Taking place: Northern sea lion foraging on Alaska groundfishery wastes

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TAKING PLACE:
NORTHERN SEA LION FORAGING ON ALASKA GROUND FISHERY WASTES

By
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B.A., The University of Montana, 1982
Presented in partial fulfillment of the requirements
for the degree of Master of Science
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Taking Place: Northern sea lion foraging on Alaska groundfishery wastes (181 pp.)

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Director: Dr. Jeffrey Gritzner

Marine mammal sighting data is gathered to describe the frequency, the character of, and the potential for injury from a recent and unstudied fishery-mammal interaction: Northern sea lion (*Eumetopias jubatus*) foraging on Alaska groundfishery wastes. Initial field observations revealed that prior to 1988, most groundfish processing occurred far offshore, and that relatively few incidents of processing waste foraging by sea lion occurred. After 1988, directed by public policy and incentive, fish processing moved to the nearshore environment of coastal Alaska. Thereafter, sea lion foraging on groundfishery waste became common, with some locations exhibiting daily visitation for weeks and months. Internal documents from fishery, mammal, and pollution agencies, and data from the literature are also gathered. These data depict waste foraging as a predictable outcome of domesticating the Alaska groundfishery and suggest that better facility siting and resource development planning within the coastal zone may have avoided much of the garbage feeding. The data suggest that subtle behavioral and nonlethal forms of injury are possible outcomes of this interaction.

Further, the "feeding" of wild marine mammals is shown in these documents to be a 'take' under the U. S. Marine Mammal Protection Act. Wastes which are illegal under the Clean Water Act are often disposed of throughout the sea lion's range and in proximity to rookeries. Unregulated and illegal waste discharges are linked to toxic exposure and mortality in hundreds of fur seals at one fish processing site. A search of the marine mammal sighting database revealed that the majority of 1991 marine mammal sighting data are missing. Finally, a method for monitoring waste foraging is proposed.
Acknowledgments

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List of Acronyms

Chapter One

2 m (meters)
3 U.S. (United States)
9 FWS (Fish and Wildlife Service)
9 NMFS (National Marine Fisheries Service)
9 MMPA (Marine Mammal Protection Act)
9 ESA (Endangered Species Act)
10 EPA (Environmental Protection Agency)
10 CWA (Clean Water Act)
15 FOIA (Freedom of Information Act)
16 WMS (White Muscle Syndrome)
19 EEZ (Exclusive Economic Zone)
21 mtDNA (Mitochondrial DNA)
37 ENSO (El Nino Southern Oscillation)

Chapter Two

56 FCMA (Fisheries Conservation and Management Act)
57 CVOA (Catcher-vessel operating area)
58 CDQs (Community Development Quotas)
60 NPFMC (North Pacific Fisheries Management Council)
74 NPDES (National Pollutant Discharge Elimination System)

Chapter Three

82 YNP (Yellowstone National Park)
84 NMML (National Marine Mammal Laboratory)

Chapter Four

111 POPs (Persistent Organic Pollutants)
112 DDT (Dichlorodiphenyl trichloroethane)
112 PCBs (Polychlorinated biphenyls)
112 OCs (organochlorine compounds)
113 AMAP (Arctic Monitorring and Assessment Programme)
CHAPTER 1

Introduction

The history of life on earth has been a history of interaction between living things and their surroundings. To a large extent, the physical form and the habits of the earth’s vegetation and its animal life have been molded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within the moment of time represented by the present century has one species-man-acquired significant power to alter the nature of his world.

During the past quarter century this power has not only increased to one of disturbing magnitude but it has changed in character. The most alarming of all man’s assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials. This pollution is for the most part irrecoverable; the chain of evil it initiates not only in the world that must support life but in living tissues is for the most part irreversible. In this now universal contamination of the environment, chemicals are the sinister and little-recognized partners of radiation in changing the very nature of the world—the very nature of its life.

