	Coquille River: Healthy; Necanicum: Sp. Concern	Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Sum/fall	Unknown	Depressed		July-Oct; APR-JUNE	HS; CSL; SSL	
TILLAMOOK BAY, OREGON							
Chinook	Spring	Apr, MAY, JUNE	Special Concern	Low numbers, declining	June-Nov; JULY-AUG	HS; CSL; SSL	670 HS; all year; SUMMER; 7 haul-outs 40 CSL; fall-spring; FALL; 1 haul-out 440 SSL; all year; SUMMER; 1 haul-out
	Fall	Aug, SEP-NOV, Dec	Healthy		June-Nov; JULY-AUG	HS; CSL; SSL	
Chum	Fall	NOV-Dec	Special Concern		Mar-May	HS; CSL; SSL	
Coho	Fall	Oct, NOV, DEC, Jan	Depressed	Significant Concern	Mar-June	HS; CSL; SSL	
SOUTH OREGON COAST (Cape Blanco to California border, except Rogue River)							
Chinook	Fall	Sep-NOV, DEC	Depressed		June-Nov; JULY-AUG	HS; CSL; SSL	940 HS; all year; SUMMER; 20 haul-outs 1,200 CSL; fall-spring; FALL; 3 haul-outs 2,700 SSL; all year; SUMMER; 3 haul-outs
Coho	Fall/w	Unknown; probably similar to other Oregon fish	Depressed		Mar, Apr, MAY, June	HS; CSL; SSL	
Steelhead	Winter	Dec-Mar	Depressed	Winchuck River: Healthy	Apr, MAY	HS; CSL; SSL	
Cutthroat	Sum/fall	Unknown	Depressed		Apr-Oct	HS; CSL; SSL	

Species	Run	Months of freshwater entry (peaks in caps)	State Status Designation[1]	Comments	Juvenile outmigrant months in estuary (peaks in caps)[2]	Pinnipeds present[3]	No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs
UMPQUA RIVER, OREGON							
Chinook	Spring	Apr, MAY-July	Mixed	N. Fork: Healthy; S. Fork: Depressed	June-Nov; JULY-AUG	HS	950 HS; all year; SUMMER; 3 haul-outs <10 CSL; occasionally
	Fall	Aug-Oct	Healthy		June-Nov; JULY-AUG	HS	
Coho	Fall/w	OCT-Dec	Depressed	N. Fork: Special Concern	Mar, Apr, MAY, June	HS	
Steelhead	Summer	May-Oct	Healthy	N. Fork: Healthy	Mar, Apr, MAY	HS	
	Winter	Nov-Apr	Depressed	N. Fork: Healthy	Mar, Apr, MAY	HS	
Cutthroat	Sum/fall	late JUNE-Jan	Endangered	ESA: Endangered	Apr, MAY, June	HS	
ROGUE RIVER, OREGON							
Chinook	Spring	Mar-MAY, JUNE	Healthy		June-Nov; JULY-AUG	HS; CSL; SSL	340 HS; all year; SUMMER; 3 haul-outs 470 CSL; fall-spring; FALL; 3 haul-outs 1,800 SSL; all year; SUMMER; 3 haul-outs
	Fall	July-SEP, Oct	Healthy	Lower Rogue tribs.: Depressed	June-Nov; JULY-AUG	HS; CSL; SSL	
Coho	Fall/w	Sep, OCT, Nov	Depressed		Mar, Apr, MAY, June	HS; CSL; SSL	
Steelhead	Summer	May, JUNE-AUG-Oct	Depressed		Apr, MAY, June	HS; SSL	
	Winter	Nov-Apr	Healthy	Illinois River: Depressed	Apr, MAY, June	HS; CSL; SSL	
Cutthroat	Sum/fall	unknown	Depressed		July-Oct; APR-JUNE	HS; CSL; SSL	
SMITH RIVER, CALIFORNIA							
Chinook	Spring	Apr-June	HRE		Mar, APR, May, June, July	HS; CSL	770 HS; all year; SUMMER; 10 haul-outs 2,260 CSL; fall-spring; SPRING
	Fall	Aug-Oct	MRE		Mar, Apr, MAY, June, July	HS; CSL	
Coho	Fall	DEC, Jan, Feb	MRE		Apr-MAY	HS; CSL	
Steelhead	Summer	June-Oct	HRE		Jan, Feb, Mar, Apr, MAY, June	HS	
Cutthroat			MRE			HS; CSL	
Species	**Run**	**Months of freshwater entry (peaks in caps)**	**State Status Designation[1]**	**Comments**	**Juvenile outmigrant months in estuary (peaks in caps)[2]**	**Pinnipeds present[3]**	**No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs**
KLAMATH RIVER, CALIFORNIA							
Chinook	Spring	Apr-June	HRE		Mar, APR, May, June, July	HS; CSL	440 HS; SUMMER; 119 haul-outs 90 CSL; SPRING 14 haul-outs
	Fall	Mid July-mid Sep	MRE	Shasta River: HRE; Scott River: Special Concern	Mar. APR, MAY, June, July	HS	
Chum			Extinct				
Coho	Fall	Sep, Oct, NOV, DEC	Special Concern		Mar, Apr, MAY, June, July	HS	
Pink			Extinct				
Steelhead	Summer	Apr-Aug	MRE	Redwood Creek: HRE	Dec-June; APR	HS	
	Winter	Sep-Oct	Unknown		Dec-June; APR		
CAPE MENDOCINO, CALIFORNIA							

Chinook	Fall	Sep-Nov	MRE	Decreasing; Minor Humbolt tribs., HRE	late Jan, Feb, Mar, APR, MAY, June,-mid July	HS; CSL	2,240 HS; all year; 50 haul-outs 1,300 CSL; fall-spring, SPRING & FALL; 15 haul-outs
Coho	Fall	Oct, NOV, DEC, Jan, Feb	MRE		Mar, Apr, May, JUNE, July, Aug	HS; CSL	
Steelhead	Summer	Mar-July	HRE (Mad River)	Eel River: MRE; Decreasing	Dec, Jan, Feb, Mar, APR, May, June	HS	
	Winter	Oct-Apr	Unknown	Decreasing	Dec, Jan, Feb, Mar, APR, May, June	HS; CSL	
NORTH COAST, CALIFORNIA							
Chinook	Fall	Sep-Oct	HRE	Decreasing	Apr, May, June	HS; CSL	5,260 HS; all year; 37 haul-outs 2,100 CSL; fall-spring; FALL & SPRING; 40 haul-outs
Coho	Fall	DEC, JAN, Feb	MRE	Decreasing	Mar, Apr, MAY, June	HS	
Pink			Extinct (?)	Unknown if Pink salmon were ever found this far south			
Steelhead	Winter	Nov-Mar	HRE	Decreasing		HS	
Species	**Run**	**Months of freshwater entry (peaks in caps)**	**State Status Designation[1]**	**Comments**	**Juvenile outmigrant months in estuary (peaks in caps)[2]**	**Pinnipeds present[3]**	**No. of pinn. in area (counts); months in area (peaks in caps); no. of haul-outs**
SAN FRANCISCO BAY, CALIFORNIA							
Chinook	Spring	May-July	HRE	Decreasing; some runs already Extinct; Sacramento, Yuba: MRE	Nov, Dec, JAN, FEB, Mar, Apr, May	HS; CSL	4,900 HS; all year; SUMMER 118 haul-outs 3,000 CSL; all year, FALL; 7 haul-outs
	Sp/sum	Mar-Oct	Extinct				
	Fall	Aug-Sep	Special Concern	Decreasing	Dec, Jan, Feb, Mar, Apr, May, June	HS; CSL	
	Winter	Dec-Jan	Endangered	Decreasing; Some runs already Extinct	July, Aug, SEPT, OCT, Nov, Dec, Jan, Feb, Mar	HS; CSL	
Chum			Extinct				
Coho	Fall	Nov, DEC, JAN, Feb	Mixed	See Appendix E for detail.	Mar, Apr, MAY, June	HS; CSL	
Pink			Extinct				
Steelhead	Winter	Oct-Apr	HRE	Some already Extinct		HS; CSL	
MONTEREY BAY, CALIFORNIA							
Coho	Fall	Mar, Apr, MAY, June	Unknown			HS; CSL	2,850 HS; all year 26 haul-outs 8,120 CSL; all year; FALL; 26 haul-outs
Steelhead	Winter	Nov-Apr	HRE (Carmel River)	Salinas River: MRE; Decreasing		HS; CSL	
CENTRAL COAST, CALIFORNIA							
Steelhead	Winter	Nov-Mar	HRE (Santa Ynez River)	Big and Little Sur Rivers: Special Concern; Decreasing		HS; CSL	3,060 HS; all year; 9 haul-outs 2,330 CSL; all year; SUM/FALL; 26 haul-outs
SOUTHERN CALIFORNIA BIGHT							
Steelhead	Winter	Sep-Mar	HRE	Some runs already Extinct		HS; CSL	3,820 HS; all year; 112 haul-outs >90,000 CSL; all year; SUMMER; 4 rookeries

1. Status classifications differ by state. See definitions listed in Appendix B.

HRE = High Risk of Extinction; MRE = Moderate Risk of Extinction.

2. Months in all capitals have the highest number of smolts in the estuaries.
3. HS = Pacific harbor seal; CSL = California sea lion; SSL = Stellar sea lion.
4. MS = Main Stem; NF = North Fork; SF = South Fork; MF = Middle Fork.

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Appendix E. Status of wild salmonid populations by species and region based on classification system of each state (except cutthroat trout). Regions are listed from north to south.

Region	Drainage	Sub-basin/spawning area	Species	Run	State status designation
WASHINGTON STATE					
Eastern Bays	Nooksack	NF, SF	Chinook	Spring	Critical
Eastern Bays	Nooksack	MS	Chinook	Fall	Unknown
Eastern Bays	Nooksack	NF, large tribs.	Chum	Fall	Healthy
Eastern Bays	Nooksack	MS and tribs., SF	Chum	Fall	Unknown
Eastern Bays	Nooksack	MS, NF, SF, MF	Coho	Fall	Unknown
Eastern Bays	Nooksack	NF and tribs., MF, SF	Pink	Odd year	Unknown
Eastern Bays	Nooksack	SF	Steelhead	Summer	Unknown
Eastern Bays	Nooksack	MS, NF and tribs., MF and tribs., SF	Steelhead	Winter	Unknown
Eastern Bays	Samish	MS	Chinook	Fall	Unknown
Eastern Bays	Samish	MS	Chum	Fall	Healthy
Eastern Bays	Samish	MS, all tribs.	Coho	Fall	Healthy
Eastern Bays	Samish	MS, Friday Ck	Steelhead	Winter	Depressed
Eastern Bays	N. Sound Creeks	Dakota, California, Chuckanut, Oyster, Colony-Whitehall	Chum	Fall	Healthy
Eastern Bays	N. Sound creeks	Dakota, California, Terrell, Fingalson, Lummi, Padden, Oyster, Colony-Whitehall	Coho	Fall	Unknown
Eastern Bays	N. Sound creeks	Dakota	Steelhead	Winter	Unknown
Eastern Bays	Skagit	Suiattle (Sauk)	Chinook	Spring	Depressed
Eastern Bays	Skagit	Upper Sauk	Chinook	Spring	Healthy
Eastern Bays	Skagit	Upper Cascade	Chinook	Spring	Unknown
Eastern Bays	Skagit	Upper MS, tribs.	Chinook	Summer	Healthy
Eastern Bays	Skagit	Lower Sauk	Chinook	Summer	Depressed
Eastern Bays	Skagit	Lower MS, tribs.	Chinook	Fall	Depressed
Eastern Bays	Skagit	MS and tribs., Sauk	Chum	Fall	Healthy
Eastern Bays	Skagit	Lower MS tribs.	Chum	Fall	Unknown
Eastern Bays	Skagit	MS, all tribs.	Coho	Fall	Depressed
Eastern Bays	Skagit	Baker Lake tribs.	Coho	Fall	Unknown
Eastern Bays	Skagit	MS, large tribs.	Pink	Odd Year	Healthy
Eastern Bays	Skagit	Baker Lake artificial spawning beaches	Sockeye	Summer	Critical
Eastern Bays	Skagit	MS, NF, and SF Sauk; Cascade, Finney Ck	Steelhead	Summer	Unknown