Rachel Carson Silent Spring 1962

Initial observation: a "smoky sea"

An immense array and amount of marine life results when North Pacific Ocean currents pour through Aleutian Island passes into the Bering Sea. These flows are pronounced, greatly influencing ecological processes downstream and disturbing even the largest of vessels navigating these Island straits. "Swift and treacherous" is a local description of the twelve-knot stream through Akun Pass. Nearby Ugamak Pass, a heavily-traveled gateway for ship traffic to and from Asia, is "broad and deep" (Nutchuk and Hatch 1943).

The Alaska Current is the pressure behind these flows. It moves northerly along the North American coast, turning counter clock-wise in the Gulf of Alaska and continuing west along the Aleutian Islands. As this Current moves through the Aleutian Chain and into the Bering Sea, it stirs and mixes with the colder
bottom-layer of water. Turbulence, eddies, and a lot of fog are created in the process. The Bering has been called the "Smoky Sea" (Nutchuk and Hatch 1943) because of this fog.

Lying in the path of these flows are deposits of sediment and organic debris. These materials (e.g., decaying organisms, pelagic diatoms, salts, and minerals) are continually shifting from the shallow continental shelf and settling in the crevices and canyons of the continental slope, until upwelled by currents and storm surges into the surface layer. Suspended in the turbulence near the surface and exposed to prolonged sunlight and foraging organisms, this upwelled nutrient-rich water literally blooms with life.

The arrangement of life forms inhabiting the Bering Sea, especially in the region along and above the continental slope and shelf, is largely patterned in response to this upwelling. The continental slope lies directly in front of currents pouring through Aleutian Island Passes, and is "scarred with valleys and some of the world’s largest submarine canyons" (Sharma 1974). Comprising 13% of the Sea floor, the slope is a distinct sub-marine province which inclines at four-to-five degrees and ranges in depth from 200 to 350 meters (m). The slope splits the Sea in half; separating the extensive and shallow (less than 200 m) continental shelf from the Aleutian basin. The basin is also a distinct region, extending to depths over 3000 meters, and maintaining its own current: "Some resident water joins new North Pacific water entering Near Strait, which sustains a permanent gyre around the deep basin in the central Bering Sea" (United States National Marine Fisheries Service 2001).

In terms of sheer size, the Bering is the third largest ‘semi-enclosed’ Sea in the world, after the Mediterranean and the South China Seas (Hood 1983).
The Bering is subject to tremendous region-wide variation in solar radiation, wind torque, ice cover, sea-surface temperature, hydrographic influences, biological productivity, and geophysical activity. Moderate earthquakes and smoking volcanoes are common throughout the area. The Aleutian Islands are formed as the North American plate is thrust below an over-riding plate. In the process, material is forced back to the surface, the Islands becoming volcanic rivets in an overlap of continental sheet metal.

Also contributing to the productivity of the Bering Sea is biological activity associated with pack ice forming and dissolving over the coastal shelf of mainland Alaska. Sharma (1974) reviewed this productivity: "The Bering Sea annual cycle of primary production apparently begins with a development of microalgae below the sea ice surface. It is followed by phytoplankton bloom in the coastal zone that extends from the Aleutians to the Bering Strait . . ."

The nutrient upwelling, combined with an extensive front of sea ice, results in a "nutrient broth" in the estimation of Morgan (1983). The outcome in Hood's analysis (1981) is "some of the highest short-term primary production rates ever measured in the world's oceans," ranking it "one of the most productive of the world's ecosystems."