Eastern Bays	Skagit	MS and tribs., Sauk	Steelhead	Winter	Healthy
Eastern Bays	Skagit	Cascade	Steelhead	Winter	Unknown
Eastern Bays	Stillaguamish	NF	Chinook	Summer	Depressed
Eastern Bays	Stillaguamish	MS, SF	Chinook	Fall	Depressed
Eastern Bays	Stillaguamish	NF, SF, Squire, Jim Cks	Chum	Fall	Healthy
Eastern Bays	Stillaguamish	MS, all tribs.	Coho	Fall	Depressed
Eastern Bays	Stillaguamish	Deer Ck	Coho	Fall	Unknown
Eastern Bays	Stillaguamish	MS, NF, SF, large tribs.	Pink	Unknown	Healthy
Eastern Bays	Stillaguamish	Deer Ck	Steelhead	Summer	Critical
Eastern Bays	Stillaguamish	SF, Canyon Ck	Steelhead	Summer	Unknown
Eastern Bays	Stillaguamish	MS, NF, SF; Pilchuck, Jim, Canyon Cks	Steelhead	Winter	Healthy
Eastern Bays	Whidbey Island	Various streams of S. Whidbey Island	Coho	Fall	Unknown
Eastern Bays	Snohomish	MS, tribs.	Chinook	Summer	Depressed
Eastern Bays	Snohomish	Wallace (Skykomish)	Chinook	Summer/Fall	Healthy
Eastern Bays	Snohomish	Pilchuck, Snoqualmie, Sultan (Skykomish), Woods and Elwell Cks (Skykomish)	Chinook	Fall	Depressed
Eastern Bays	Snohomish	NF, SF Skykomish; Bridal Veil Ck	Chinook	Fall	Unknown
Eastern Bays	Snohomish	Skykomish, Wallace (Skykomish)	Chum	Fall	Healthy
Eastern Bays	Snohomish	Snoqualmie, MS, SF Tolt (Snoqualmie)	Chum	Fall	Unknown
Eastern Bays	Snohomish	MS, Lower MS tribs.	Coho	Fall	Depressed
Eastern Bays	Snohomish	MS, NF, SF, Skykomish; Sultan and Wallace (Skykomish); Snoqualmie and tribs.	Coho	Fall	Healthy
Eastern Bays	Snohomish	MS, Snoqualmie, Skykomish, Sultan and Wallace (Skykomish)	Pink	Odd Year	Healthy
Eastern Bays	Snohomish	MS, Skykomish	Pink	Even year	Healthy
Eastern Bays	Snohomish	Tolt (Snoqualmie)	Steelhead	Summer	Depressed
Eastern Bays	Snohomish	NF Skykomish and tribs.	Steelhead	Summer	Unknown
Eastern Bays	Snohomish	SF Skykomish, Beckler Ck (Skykomish)	Steelhead	Summer	Healthy
Eastern Bays	Snohomish	MS, Pilchuck, Skykomish, Sultan, and Wallace (Skykomish); Snoqualmie, Tolt and Raging (Snoqualmie)	Steelhead	Winter	Healthy
Puget Sound	Lake Washington	EF Issaquah Cks (Sammamish)	Chinook	Summer/Fall	Healthy
Puget Sound	Lake Washington	Cedar, Swamp, North, Bear, Little Bear, and Cottage Lake Cks (Sammamish)	Chinook	Summer/Fall	Unknown
Puget Sound	Lake Washington	Cedar and tribs.	Coho	Fall	Healthy
Puget Sound	Lake Washington	All tribs. except Cedar	Coho	Fall	Depressed
Puget Sound	Lake Washington	Cedar, Big Bear, and Issaquah Cks (Sammamish), Lake Washington Beach	Sockeye	Summer	Depressed
Puget Sound	Lake Washington	All tribs.	Steelhead	Winter	Critical
Puget Sound	Duwamish	Green, Newaukum Ck (Green)	Chinook	Summer/Fall	Healthy

Puget Sound	Duwamish	MS Green	Chum	Fall	Unknown
Puget Sound	Duwamish	Crisp Ck (Green)	Chum	Fall	Healthy
Puget Sound	Duwamish	Green tribs. except Newaukum Ck	Coho	Unknown	Healthy
Puget Sound	Duwamish	Newaukum Ck (Green)	Coho	Unknown	Depressed
Puget Sound	Duwamish	MS Green and tribs.	Steelhead	Summer	Healthy
Puget Sound	Duwamish	MS Green and tribs.	Steelhead	Winter	Healthy
Puget Sound	Puyallup	White	Chinook	Spring	Critical
Puget Sound	Puyallup	White, South Prairie Ck (Carbon)	Chinook	Summer/Fall	Unknown
Puget Sound	Puyallup	Carbon, MS tribs., White tribs., Hylebos Ck	Chum	Fall	Unknown
Puget Sound	Puyallup	Fennel Ck	Chum	Fall	Healthy
Puget Sound	Puyallup	MS, all tribs. except White	Coho	Fall	Depressed
Puget Sound	Puyallup	White tribs.	Coho	Fall	Healthy
Puget Sound	Puyallup	MS, South Prairie Ck (Carbon)	Pink	Odd Year	Healthy
Puget Sound	Puyallup	MS, White, Clearwater, and Greenwater (White), Carbon, Voight, South Prairie Cks	Steelhead	Winter	Healthy
Puget Sound	East Kitsap	Grovers Ck (Miller Bay), Gorst Ck (Sinclair Inlet)	Chinook	Summer/Fall	Healthy
Puget Sound	East Kitsap	Blackjack Ck	Chum	Summer	Healthy
Puget Sound	East Kitsap	Liberty Bay tribs., Dyes Inlet tribs., Sinclair Inlet tribs., Ollala Ck, Gig Harbor tribs.	Chum	Fall	Healthy
Puget Sound	East Kitsap	All tribs.	Coho	Fall	Healthy
Puget Sound	East Kitsap	Miller Bay, Liberty Bay, Dyes Inlet, Sinclair Inlet, Yukon Harbor, Colvos Passage tribs.	Steelhead	Winter	Unknown
Puget Sound	Nisqually	MS, Mashel, Ohop Ck	Chinook	Summer/Fall	Healthy
Puget Sound	Nisqually	MS and tribs., McAllister, Mounts Cks	Chum	Winter	Healthy
Puget Sound	Nisqually	All tribs.	Coho	Fall	Healthy
Puget Sound	Nisqually	MS, Mashel, Ohop Ck	Pink	Odd year	Healthy
Puget Sound	Nisqually	MS, Mashel, Muck, Tanwax, Ohop Cks	Steelhead	Winter	Healthy
Puget Sound	Deep South Sound	Deschutes, Carr Inlet tribs., Chambers, and McAllister Cks	Chinook	Summer/Fall	Healthy
Puget Sound	Deep South Sound	Johns Ck (Hammersley Inlet), Coulter, and Sherwood Cks (Case Inlet)	Chum	Summer	Healthy
Puget Sound	Deep South Sound	Woodland, Woodard, and Adams Cks (Henderson Inlet)	Chum	Fall	Unknown
Puget Sound	Deep South Sound	Eld Inlet, Totten Inlet, Skookum Inlet, Hammersley Inlet, Case Inlet, Carr Inlet tribs	Chum	Fall	Healthy .
Puget Sound	Deep South Sound	Chambers Ck	Chum	Winter	Healthy
Puget Sound	Deep South Sound	Deschutes, Chambers Ck, all South Sound tribs.	Coho	Fall	Healthy
Puget Sound	Deep South Sound	Deschutes and tribs.	Steelhead	Winter	Healthy

Puget Sound	Deep South Sound	Perry, McLane Cks (Eld Inlet), Skookum, Kennedy, and Schneider Cks (Totten Inlet), Hammersly Inlet, Case Inlet, Carr Inlet tribs.	Steelhead	Winter	Unknown
Hood Canal	Hood Canal	Skokomish	Chinook	Summer/Fall	Healthy
Hood Canal	Hood Canal	Dosewallips, Duckabush, Hamma Hamma, Dewatto, Tahuya, Union	Chinook	Summer/Fall	Depressed
Hood Canal	Hood Canal	Quilcene, Dosewallips, Duckabush, Hamma Hamma, Dewatto, Tahuya	Chum	Summer	Critical
Hood Canal	Hood Canal		Chum	Summer	Healthy
Hood Canal	Hood Canal	All tribs. except Purdy and Weaver Cks (lower Skokomish)	Chum	Fall	Healthy
Hood Canal	Hood Canal	Purdy and Weaver Cks (lower Skokomish)	Chum	Fall	Unknown
Hood Canal	Hood Canal	All East Canal tribs., Union, Duckabush, Fulton Ck, all Dabob Bay tribs.	Coho	Fall	Depressed
Hood Canal	Hood Canal	Skokomish, Hamma Hamma, Dosewallips, SW Canal tribs.	Coho	Fall	Healthy
Hood Canal	Hood Canal	Dosewallips	Pink	Fall	Depressed
Hood Canal	Hood Canal	Hamma Hamma, Duckabush	Pink	Fall	Healthy
Hood Canal	Hood Canal	MS, NF, SF Skokomish, and tribs., Duckabush, Dosewallips	Steelhead	Summer	Unknown
Hood Canal	Hood Canal	Dewatto, Tahuya, MS, NF, SF Skokomish, and tribs., Duckabush, Dosewallips	Steelhead	Winter	Depressed
Hood Canal	Hood Canal	Hamma Hamma, Union, Quilcene, Little Quilcene, Tarboo Ck (Dabob Bay)	Steelhead	Winter	Unknown
SJI/SJF	San Juan Islands	Cascade Ck (Orcas Island)	Coho	Fall	Unknown
SJI/SJF	East Strait Tribs.	MS Dungeness, Gray Wolf (Dungeness)	Chinook	Spring/Summer	Critical
SJI/SJF	East Strait Tribs.	Elwha, Morse	Chinook	Summer/Fall	Healthy
SJI/SJF	East Strait Tribs.	Snow and Salmon Cks (Discovery Bay)	Chum	Summer	Critical
SJI/SJF	East Strait Tribs.	Jimmycomelately Ck (Sequim Bay)	Chum	Summer	Critical
SJI/SJF	East Strait Tribs.	Dungeness, Elwha, Morse, McDonald, Siebert, Bakley Cks	Chum	Fall	Unknown
SJI/SJF	East Strait Tribs.	Elwha, Chimacum Ck	Coho	Fall	Healthy
SJI/SJF	East Strait Tribs.	Snow, Salmon Cks (Discovery Bay)	Coho	Fall	Critical
SJI/SJF	East Strait Tribs.	Dungeness, Morse, McDonald, Siebert Cks, Jimmycomelately Ck (Sequim Bay)	Coho	Fall	Depressed
SJI/SJF	East Strait Tribs.	Upper MS, EF Dungeness, Gray Wolf (Dungeness)	Pink	Odd Year	Depressed
SJI/SJF	East Strait Tribs.	Lower MS Dungeness, Elwha	Pink	Odd year	Critical
SJI/SJF	East Strait Tribs.	Dungeness, Gray Wolf (Dungeness), Elwha	Steelhead	Summer	Depressed