Figure 1.1 shows selected ecological features of the marine upwelling in the Southeastern Bering Sea. The upwelling is a process resulting in localized patches of fish. Shown are dominant current pathways, the continental shelf, slope, and associated canyons, and the primary harvest locations of commercially-important demersal (i.e., near-bottom dwelling) fishes, commonly known and managed as "groundfish." Included is the largest-volume single-species fishery in the United States (U.S.), which harvests and processes
Figure 1.1 Selected Ecological Features of the Bering Sea Upwelling Region
Walleye pollock (*Theragra chalcogramma*) from the Bering Sea and Gulf of Alaska. Areas of high groundfish harvest in the eastern Bering Sea are represented by that of Japanese trawlers in 1977 (after Bakkala 1981). These harvest areas demonstrate that groundfish are being caught from discreet aggregations which apparently correspond to the Zhemchug, Pribilof, and Bering Canyons.

Three further consequences of the nutrient upwelling, all based on exploiting groundfish, are shown in Figure 1.2. Historically, the most densely populated Northern fur seal (*Callorhinus ursinus*) and Northern sea lion (*Eumetopias jubatus*) rookeries (i.e., coastal breeding grounds) are distributed around the area influenced most directly by the upwelling. This biogeography is key to understanding why, of the twenty-five marine mammal inhabitants of the Bering Sea, sea lion are the most liable to interact with groundfish fishery activities. Sea lion are especially vulnerable to foraging in the ‘outfall mixing zones’ of both vessels and shoreplants because of long-evolved behavioral patterns and physical adaptations. As Chapter 3 documents, Northern sea lion routinely forage, sometimes for weeks or longer, on processing wastes discharged by the fisheries for groundfish.

As depicted by the distribution of rookeries in Figure 1.2, Northern fur seal and Northern sea lion have partitioned their use of Bering Sea coastal habitats for breeding and pup rearing. Fur seal and sea lion are closely-related and share many habits, physical attributes, and habitats. Both are dependant on schooling fishes as prey, relying heavily on some of the same groundfish species. This partitioning of resources (or ‘niche differentiation’) has been achieved by differences in each species maternal foraging range and duration
Figure 1.2 General Locations of Northern Sea Lion and Northern Fur Seal Rookeries, and Groundfish Processors, West of Cape Suckling, Alaska
of neonatal nursing periods. Costa (1991a; 1991b) studied pinniped energetics and foraging, demonstrating these differences result in provision of different qualities of milk to pups. A higher proportion of protein-to-fat mean sea lion pups build hard tissue (versus blubber) earlier, and are thus physically larger. Sea lion are known to attack and kill fur seal; the distinction in habitat use by foraging mother sea lion reduces competitive interactions between fur seal and sea lion. Fur seal congregate mainly in the four Pribilof Islands, limiting the availability of nearshore foraging range and requiring fur seal pups to forage offshore sooner after birth than sea lion. Sea lion inhabit a much wider distribution of rookeries, affording a prolonged period of maternal foraging and onshore nursing.

Figure 1.2 also shows the general locations of floating and shorebased seafood processors in the Alaska pollock fishery. As shown, near- or on-shore processing facilities, including all shoreplants and seasonally-located floating operations, occupy the same general region as Northern sea lion rookeries (from Kiska Island in the Western Aleutians to the Kenai Peninsula in the northwest Gulf of Alaska). Given the reliance on stocks of groundfish by both sea lion and industry, it is no coincidence that processors and rookeries locate themselves adjacent to each other in numerous localities.

The productivity of the Bering Sea is remarkable and rare, but it is also characteristic of upwellings in general. Ryther (1969) noted that marine upwelling regions total "no more than about one-tenth of 1% of the ocean surface (an area roughly the size of California), [yet they] produce about half the world's fish supply." Bering Sea productivity is important to subsistence and industrial economies in every nation bordering the Northern Pacific Rim.
Christensen et al. (1996) noted that at least 5% of the total global commercial fishery production is derived from the Bering Sea. Prior to a 30% decline in biological productivity during the last two decades, according to Mate and Goldstein (1999/2000), the Bering Sea yielded 10% of the world’s fish catch, and 40% of the total U.S. catch. The Bering Sea is inhabited by four hundred and fifty species of fish, crustaceans, and mollusks, of which fifty are commercially important (Christensen et al. 1996). Of the two thousand fish species which inhabit the larger North Pacific region, eighty are utilized commercially (Miles et al. 1982).