SJI/SJF	East Strait Tribs.	Dungeness, Gray Wolf (Dungeness), Elwha, Morse, McDonald, Siebert Cks, Snow, and Salmon Cks (Discovery Bay)	Steelhead	Winter	Depressed
SJI/SJF	East Strait Tribs.	Jimmycomelately, Johnson, Gierin Cks (Sequim Bay)	Steelhead	Winter	Unknown
SJI/SJF	West Strait Tribs.	Hoko, Pysht, Clallam, Sekieu, Lyre	Chinook	Fall	Depressed
SJI/SJF	West Strait Tribs.	Lyre, Hoko, Clallam, Sekiu	Chum	Fall	Unknown
SJI/SJF	West Strait Tribs.	East and West Twin, Pysht, Deep Ck	Chum	Fall	Healthy
SJI/SJF	West Strait Tribs.	Hoko, Salt Ck	Coho	Fall	Healthy
SJI/SJF	West Strait Tribs.	Pysht, East and West Twin, Sekiu, Sail, Deep Ck.	Coho	Fall	Depressed
SJI/SJF	West Strait Tribs.	Lyre, Clallam	Coho	Fall	Unknown
SJI/SJF	West Strait Tribs.	Pysht, East and West Twin, Hoko, Little Hoko, Deep Ck	Steelhead	Winter	Healthy
SJI/SJF	West Strait Tribs.	Lyre, Clallam, Sekiu, Sail, Salt, Whiskey, Colville, Field Cks	Steelhead	Winter	Unknown
WA Coast	Mukkaw Bay	Sooes, Waatch	Coho	Fall	Unknown
WA Coast	Mukkaw Bay	Sooes and tribs., Waatch and tribs.	Steelhead	Winter	Unknown
WA Coast	Ozette	MS Big, Umbrella, and Crooked Cks	Chum	Fall	Unknown
WA Coast	Ozette	Lake Ozette tribs.	Coho	Fall	Unknown
WA Coast	Ozette	Lake Ozette beaches	Sockeye	Spring/Summer	Depressed
WA Coast	Ozette	MS, Big	Steelhead	Winter	Unknown
WA Coast	Quillayute	Sol Duc	Chinook	Spring	Healthy
WA Coast	Quillayute	Sol Duc, Beaver, and Bear Cks (Sol Duc)	Chinook	Summer	Healthy
WA Coast	Quillayute	MS, MS Bogachiel, MS, SF, and NF Calawah, Sitkum (Calawah)	Chinook	Summer	Unknown
WA Coast	Quillayute	MS, MS Bogachiel, Dicky, Sol Duc, Calawah, Sitkum (Calawah)	Chinook	Fall	Healthy
WA Coast	Quillayute	MS, MS Bogachiel, EF, WF Dicky, Sol Duc, Calawah, Sitkum (Calawah)	Chum	Fall	Unknown
WA Coast	Quillayute	Sol Duc, Bear, Camp and Beaver Cks (Sol Duc)	Coho	Summer	Healthy
WA Coast	Quillayute	MS Bogachiel, Dicky, Sol Duc, Calawah, tribs. of all	Coho	Fall	Healthy
WA Coast	Quillayute	Lake Pleasant Beaches (Sol Duc)	Sockeye	Spring/ Summer	Unknown
WA Coast	Quillayute	Upper Sol Duc, Upper Bogachiel, Upper MS, SF Calawah, Sitkum (Calawah)	Steelhead	Summer	Unknown
WA Coast	Quillayute	MS, MS Bogachiel, MS, EF, WF Dickey, MS Sol Duc, MS, NF, SF Calawah, Sitkum (Calawah), tribs. of all	Steelhead	Winter	Healthy
WA Coast	North Coast Creeks	Goodman, Mosquito, MS, EF, WF Kalaloch	Coho	Fall	Unknown

WA Coast	North Coast Creeks	Goodman, Mosquito, MS, EF, WF Kalaloch	Steelhead	Winter	Unknown
WA Coast	Hoh	MS, NF, SF, Mt. Tom Ck, large tribs.	Chinook	Spring/ Summer	Healthy
WA Coast	Hoh	MS, NF, SF, large tribs.	Chinook	Fall	Healthy
WA Coast	Hoh	MS	Chum	Fall	Unknown
WA Coast	Hoh	NF, SF, and tribs.	Coho	Fall	Healthy
WA Coast	Hoh	MS, SF, and tribs.	Steelhead	Summer	Unknown
WA Coast	Hoh	MS, SF, and tribs.	Steelhead	Winter	Healthy
WA Coast	Queets	MS, SaMS, MS Clearwater, Matheny Ck	Chinook	Spring/ Summer	Depressed
WA Coast	Queets	MS, Sams, Salmon, Matheny Ck, Clearwater and tribs., Snahapish (Clearwater), Solleks (Clearwater)	Chinook	Fall	Healthy
WA Coast	Queets	MS Clearwater, Salmon, Matheny Ck	Chum	Fall	Unknown
WA Coast	Queets	MS, Sams, Salmon, Matheny Ck, Clearwater and tribs., Snahapish and Solleks (Clearwater)	Coho	Fall	Healthy
WA Coast	Queets	Upper MS	Steelhead	Summer	Healthy
WA Coast	Queets	Upper Clearwater	Steelhead	Summer	Unknown
WA Coast	Queets	MS, Sams, Salmon, Matheny Ck, Clearwater and tribs; Snahapish and Solleks (Clearwater)	Steelhead	Winter	Healthy
WA Coast	Rafts	Unknown	Chinook	Fall	Unknown
WA Coast	Rafts	MS, NF, tribs.	Coho	Fall	Unknown
WA Coast	Rafts	MS, NF, tribs.	Steelhead	Winter	Unknown
WA Coast	Quinault	Upper and lower MS, NF	Chinook	Spring/ Summer	Depressed
WA Coast	Quinault	Upper and lower MS, NF, Cook Ck	Chinook	Fall	Healthy
WA Coast	Quinault	Upper and lower MS, major tribs.	Chum	Fall	Healthy
WA Coast	Quinault	Upper and lower MS, Cook Ck	Coho	Fall	Healthy
WA Coast	Quinault	Upper and lower MS, NF and tribs. Lower MS tribs.	Coho	Late Fall	Unknown
WA Coast	Quinault	Upper MS and tribs.	Sockeye	Spring/Summer	Healthy
WA Coast	Quinault	Upper MS, NF, tribs.	Steelhead	Summer	Unknown
WA Coast	Quinault	Upper and Lower MS	Steelhead	Winter	Healthy
WA Coast	South Coast tribs.	Moclips, Copalis	Chinook	Fall	Unknown
WA Coast	South Coast tribs.	Moclips, Copalis	Coho	Fall	Unknown
WA Coast	South Coast tribs.	Moclips	Steelhead	Winter	Healthy
WA Coast	South Coast tribs.	Copalis	Steelhead	Winter	Unknown
Grays Harbor	Humptulips	MS, EF, WF, Big, Stevens, Donkey, O'Brien, Newberry, Rainbow, and Grouse Cks	Chinook	Fall	Healthy
Grays Harbor	Humptulips	MS, EF, WF, Big, and Stevens Cks	Chum	Fall	Healthy
Grays Harbor	Humptulips	MS, EF, WF, all tribs.	Coho	Fall	Healthy
Grays Harbor	Humptulips	Upper reaches	Steelhead	Summer	Unknown
Grays Harbor	Humptulips	MS, EF, WF, tribs.	Steelhead	Winter	Healthy

Grays Harbor	Hoquiam	EF, WF	Chinook	Fall	Healthy
Grays Harbor	Hoquiam	Basin wide	Steelhead	Winter	Healthy
Grays Harbor	Chehalis	Upper MS, Skookumchuck, Newaukum	Chinook	Spring	Healthy
Grays Harbor	Chehalis	MS, EF Satsop	Chinook	Summer	Depressed
Grays Harbor	Chehalis	MS, Wishkah, MS Wynoochee, Carter, Schafer, and Helm Cks (Wynoochee),MS, MF, EF, WF Satsop, Black and Decker Cks (Satsop), Cloquallum, Porter Cks, Black, Skookumchuck	Chinook	Fall	Healthy
Grays Harbor	Chehalis	MS, Wishkah, MS Wynoochee, MS Satsop, EF Hoquiam, Black, Cloquallum Ck	Chum	Fall	Healthy
Grays Harbor	Chehalis	Upper MS, EF, WF, Wishkah, MS Wynoochee; Carter, Schafer, and Big Cks (Wynoochee), EF, MF, WF Satsop, tribs. of all	Coho	Fall	Healthy
Grays Harbor	Chehalis	Upper Wynoochee	Steelhead	Summer	Unknown
Grays Harbor	Chehalis	MS and all forks Satsop, Bingham Ck (Satsop), Skookumchuck, Newaukum	Steelhead	Winter	Depressed
Grays Harbor	Chehalis	MS and all forks, Wishkah, Wynoochee and tribs., Cloquallam Ck, tribs.	Steelhead	Winter	Healthy
Grays Harbor	South Harbor	MS, NF Johns, Elk	Chinook	Fall	Unknown
Grays Harbor	South Harbor	MS, NF, SF Johns, Elk, other tribs.	Coho	Fall	Healthy
Grays Harbor	South Harbor	Johns, Elk, Andrews Ck, other tribs.	Steelhead	Winter	Unknown
Willapa Bay	Willapa	MS North, Fall (North)	Chinook	Early Fall	Depressed
Willapa Bay	Willapa	North, Willapa, Palix, Nemah, Naselle	Chinook	Fall	Healthy
Willapa Bay	Willapa	Lower Salmon and Bitter Cks (North), SF Willapa and Wilson, Mill and Trap Cks, Canon (Palix), MF, NF Nemah, and Williams Ck, MS Naselle and Ellsworth, Dell, Davis, Bean, Cement, and Salmon Cks, Bear	Chum	Fall	Healthy
Willapa Bay	Willapa	North, Willapa, Palix, Nemah, Naselle, Bear, tribs. of all	Coho	Fall	Unknown
Willapa Bay	Willapa	Cedar, MS North, Smith Ck (North), Palix and Canon, Nawiakum and Bone Cks (Palix), NF, MF, SF Nemah, Williams Ck (Nemah), Bear	Steelhead	Winter	Unknown
Willapa Bay	Willapa	MS, SF Willapa, Wilson and Mill Cks Naselle, Salmon Ck (Naselle)	Steelhead	Winter	Healthy
Columbia River	Lower Columbia River, WA	Cowlitz, Kalama, NF Lewis	Chinook	Spring	Healthy
Columbia River	Lower Columbia River, WA	SF Toutle (Cowlitz), Green (Toutle)	Chinook	Fall	Depressed

Columbia River	Lower Columbia River, WA	Grays, Elochoman, Cowlitz, Coweeman (Cowlitz), Kalama, NF, EF Lewis, Abernathy, Germany Cks	Chinook	Fall	Healthy
Columbia River	Lower Columbia River, WA	MS, WF Grays, Crazy Johnson and Gorley Cks (Grays), Hamilton Ck	Chum	Fall	Depressed
Columbia River	Lower Columbia River, WA	Hardy Ck	Chum	Fall	Healthy
Columbia River	Lower Columbia River, WA	Grays, Elochoman, Cowlitz, Coweeman (Cowlitz), NF, SF Toutle (Cowlitz), Green (Toutle), Kalama, NF, EF Lewis Washougal, Skamokawa, Mill, Abernathy, Germany, Salmon, Duncan, Hardy, Hamilton, and Greenleaf Cks, tribs. of all	Coho	Fall	Depressed
Columbia River	Lower Columbia River, WA	Kalama and tribs., NF Lewis, Cedar Ck (NF Lewis)	Steelhead	Summer	Depressed
Columbia River	Lower Columbia River, WA	EF Lewis, MS, WF Washougal and tribs.	Steelhead	Summer	Unknown
Columbia River	Lower Columbia River, WA	Grays, Elochoman, Cowlitz, Coweeman (Cowlitz), MS, NF, Toutle (Cowlitz), Green (Toutle), NF, EF Lewis; Mill, Abernathy, Germany, and Salmon Cks	Steelhead	Winter	Depressed
Columbia River	Lower Columbia River, WA	SF Toutle (Cowlitz), Kalama	Steelhead	Winter	Healthy
Columbia River	Lower Columbia River, WA	MS, WF Washougal, Skamokawa, and Hamilton Cks	Steelhead	Winter	Unknown
Columbia River	Lower Columbia River, OR	Youngs, Lewis and Clark, Klaskanine, Clatskanie, Willamette, and Sandy Rivers and tribs., Big, Little, Bear, Plympton, Great, and Scappoose Cks	Chinook	Fall	Depressed
Columbia River	Lower Columbia River, OR	Willamette and tribs., Sandy River	Chinook	Spring	Depressed
Columbia River	Lower Columbia River, OR	Youngs, Lewis and Clark, Klaskanine, Clatskanie, Willamette, and Sandy Rivers and tribs., Big, Little, Bear, Great, Milton, Scappoose, and Tanner Cks	Coho	Fall	Depressed
Columbia River	Lower Columbia River, OR	Clatskanie and Clackamas Rivers	Coho Late	Fall	Depressed
Columbia River	Lower Columbia River, OR	Youngs, Lewis and Clark, Klaskanine, Clatskanie, Willamette, Sandy Rivers and tribs., Big, Little, Bear, Plympton, Great, Milton, Scappoose, and Tanner Cks	Steelhead	Winter	Depressed