From a variety of perspectives there is fog in the Bering Sea. An oft-heard claim that the region is desolate and poorly-understood is true: "The Aleutian chain is one of the loneliest and least-known spots on earth. . . In the entire thousand-mile stretch there is no tree or shrub higher than your knee, nothing but bare hills and beaches purple with volcanic cinders, fogbound and cold and still as death" (Ford 1966).

Despite the protected status and importance of many of its resources, a lack of scientific knowledge confounds our technical understanding of the marine environment. New species are still routinely found, for example, and the relationships between species is largely theoretical. Wooster (1993) noted that ". . . even for exploited species (e.g., pollock and herring), population estimates are only made for large areas, and little is known about local prey abundance and availability in the feeding areas which may not be correlated with large-scale abundance as estimated from population models. Even the locations and dimensions of feeding areas are in most cases poorly known."

Adding to the fogginess in the Bering Sea is the disjointed and narrowly-
focused bureaucratic management of maritime resources. Because they are species uniquely adapted to both the sea and land, polar bear, sea otter, walrus, fur seal, and sea lion bridge gaps in the U.S. regime of natural resources management. Virtually all of the Aleutian Islands were designated ‘Alaska Maritime National Wildlife Refuge’ in 1913 (Morgan 1983), subjecting wildlands critical to sea mammals to management by the U.S. Fish and Wildlife Service (FWS) within the Department of the Interior. While the polar bear, sea otter, and walrus are managed by the FWS, marine habitat, marine fishes, and the remaining marine mammals (fur seal, sea lion, other seals, etc.) are managed by the U.S. National Marine Fisheries Service (NMFS), within the Department of Commerce. The issue of seafood-waste foraging by sea lion, as a management responsibility, falls between the jurisdiction of five or more public resource agencies concerned with marine fisheries, sea mammals, marine habitat, seafood waste discharges, land-use development, and harbor/outfall construction. Though it is not attempted here, the issue of nearshore waste-foraging by sea lion may be an ideal topic with which to challenge the efficacy of ‘ecosystem management,’ as well as the effectiveness of interagency coordination mandates within Section 7 of the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA), and the Coastal Zone Management Act. Bureaucratic fragmentation is recognized in this study to be an impediment to the management of waste foraging as a fishery interaction with sea lion. Such waste foraging is an example of how distinctly managed issues interact, how such interactions are difficult to address, and how the need for interagency coordination and problem solving is constant.

In some locations, in my experience, food-conditioning is occurring to
numerous small groups of sea lions. In many of these situations, the discharges are periodically illegal under the federal Clean Water Act (CWA) and State of Alaska standards (Florence Carroll pers. comm. 1995). Especially problematic is the interaction between sea lion and floating processors, which tend to be highly-mobile operations with limited treatment and waste-storage capacity. Because of their mobility and the isolation of coastal Alaska, ‘floaters’ as they are known, are difficult to monitor in terms of both waste discharges and interactions with marine mammals. The impacts to public resources from such operations is not limited to the marine environment. Wastes such as rubber gloves, plastics, and assorted debris, often washup on beaches. Group excursions from these processors to shore (very often to lands designated as federal wildlife refuge and/or wilderness areas), for the purpose of recreational fishing and hunting, hiking, artifact collecting, and beach fires are also common. Because floating processors have little capacity to treat or store waste, they are the processor-type most likely to impact sea lion and the immediate environment by the dumping of whole-fish and large fish-parts. Both these waste forms attract and reward foraging sea lions. As well, whole fish and fish parts also accumulate in decaying piles on the floor of the bay, consuming available oxygen, and degrading nearshore habitats.