Columbia River	Mid and upper Columbia River, WA	Wind, Klickitat, Upper Yakima, Naches and Little Naches (Yakima), American (Naches), Chiwawa (Wenatchee), Little Wenatchee, White (Wenatchee), Entiat, Methow, Twisp (Methow), Chewuch (Methow), Lost, Methow, Rattlesnake Ck (Naches), Nason Ck (Wenatchee)	Chinook	Spring	Depressed
Columbia River	Mid Columbia River, OR	Deschutes and John Day Rivers	Chinook	Spring	Depressed
Columbia River	Mid Columbia River, OR	Hood, Umatilla, and Walla Walla Rivers	Chinook	Spring	Extripated
Columbia River	Upper Columbia River, WA	Wenatchee	Chinook	Summer	Healthy
Columbia River	Upper Columbia River, WA	Methow, Okanogan, Similkameen (Okanogan)	Chinook	Summer	Depressed
Columbia River	Mid Columbia River, WA	Wind, lower White Salmon	Chinook	Early Fall (Tule)	Depressed
Columbia River	Mid Columbia River, WA	Klickitat	Chinook	Early Fall (Tule)	Healthy
Columbia River	Mid and upper Columbia River, WA	Wind, lower White Salmon, Klickitat, Yakima, Marion Drain (Yakima), Hanford Reach	Chinook	Late Fall (Bright)	Healthy
Columbia River	Mid Columbia River, OR	Deschutes River	Chinook	Fall	Healthy
Columbia River	Mid Columbia River, WA	Klickitat, Dofner Ck	Coho	Fall	Extirpated
Columbia River	Mid Columbia River, OR	Hood, Deschutes, John Day, Umatilla and Walla Walla Rivers	Coho	Fall	Extirpated
Columbia River	Upper Columbia River, WA	Little Wenatchee, White (Wenatchee), Okanogan	Sockeye	Summer	Healthy
Columbia River	Mid and upper Columbia River, WA	MS Wind, lower White Salmon, Walla Walla, Yakima, Wenatchee, Entiat, Methow, Okanogan and tribs. of all	Steelhead	Early Summer(A)	depressed
Columbia River	Mid Columbia River, WA	Klickitat, Rock Ck	Steelhead	Early Summer(A)	
Columbia River	Mid Columbia River, OR	Hood, Deschutes, John Day, Umatilla and Walla Walla Rivers	Steelhead	Summer	Depressed
Columbia River	Mid Columbia River, WA	Wind, Klickitat, tribs.	Steelhead	Winter	Unknown
Columbia River	Mid Columbia River, WA	Lower White Salmon	Steelhead	Winter	Depressed
Columbia River	Mid Columbia River, OR	Hood River and Fifteen Mile Ck	Steelhead	Winter	Depressed
Columbia River	Snake River, WA and ID	Tucannon, upper MS and tribs., Asotin Ck	Chinook	Spring/ Summer	
Columbia River	Snake River, OR	Grande Rhonde and Imnaha Rivers and tribs.	Chinook	Spring	Threatened

Columbia River	Snake River, WA	Toucannon, Paluose, Grande Rhonde, Upper MS and tribs.	Chinook	Fall	Threatened
Columbia River	Snake River	Snake River Basin	Chinook	Fall	Threatened
Columbia River	Snake River		Coho	Fall	Extirpated
Columbia River	Snake River	Redfish Lake	Sockeye	Summer	Endangered
Columbia River	Snake River, WA	Touchet, Toucannon, Grande Rhonde	Steelhead	Early Summer (A)	Depressed
Columbia River	Snake River, OR	Grande Rhonde and Imnaha Rivers and tribs.	Steelhead	Summer	Healthy
Columbia River	Snake River, WA and ID	Touchet, Toucannon, Grande Ronde, upper MS and tribs., Asotin Ck	Steelhead	Late Summer (B)	Depressed

1. MS = Main Stem, NF = North Fork, SF = South Fork, MF = Middle Fork, EF = East Fork, WF = West Fork.
2. SJI/SJF = San Juan Islands/Strait of Juan de Fuca

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Appendix F Summary of food habit studies of California sea lions in Washington, Oregon, and California Since 1970. Prey species noted are those which occurred in more than 10% of samples (except salmonids).

Area	Year	Sampling time period	n[1]	Prey	Percent of samples[2]	Methods	Source
Everett, WA	1979	May	9	Pacific whiting walleye pollock	unk unk	scat, spewings/otoliths	Everitt et al. 1981
	1986	April	100	Pacific whiting Pacific herring	88 26	scat, spewings/otoliths, bones	Gearin et al. 1988a
				salmonids	5		
	1987	Feb, May	48	Pacific whiting Pacific herring dogfish shark	92 50 15	scat, spewings/otoliths, bones	Gearin et al. 1988a
				salmonids	6		
Shilshole Bay, WA	1987	Feb to May	71	Pacific whiting squid Pacific herring dogfish shark	72 37 28 11	scat, spewings/otoliths, bones	Gearin et al. 1988a
				salmonids	25		
Puget Sound, WA	1988	Dec to March	106	Pacific whiting Pacific herring dogfish shark codfish	34 30 19 12	scat, spewings/otoliths, bones	NMFS/AFSC data[3]
				salmonids	21		
Columbia River	1980-81	Jan to June	16	eulachon anchovy lamprey Pacific herring Pacific tomcod sand sole	44 19 13 13 13 13	gastrointestinal tracts from beachcast sea lions/otoliths, bones, lenses, scales, flesh	Beach et al. 1985
				salmonids	13		
Area	**Year**	**Sampling time period**	**n[1]**	**Prey**	**Percent of samples[2]**	**Methods**	**Source**
Columbia River (continued)	1991-93	Jan to May (one October sample)	18	eulachon rockfish Pacific herring lamprey sand lance	61 22 17 17 11	gastrointestinal tracts from incidentally caught sea lions and beachcast specimens/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Brown et al. 1995
				salmonids	28		
East Mooring Basin, Columbia River	1992, 1993	March	110	salmonids	19	scat/otoliths, bones, teeth, lenses (for presence of salmonids only)	Riemer and Brown 1996
Cascade Head, OR	1994	February	82	mackerel smelt sardine cephalopods Pacific herring lamprey dogfish shark rockfish skate Pacific whiting sand lance anchovy	52 34 29 27 24 22 22 21 16 15 13 13	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
				salmonids	29		
		October	38	Pacific whiting mackerel jack mackerel Pacific herring cephalopod	74 66 37 32 11	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
				salmonids	8		

Area	Year	Sampling time period	n[1]	Prey	Percent of samples[2]	Methods	Source
Rogue River, OR	1976-78	Jan to June, Nov	86	salmonids	24	observations of actively feeding sea lions (86 observations)	Roffe and Mate 1984
	1978-79	March to May	28	lamprey	92	gastrointestinal tracts from collected animals/ otoliths, bones, teeth, flesh	Roffe and Mate 1984
				steelhead chinook	54 11		
Klamath River, CA	1978-79	Spring	1126	lamprey	96	observations of actively feeding sea lions (1126 observations)	Bowlby 1981
				salmonids	1		
		Apr, May, July	12	lamprey surf smelt eulachon	92 25 17	gastrointestinal tracts from beachcast sea lions/otoliths	
				salmonids	8		
		Apr, May	25	lamprey cephalopods Pacific whiting	52 16 16	scat/otoliths	
				salmonids	4		
Little Jackass Beach, CA	1980-82	Aug to Nov	24	Pacific whiting market squid Pacific herring	38 13 13	scat/otoliths, fish scales	J. B. Wexler, Humboldt State Univ., Arcata, CA. Pers. commun., April 1996.
Farallon Islands, CA	1974-78	Year-round	unk	Pacific whiting rockfish	unk unk	scat, spewings/otoliths only	Ainley et al. 1982
Año Neuvo Island, CA	1992	Summer, fall	115	Pacific whiting shortbelly rockfish market squid	47 53 52	scat/otoliths	NMFS/SWFSC data[4]
Area	**Year**	**Sampling time period**	**n[1]**	**Prey**	**Percent of samples[2]**	**Methods**	**Source**
San Francisco, CA, Pier 39	1993-94	Jan, Sep	76	Pacific herring spiny dogfish	common infrequent	scat/otoliths, bones, beaks Marine Mammal Center data	
				salmonid smolts	infrequent		
Channel Islands, CA	1981-93	Year-round	9513	market squid Pacific whiting shortbelly rockfish jack mackerel Pacific mackerel anchovy	common common common common common common	scat/otoliths	NMFS/SWFSC/ AFSC
				salmonids	trace		

1. n = number of samples
2. Percent of samples (scat, stomach, etc.) examined that contained the identified prey. This is not the percentage of that prey in the total diet. Only species that occurred in quantities equal to or greater than 10% were included in this table (except salmonids, which were reported at any level).
3. National Marine Fisheries Service/Alaska Fisheries Science Center
4. National Marine Fisheries Service/Southwest Fisheries Science Center

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Appendix G Summary of Food Habit Studies of Pacific Harbor Seals in Washington, Oregon, and California Since 1970. Prey species noted are those which occurred in more than 10% of samples (except salmonids).

Area	Year	Sampling time period	n[1]	Prey	Percent of samples	Methods	Source
So. Puget Sound, WA	1977	Unknown	unk	staghorn sculpin Pacific whiting	unk unk	scat/otoliths	Calambokidis et al. 1978
Nisqually River, WA	1988	March	21	Pacific Whiting Pacific tomcod flatfish walleye pollock plainfin midshipman shiner perch Pacific herring	76 62 38 28 24 19 19	scat/otoliths and bones	NMFS/AFSC data[3]
Gertrude Island, WA	1979	Summer, fall	101	Pacific Whiting plainfin midshipman shiner perch flatfish	unk unk unk unk	scat/otoliths	Everitt et al. 1981
	1994-95	Year-round	207	Pacific tomcod plainfin midshipman Pacific herring Pacific whiting market squid English sole shiner surf perch slender sole	54 39 39 32 28 22 16 11	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	WDFW data[4]
				salmonids	2		
Hood Canal, WA	1977-78	Apr to Oct	unk	Pacific whiting plainfin midshipman shiner perch blackfin sculpin walleye pollock	unk unk unk unk unk	scat/otoliths	Calambokidis et al. 1978
Area	**Year**	**Sampling time period**	**n[1]**	**Prey**	**Percent of samples[2]**	**Methods**	**Source**

Smith Island, WA	1977	July/August	unk	eel pout Pacific herring sand lance	unk unk unk	scat/otoliths	Calambokidis et al. 1978
Protection Island, WA	1978-79	Year-round	129	walleye pollock shiner perch Pacific herring flatfish	unk unk unk unk	scat/otoliths	Calambokidis et al. 1978
		Fall Winter		pink salmon steelhead	unk unk		
Everett, WA	1989 1995	Jan, Mar, Apr, Oct, Nov	142	Pacific Whiting Pacific herring	80 30	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	NMFS/AFSC data
				salmonids	2		
Grays Harbor, WA	1976-77	May to Sep, Feb, Mar	24	small crustaceans anchovy gadids	21 17 17	gastrointestinal tracts from collected seals/otoliths, flesh, scales	Johnson and Jeffries 1983
		Aug		salmonids	4		
	1980-82	Year-round	403	anchovy flatfish smelt sculpin small crustaceans gadids lamprey	28 27 22 21 18 17 13	scats/otoliths	Beach et al. 1985
		Jul, Aug June		steelhead chinook	3 <1		
		Apr to Nov	371	salmonids	10	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Reanalysis by Riemer and Brown 1996
Area	**Year**	**Sampling time period**	**n[1]**	**Prey**	**Percent of samples[2]**	**Methods**	**Source**
Grays Harbor, WA (continued)	1991-93	Summer/fall	10	smelt Pacific whiting anchovy	40 20 20	gastrointestinal tracts from seals caught in gillnets and beachcast specimens/ otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Brown et al. 1995
				salmonids	50		

Willapa Bay, WA	1980-82	Mar to Sep	211	flatfish anchovy sculpin surf perch crustaceans gadids lamprey Pacific herring	55 40 35 31 17 11 10 10	scat/otoliths	Beach et al. 1985
		Jun to Aug Aug		steelhead chinook	4 1		
		Jun to Sept	197	salmonids	28	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Reanalysis by Riemer and Brown 1996
	1991-93	Summer/fall	10	anchovy flatfish smelt Pacific herring gadids	30 30 30 20 20	gastrointestinal tracts from seals incidentally caught in gillnets and beachcast specimens/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Brown et al. 1995
				salmonids	20		
Area	**Year**	**Sampling time period**	**n[1]**	**Prey**	**Percent of samples[2]**	**Methods**	**Source**
Columbia River	1980-82	Year-round	436	whitebait smelt anchovy lamprey flatfish gadids staghorn sculpin eulachon	36 21 14 12 12 11 10	scat/otoliths, teeth, beaks, cartilaginous parts	Beach et al. 1985
		Apr-Aug		steelhead sockeye	<1 <1		
		Apr-Oct	342	salmonids	6	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Reanalysis by Riemer and Brown 1996
	1986-88	Winter	83	eulachon longfin smelt lamprey	100 14 10	gastrointestinal tracts from seals caught incidentally in gillnets and beachcast specimens/otoliths, flesh, whole fish	Brown et al. 1989
	1991-94	Oct to June (most in Feb)	61	eulachon	85	gastrointestinal tracts from seals taken incidentally in gillnets and beachcast specimens/otoliths, bones, teeth, lenses, cartilaginous parts	Brown et al. 1995
				salmonids	12		

Area	Year	Sampling time period	n[1]	Prey	Percent of samples[2]	Methods	Source
	1992-93	Feb to March	51	eulachon lamprey starry flounder	88 20 12	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Brown et al. 1995
	1994	Sep to Oct	36	northern anchovy Pacific herring smelt staghorn sculpin	50 44 25 19	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
				salmonids	39		
Columbia River (continued)	1995	April	67	staghorn sculpin starry flounder Pacific herring smelt lamprey prickleback	49 36 28 18 16 15	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
				salmonids	19		
			10	Pacific herring staghorn sculpin	40 30	enema/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
				salmonids	10		
			2	staghorn sculpin American shad flatfish shrimp	50 50 50 50	lavage/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
Columbia River and adjacent estuaries	1980-82	Year-round	50	eulachon anchovy Pacific tomcod Pacific herring	40 26 16 14	gastrointestinal tracts from stranded seals/otoliths, teeth, beaks, cartilaginous parts	Beach et al. 1985
				salmonids salmonids	6 12	otoliths only otoliths, bones, flesh, scales	
Tillamook Bay, OR	1981	Sep to Oct	38	flatfish crustaceans sand lance	71 29 11	scat/otoliths, teeth, beaks, cartilaginous parts	Beach et al. 1985
				salmonids	8		
		Sep to Oct	38	salmonids	19	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Reanalysis by Riemer and Brown 1996

Area	Year	Sampling time period	n[1]	Prey	Percent of samples[2]	Methods	Source
Netarts Bay, OR	1977-79	Aug to Oct	95	sand lance English sole rex sole sanddab staghorn sculpin Dover sole slender sole	39 32 26 18 17 17 12	scat/otoliths	Brown and Mate 1983
				steelhead	1		
Siletz River, OR	1983-85	Year-round	18	Dover sole rex sole Pacific whiting	67 28 11	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
				salmonids	11		
Alsea Bay, OR	1986	Sep	6	rex sole Pacific whiting Dover sole smelt	83 33 33 17	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
				salmonids	17		
Umpqua River, OR	1988-93	Summer/ winter	25	lamprey surfperch sculpin cephalopods	56 20 16 12	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	Riemer and Brown 1996
Coos Bay, OR	1978-81	Feb to Sep	279	staghorn sculpin English sole surfperch Pacific herring cephalopods sanddab rex sole	29 22 20 19 14 13 10	scat/otoliths, jaw parts, beaks	Graybill 1981
				salmonids	1		
Rogue River, OR	1976-79	Year-round	60	lamprey	27	observations of seals feeding actively (60 observations)	Roffe and Mate 1984
				salmonids	30		
		Mar to May, Aug, Sep	13	lamprey eulachon	92 23	gastrointestinal tracts from collected seals/otoliths, some bones, jaw parts, beaks	Roffe and Mate 1984

				salmonids	31		
		Spring/fall	89	lamprey eulachon	81 12	scat/otoliths, jaw parts, some bones	Roffe and Mate 1984
		Sep		salmonids	6		
	1994, 1995	Oct to May	394	lamprey rex sole rockfish Pacific tomcod octopus flatfish Pacific herring slender sole	26 23 21 20 17 15 14 12	scat/otoliths, bones, teeth, lenses, cartilaginous parts, beaks	ODFW data[5]
				salmonids	13		
Area	**Year**	**Sampling time period**	**n[1]**	**Prey**	**Percent of samples[2]**	**Methods**	**Source**
Klamath River, CA	1978-79	Mar to Nov	193	lamprey surf smelt eulachon	72 13 10	scat/otoliths	Bowlby 1981
				salmonids	3		
	1978-79	Apr to Aug	8	surf smelt lamprey eulachon sculpin	75 25 13 13	gastrointestinal tracts from beachcast seals/otoliths	Bowlby 1981
				salmonids	13		
Russian River, CA	1989-91	Year-round	155	flatfish octopus Pacific whiting hagfish plainfin midshipman	67 44 40 28 23	scat/otoliths, bones, teeth	Hanson 1993
				salmonids	7		
San Francisco Bay, CA	1991-92	Year-round	153	plainfin midshipman anchovy sculpin	21 20 14	scat/otoliths	Torok 1994

Area	Year	Sampling time period	n[1]	Prey	Percent of samples[2]	Methods	Source
Monterey Bay, CA	1991	Year-round	306	octopus spotted cuskeel market squid plainfin midshipman rockfish white croaker Pacific sanddab staghorn sculpin	56 43 29 20 19 19 15 12	scat/otoliths, beaks	Oxman 1995
Monterey Bay, CA	1991-92	Year-round	219	octopus market squid rockfish cuskeel plainfin midshipman Pacific sanddab	50 45 22 18 15 13	scat/otoliths, beaks	Trumble 1995
Channel Islands, CA	1980-93	Year-round	1,867	rockfish cuskeel	50 12	scat/otoliths, beaks	Stewart and Yochem 1994
Southern California	1990-93	Year-round	398	octopus plainfin midshipman market squid	50 43 23	scat/otoliths, beaks	Beeson 1995

1. n=number of samples
2. Percent of samples (scat, stomach, etc.) examined that contained the identified prey. This is not the percentage of that prey in the total diet. Only species that occurred in quantities equal to or greater than 10% were included in this table (except salmonids, which were reported at any level).
3. National Marine Fisheries Service/Alaska Fisheries Science Center
4. Washington Department of Fish and Wildlife
5. Oregon Department of Fish and Wildlife

APPENDIX H. COMMON NAMES AND GENUS/SPECIES OF PINNIPED PREY SPECIES REPORTED IN WASHINGTON, OREGON, AND CALIFORNIA

Common name	Species name	Family name
Fish		
Arrowtooth flounder	*Atheresthes stomias*	Pleuronectidae
Barred sand bass	*Paralabax nebulifer*	Serranidae

Blacksmith	*Chromis punctipinnis*	Pomacentridae
Bocaccio	*Sebastes pausispinis*	Scorpaenidae
Bonito, Pacific	*Sarda chiliensis*	Scombridae
California flyingfish	*Cypcelurus californicus*	Exocoetidae
California halibut	*Paralichthys californicus*	Bothidae
California headlightfish	*Diaphus theta*	Myctophidae
California smoothtongue	*Leuroglossus stilbius*	Bathylagidae
Carp, common	*Cyprinus carpio*	Cyprinidae
Codfish, unid.	*Gadidae*	Gadidae
Combfish, unid.	*Zaniolepis* spp.	Hexagrammidae
Croaker, unid.	*Sciaenidae*	Sciaenidae
Croaker, White	*Genyonemus lineatus*	Sciaenidae
Cusk-eel, Spotted	*Chilara taylori*	Ophidiidae
Eulachon	*Thaleichthys pacificus*	Osmeridae
Flatfish, unid.	*Pleuronectidae/Bothidae*	- - - -
Flounder, unid. lefteye	*Bothidae*	Bothidae
Flounder, unid. righteye	*Pleuronectidae*	Pleuronectidae
Gadids, unid.	*Gadidae*	Gadidae
Goby, Bay	*Lepidogobius lepidus*	Gobbidae
Greenling, Kelp	*Hexagrammos decagrammus*	Hexagrammidae
Gunnel, unid.	*Pholis* spp.	Pholidae
Hagfish, unspec.	*Eptatretus* spp.	Myxinidae
Halfmoon	*Maedialuna californiensis*	Kyphosidae
Kelp bass	*Paralabrax clathratus*	Serranidae
Irish lord, Brown	*Hemilepidotus spinosus*	Cottidae
Lampfish, Dogtooth	*Ceratoscopelus townsendi*	Myctophidae
Lampfish, Northern	*Stenobrachius leucopsarus*	Myctophidae
Lamprey, Pacific	*Lampetra tridentata*	Petromyzontidae
Lamprey, River	*Lampetra ayresi*	Petromyzontidae
Lamprey, unid.	*Lampetra* spp.	Petromyzontidae
Lanternfish, unid.	*Myctophidae*	Myctophidae
Lanternfish, Blue	*Tarlentonbeania crenularis*	Myctophidae
Lingcod	*Ophiodon elongatus*	Hexagrammidae
Mackerel, Chub (Pacific)	*Scomber japonicus*	Scombridae
Mackerel, Jack	*Trachurus symmetricus*	Carangidae
Medusafish	*Ichychthys lockingtoni*	Stromateidae

Northern anchovy	*Engraulis mordax*	Engraulidae
Northern ronquil	*Ronquilus jordani*	Bathymasteridae
Pacific argentine	*Argentina sialis*	Argentinidae
Pacific herring	*Clupea pallasi*	Clupeidae
Pacific pompano	*Peprilus simillimus*	Stromateidae
Pacific sandfish	*Trichodon trichodon*	Trichodontidae
Pacific sardine	*Sardinops sagax*	Clupeiformes
Pacific saury	*Cololabis saira*	Scomberesocidae
Pacific whiting	*Merluccius productus*	Gadidae
Perch, Kelp	*Brachyistius frenatus*	Embiotocidae
Perch, Pile	*Rhacochilus vacca*	Embiotocidae
Perch, Shiner	*Cymatogaster aggregata*	Embiotocidae
Plainfin midshipman	*Porichthys notatus*	Batachididae
Poacher, unid.	*Xeneretmus* spp.	Agonidae
Poacher, Stripefin	*Xeneretmus ritteri*	Agonidae
Prickleback, Bluebarred	*Plectobranchus evides*	Stichaeidae
Prickleback, Snake	*Lumpenus sagitta*	Stichaeidae
Prickleback, Whitebarred	*Poroclinus rothrocki*	Stichaeidae
Rockfish, unid.	*Scorpaenidae*	Scorpaenidae
Rockfish, unspecified	*Sebastes* spp.	Scorpaenidae
Rockfish, Aurora	*Sebastes aurora*	Scorpaenidae
Rockfish, Bank	*Sebastes rufus*	Scorpaenidae
Rockfish, Chilipepper	*Sebastes goodei*	Scorpaenidae
Rockfish, Halfbanded	*Sebastes semicinctus*	Scorpaenidae
Rockfish, Honeycomb	*Sebastes umbrosus*	Scorpaenidae
Rockfish, Shortbelly	*Sebastes jordani*	Scorpaenidae
Rockfish, Splitnose	*Sebastes diploproa*	Scorpaenidae
Rockfish, Squarespot	*Sebastes hopkinsi*	Scorpaenidae
Sablefish	*Anoplopoma fimbria*	Anoplopomatidae
Salmon, Chinook	*Oncorhynchus tshawytscha*	Salmonidae
Salmon, Chum	*Oncorhynchus keta*	Salmonidae
Salmon, Coho	*Oncorhynchus kisutch*	Salmonidae
Salmon, Pink	*Oncorhynchus gorbuscha*	Salmonidae
Salmon, Sockeye	*Oncorhynchus nerka*	Salmonidae
Sand lance, Pacific	*Ammodytes hexapterus*	Ammodytidae
Sanddab, unspecified	*Citharichthys* spp.	Bothidae