Fish waste when discharged from shore is managed by the Environmental Protection Agency (EPA). But when this same waste is discharged offshore from vessels, NMFS, the State of Alaska, and/or the Coast Guard are the regulating agencies. While marine fisheries planning is overseen by NMFS, the actual task of writing plans is performed by Regional Fisheries Councils. Construction of outfalls and harbors—both necessary for fisheries development—
are overseen by the Army Corps of Engineers under the Rivers and Harbors Act. Various research (Salwasser et al. 1978; Yaffee 1988; Grumbine 1991; Clark 1992; Press et al. 1996) has recognized similar problems from fragmented responsibility among natural resource agencies with varied motives and priorities.

The interaction of ‘in situ’ sea lion and a ‘distant-water’ fishery

Northern sea lion are often referred to by other names, such as "Steller," "Steller’s," or "stellar." These names derive from Georg Wilhelm Steller, who first described sea lion scientifically as the naturalist aboard Vitus Bering’s 1741-42 exploratory voyages to the northwest coast of North America (then under Russian control). Steller described many species, including the Steller sea cow (thought to be now extinct) and a mysterious "sea ape." Neither animal was ever reported again (see Ford 1966, Where the sea breaks its back for an interesting account of Steller’s role in that early expedition to the coast of what is now Alaska).

My preference as a regional geographer, used here and by Reeves et al. (1992), Whitaker (1998), and others, is to describe the species in terms of their geographical habitation. The Northern sea lion is the northern variant of five sea lion species found throughout the Pacific Ocean (Reeves et al. 1992). It should be noted that the nomenclature of many arctic and marine phenomena vary in common usage, and even in the more technical literature. The groundfish species, Walleye pollock, for example, may be termed ‘pollack’ in some international publications.

To understand why sea lion so frequently forage on seafood waste it is essential to understand their evolution and ecology. Briefly, as the subject is
fully explained in Chapter 2, the Otariid pinnipeds (i.e., the ‘eared’ or ‘walking’
seals, including Northern fur seal and Northern sea lion) which inhabit the Bering
Sea are truly ‘in situ’ ('in it’s proper or original place') animals. Otariid evolution
in the North Pacific Basin was explained by Repenning (1980):

  The North Pacific Basin is where the Otariid (fur seals and sea lions)
and Odobenid (walrus) species radiated into the sea from a bear-like land
carnivore, in response to a cooling climate and a subsequent change in
oceanic currents. Halfway between the time of the extinction of the
dinosaurs and the present day, some 36 million years ago, there was
another major change in the global environment. An abrupt cooling of
oceans caused changes in oceanic circulation and altered cyclonic
patterns in the atmosphere. . . . From the standpoint of the pinnipeds, the
greatest significance of this change was the resulting upwelling of colder
waters in the North Pacific and North Atlantic that brought nutrient-rich
waters to the surface adjacent to the coasts of North America and Europe.
Aquatic land carnivores, attracted by the abundance of food in these
waters, entered the sea to become the first pinnipeds.

  From an "ursid arctoid land carnivore" (Repenning et al. 1979) who
scavenged the coastal fringe, to marine mammals uniquely reliant on land and
sea, this legacy carries specific consequences meaningful for siting fisheries
development. The developmental evolution of marine mammal groups are
briefly described here, but more fully in Chapter 2, to emphasize the ‘landlocked’
nature of the Otariids, particularly the sea lion. It is this landlocked character, in
combination with encroachment of fisheries development into critical foraging
habitats, which places sea lion most at risk to interact with Alaska groundfish
fisheries.

  A sea lion’s physiology and behavioral patterns are adapted for extensive use
of coastal habitats. From centrally-placed rookery sites, maternal foraging bouts
of about 17 hours duration are intertwined with on-shore nursing of pups.
Relative to other seals and fur seal, sea lion have a prolonged period where rookery-bound pups rely on milk for sustenance. Because development has moved into the nearshore zone, often in close proximity to rookery and haul-out sites, sea lion are effectively set up to forage at outfalls.