Sanddab, Pacific	*Citharichthys sordidus*	Bothidae
Sanddab, Speckled	*Citharichthys stigmaeus*	Bothidae
Sculpin, unid.	*Cottidae*	Cottidae
Sculpin, unid.	*Myoxocephalus* spp.	Cottidae
Sculpin, unid.	*Cottus* spp.	Cottidae
Sculpin, unid.	*Icelinus* spp.	Cottidae
Sculpin, Buffalo	*Enophrys bison*	Cottidae
Sculpin, Slim	*Radulinus asprellus*	Cottidae
Sculpin, Staghorn	*Leptocottus armatus*	Cottidae
Sculpin, Threadfin	*Icelinus filamentosus*	Cottidae
Sea Bass	*Paralabrax* spp	Serranidae
Señorita	*Oxyjulis californica*	Labridae
Shad, American	*Alosa sapidissima*	Clupeidae
Shark, Spiny dogfish	*Squalus acanthias*	Squalidae
Shark, Soupfin	*Galeorhinus zyopterus*	Carcharhinidae
Shortspine thornyhead	*Sebastolobus alascanus*	Scorpaenidae
Silverside, unid.	*Atherinidae*	Atherinidae
Smelt, Unid.	*Osmeridae*	Osmeridae
Smelt, Eulachon	*Thaleichthys pacificus*	Osmeridae
Smelt, Longfin	*Spirinchus thaleichththys*	Osmeridae
Smelt, Surf	*Hypomesus pretiosus*	Osmeridae
Smelt, Whitebait	*Allosmerus elongatus*	Osmeridae
Sole, Butter	*Isopsetta isolepsis*	Pleuronectidae
Sole, Dover	*Microstomus pacificus*	Pleuronectidae
Sole, English	*Parophrys vetulus*	Pleuronectidae
Sole, Flathead	*Hippoglossoides elassodon*	Pleuronectidae
Sole, Petrale	*Eopsetta jordani*	Pleuronectidae
Sole, Rex	*Glyptocephalus zachirus*	Pleuronectidae
Sole, Rock	*Lepidopsetta bilineata*	Pleuronectidae
Sole, Sand	*Psettichthys melanosticuts*	Pleuronectidae
Sole, Slender	*Lyopsetta exilis*	Pleuronectidae
Starry flounder	*Platichthys stellatus*	Pleuronectidae
Steelhead	*Oncorhynchus mykiss*	Salmonidae
Surfperch, unid.	*Embiotocidae*	Embiotocidae
Surfperch, Pink	*Zalembius rosaceus*	Embiotocidae
Surfperch, Redtail	*Amphistichus rhodoterus*	Embiotocidae

Surfperch, Spotfin	*Hyperprosodon anale*	Embiotocidae
Tomcod, Pacific	*Microgadus proximus*	Gadidae
Topsmelt	*Atherinops affinis*	Atherinidae
Walleye pollock	*Theragra chalcogramma*	Gadidae
White seaperch	*Phanerodon furcatus*	Embiotocidae
Wrasse, unid.	*Labridae*	Labridae

Cephalopods

Octopus	*Octopus spp.*	
Squid, market	*Loligo opalescens*	
Squid	*Chiroteuthis calyx*	
Squid	*Cranchia scabra*	
Squid	*Gonatopsis borealis*	
Squid	*Gonatus berryi*	
Squid	*Mastigoteuthis pyrodes*	
Squid	*Gonatus onyx*	
Squid	*Ocythoe tuberculata*	
Squid	*Onychoteuthis borealijaponicus*	
Squid	*Histioteuthis heteropsis*	
Squid	*Octopodoteuthis deletron*	
Squid, unid.	*Abraliopsis* spp.	
Squid, unid.	*Cranchiidae*	
Squid, unid.	*Gonatidae*	

Crustaceans

Crab	*Cancer* spp.	
Crangon shrimp	*Crangon* spp.	
Dungeness crab	*Cancer magister*	
Ghost shrimp	*Callianassa* spp.	
Pelagic red crab	*Pleuroncodes planipes*	

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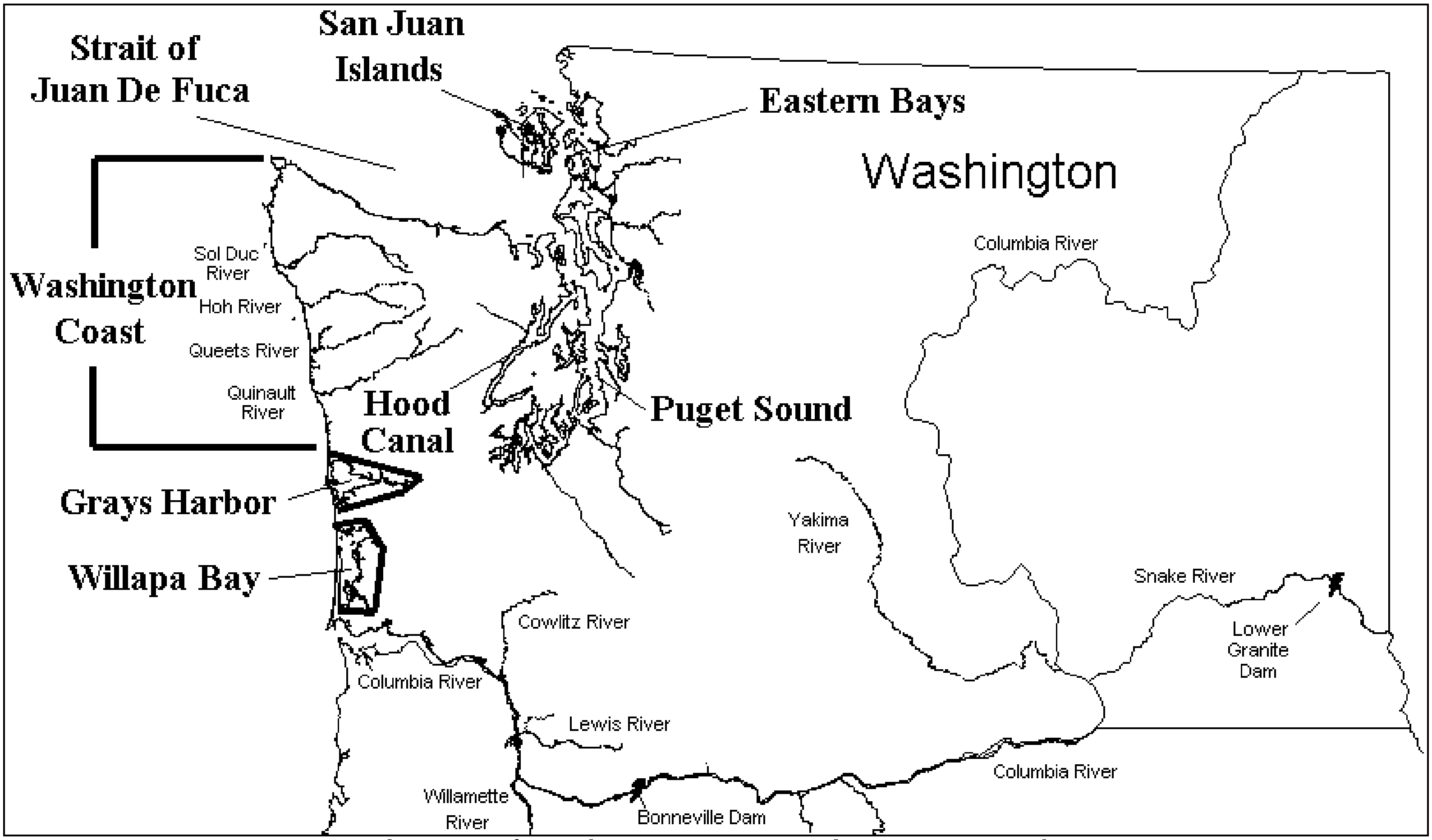

Figure 1. Region designations for Washington outer coast. Inside water regions are shown in Figure 2.

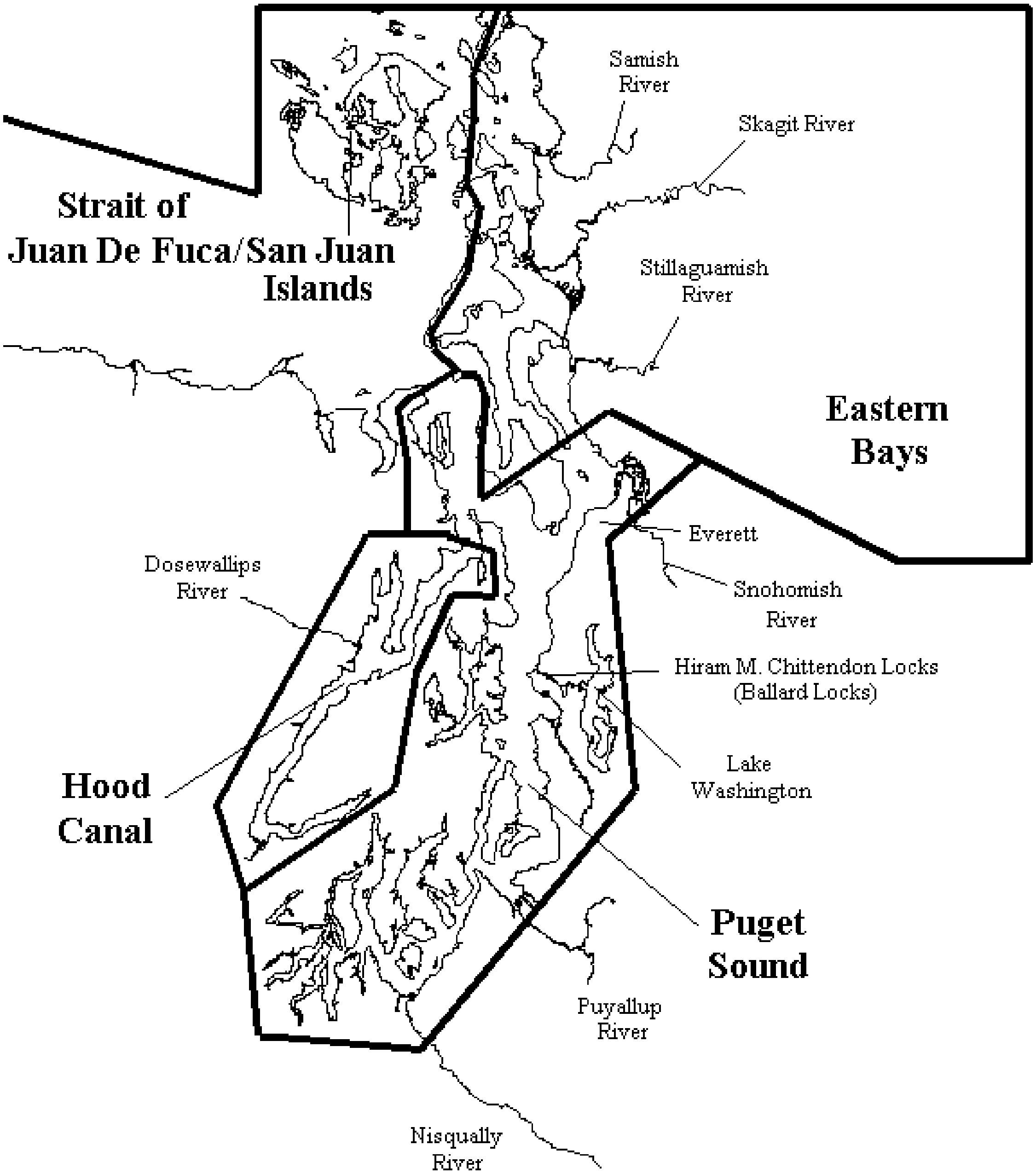

Figure 2. Region designations for inside waters of Washington

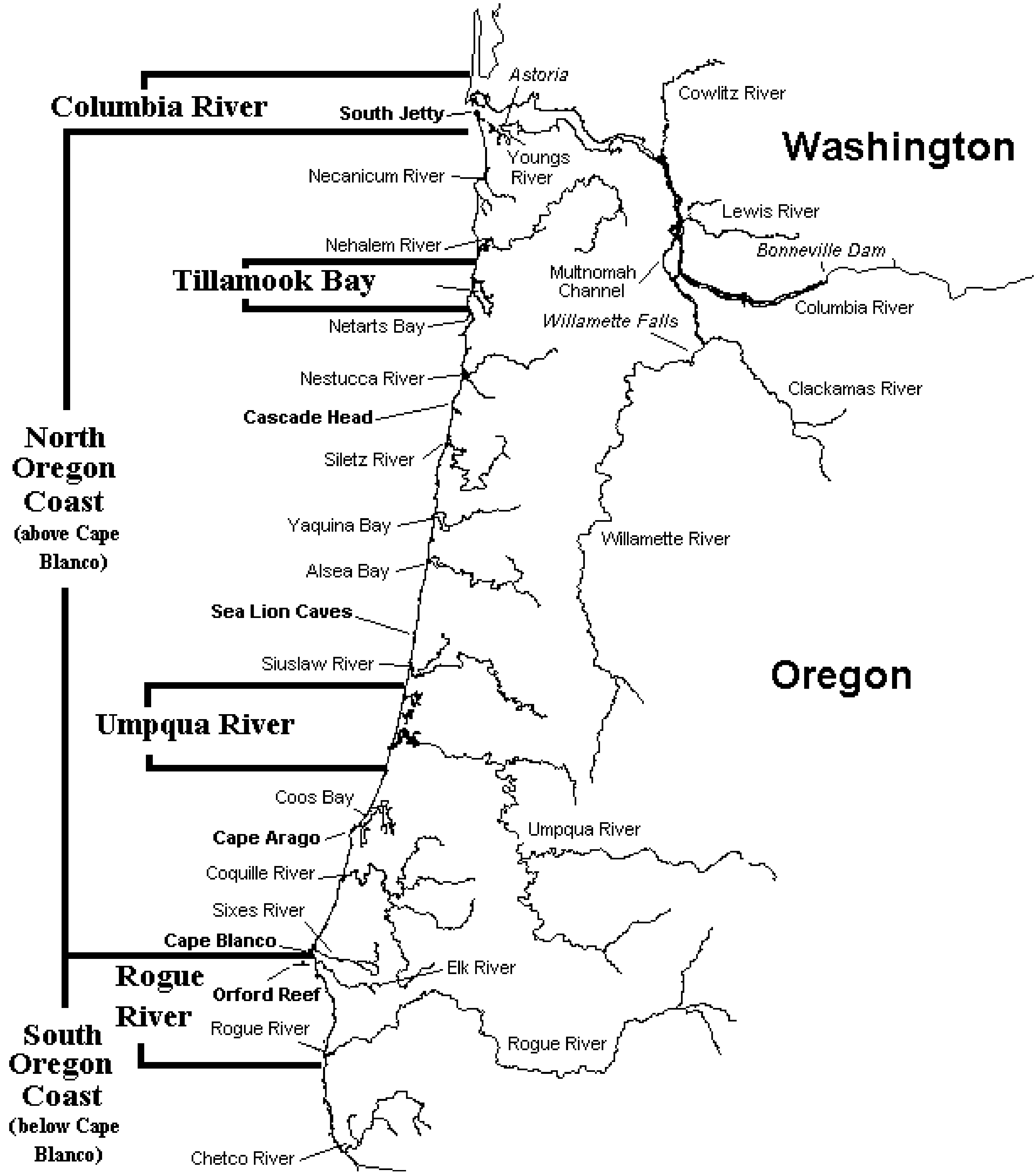
Columbia River
Astoria
South Jetty
Cowlitz River
Washington
Youngs River
Necanicum River
Lewis River
Nehalem River
Bonneville Dam
Tillamook Bay
Multnomah Channel
Columbia River
Netarts Bay
Willamette Falls
Nestucca River
Clackamas River
Cascade Head
North Oregon Coast (above Cape Blanco)
Siletz River
Yaquina Bay
Willamette River
Alsea Bay
Sea Lion Caves
Siuslaw River
Oregon
Umpqua River
Coos Bay
Umpqua River
Cape Arago
Coquille River
Sixes River
Cape Blanco
Elk River
Rogue River
Orford Reef
Rogue River
Rogue River
South Oregon Coast (below Cape Blanco)
Chetco River

Figure 3. Region designations for Oregon

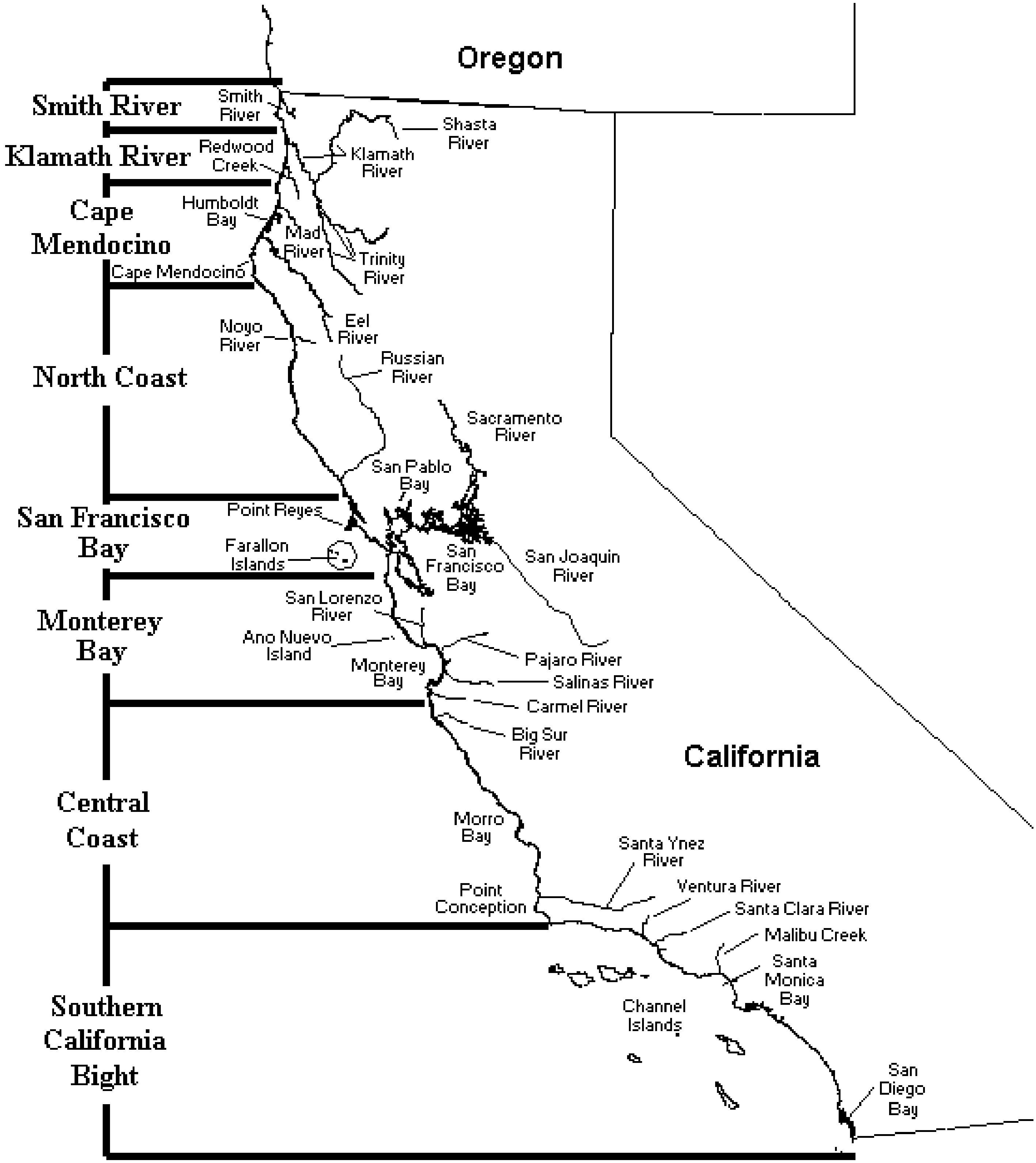

Figure 4. Region designations for California

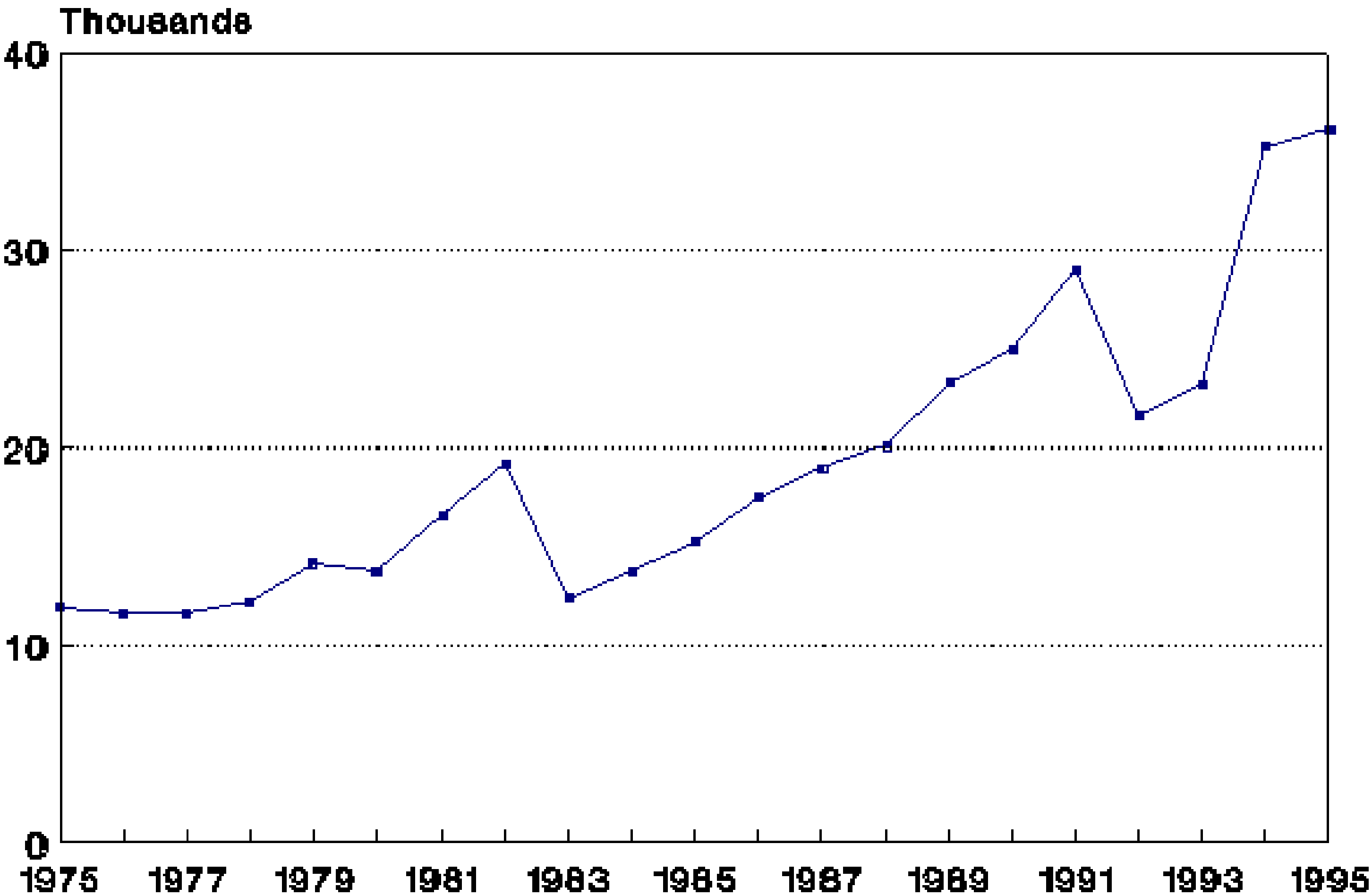

Figure 5. California sea lion pup counts in southern California

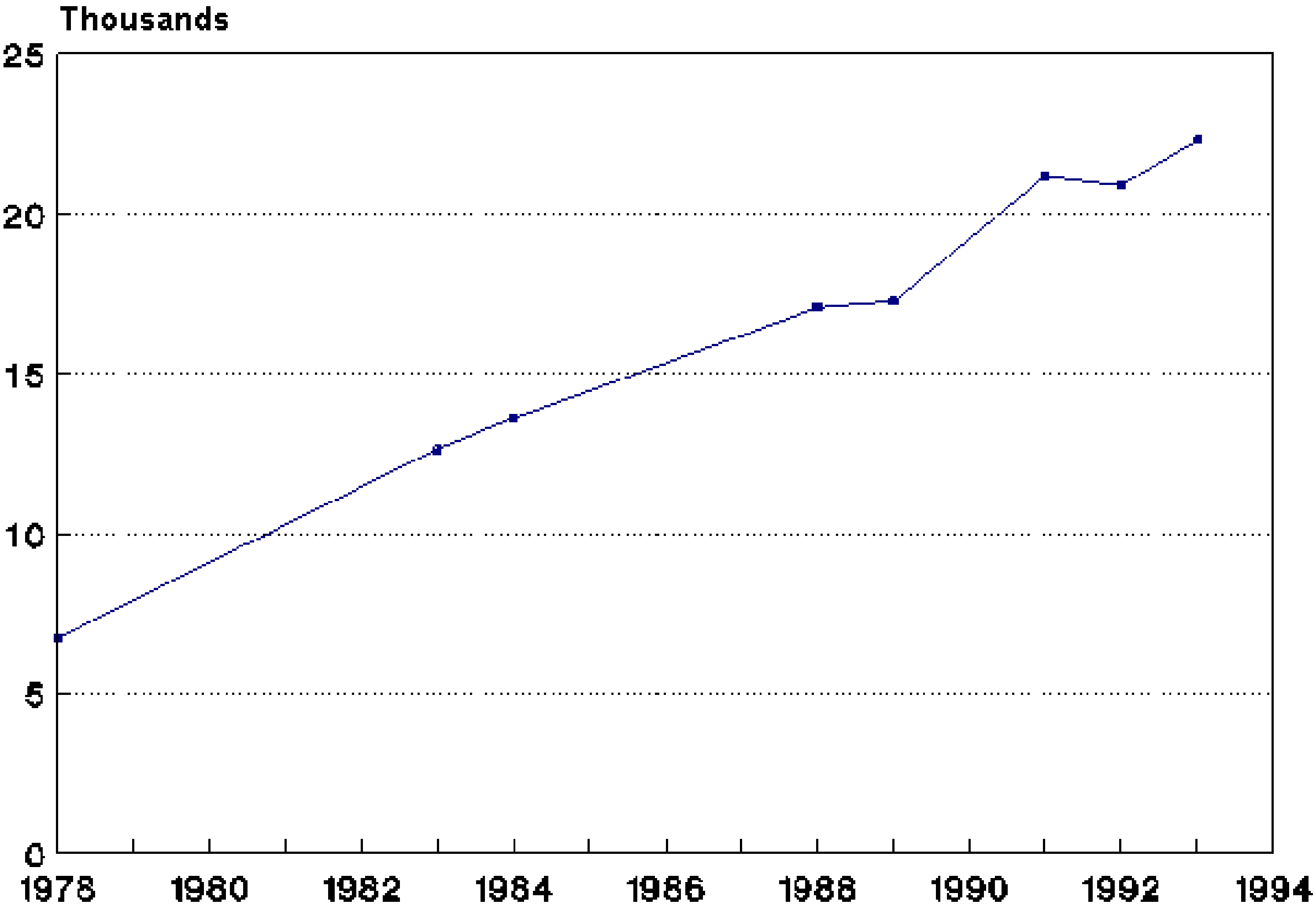

Figure 6. Harbor seal counts in Washington

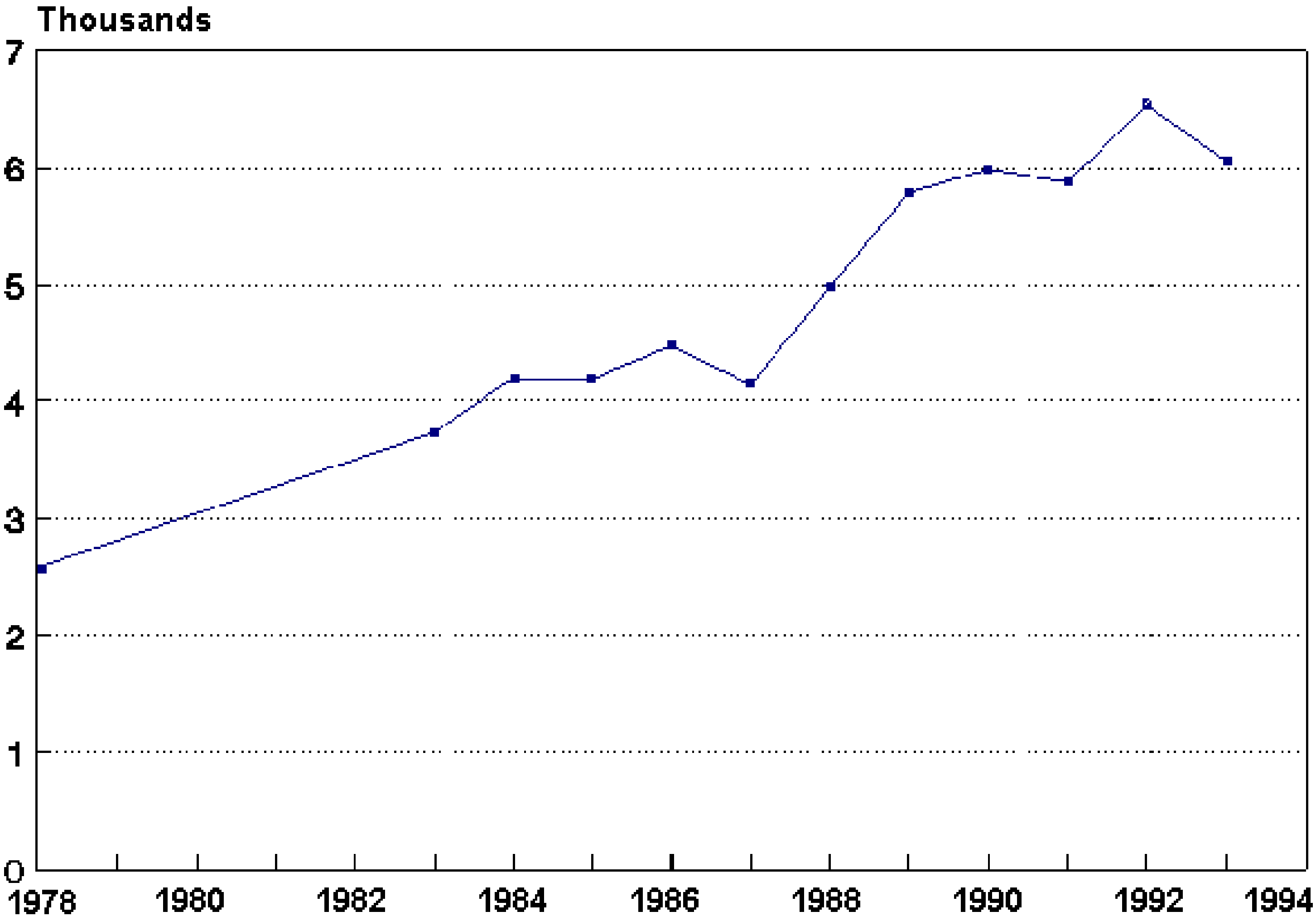

Figure 7. Harbor seal counts in Oregon

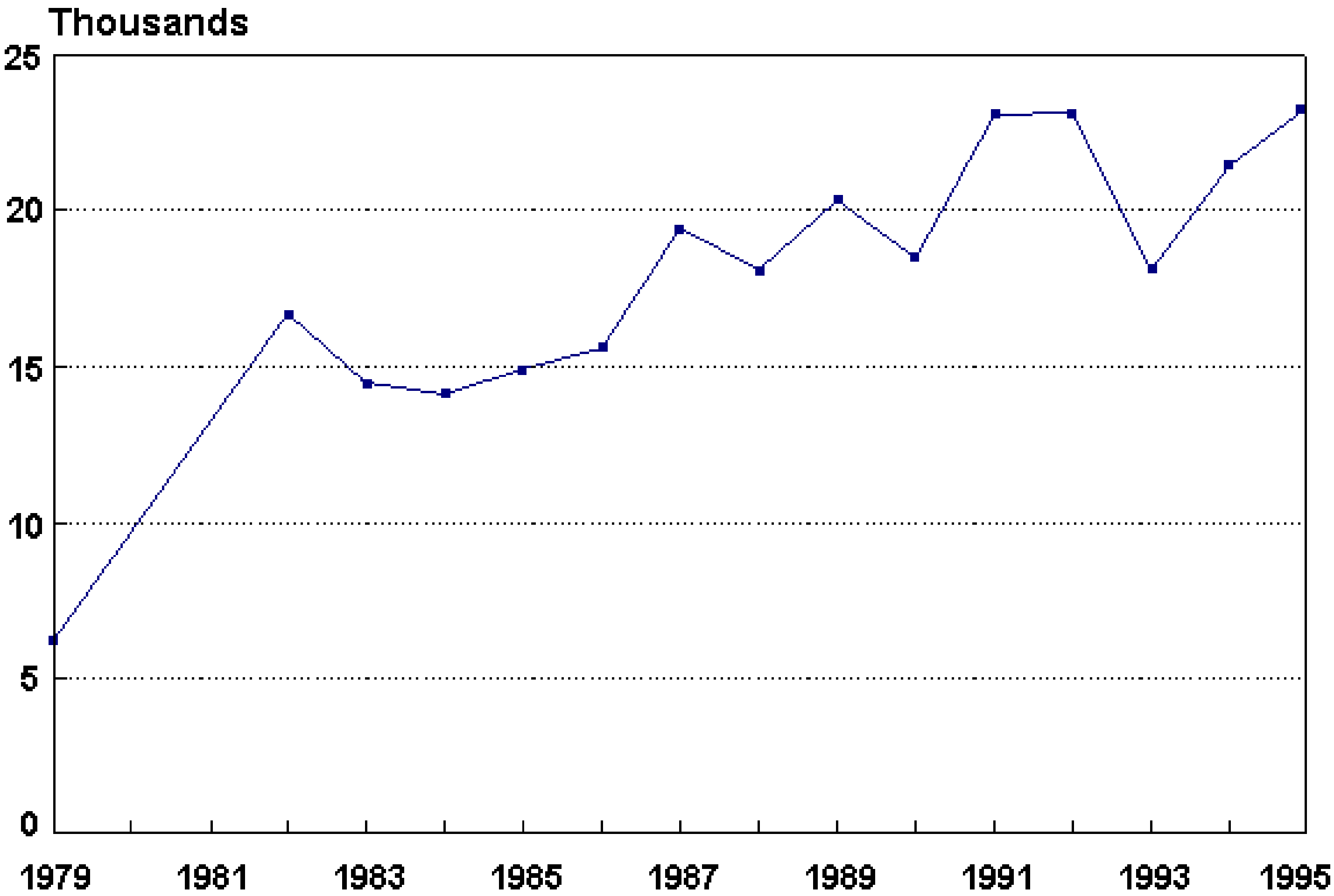

Figure 8. Harbor seal counts in California