Sea lion limbs and shoulder joints, for example, are well suited for scrambling over rocky coastal-shelf habitat. Sea lion rookeries—typically on shoreline exposed to the weather and surf—are in numerous localities directly adjacent to or very near the isolated bays where the groundfish industry is locating. Sea lion limbs also allow them to access man-made structures; they often climb on docks, buoys, and seem quite at ease on the trawl-ramps of fishing vessels. Figure 1.3 shows two photographs depicting sea lion use of fishery platforms (top) and natural rookery habitat (bottom). The top photograph depicts several Northern sea lion on the trawl ramp of an unidentified vessel in the central Aleutian Islands. The bottom photograph in Figure 1.3 shows an example of natural sea lion rookery habitat in southeastern Alaska. The photographs illustrate how a fundamental character of sea lions, the physical ability to ‘walk’ on the hard broken substrate of coastal shelf habitat, where their rookeries are sited, lends itself to direct interactions with fishery operations, such as the common behavior of climbing on the trawl ramp of large trawler-processors. Sea lions are the most recent-developed specie of the Otariids, as evidenced by the degree to which their limbs are adapted both for sea and mobility on land. The evolution of sea lions ‘hands’ indicates a ‘landlocked’ reproductive strategy that includes prolonged neonatal nursing and requisite nearshore foraging range.

Though less frequently than sea lion, fur seal also forage at outfalls. Fur seal forage on fisheries dishcargers mainly in the Pribilof Islands, where 75% of their
Figure 1.3 Photographs depicting Sea Lions on a Trawler-Processor Trawl Ramp (top - photo courtesy of John Varner); and Sea Lion Rookery Habitat at Lowrie Island in Southeastern Alaska (bottom – photo by Donald Grybeck from Southeast: Alaska's Panhandle, Alaska Geographic 5:2, used without permission)
global population breed, give birth, and nurse pups. Given the predictability of sea lion (and fur seal) foraging on fisheries waste discharges, it appears to this observer at least, that federal fisheries management have not sited processors to avoid interactions with marine mammal predators likely to interact with fishery operations. Simply given their history as aquarium performers, it seems predictable that sea lion would habitually forage at seafood processor outfalls. In terms of the broad range of interactions with groundfish processing facilities, and from my experiences at a wide array of fishing vessels and many processors throughout the Gulf of Alaska and Bering Sea, it is my opinion that federal agencies responsible for permitting fish processing and waste disposal have inadequately considered the ecological characteristics of Otariid species, nor the propensity of industry to dump wastes attractive to protected marine mammal predators. Processing facilities, from my experiences at a wide array of fishing vessels and an assortment of processors throughout the Gulf of Alaska and Bering Sea, has inadequately considered the ecological characteristics of the Otariid species.

The problem of failed seafood processing planning was evidenced in the harbor at Saint Paul, in the Pribilof Islands, according to numerous documents obtained through a Freedom of Information Act (FOIA) request. There, 300 fur seal pups were found dead only on the rookeries adjacent to Saint Paul harbor. The seals reportedly died from an ailment never before reported in marine mammals, according to the two mammal pathologists who found them (Spraker and DeGhetto 1991), the injury resulted from exposure to a wave-deposited toxic substance. One suspected agent was a caustic material used to hasten the drying of concrete, according to a wastewater compliance officer with Region 10
of EPA (Florence Carroll, pers. comm. 1995). At the time, concrete was being used in the construction of fish processing and harbor development at Saint Paul Island. The skin and internal organs of the dead pups appeared to have been oxidized only on the side of the seal in contact with the beach. And only the gravelly sections of the rookeries had affected seals; thus it was believed a substance had washed ashore and was depositing onto the same shore where the pups lay awaiting milk from their foraging mothers. The disease was termed "white muscle syndrome" (Spraker and DeGhetto 1991; see also Spraker and Bradley 1996), because of the oxidizing impact on tissue. NMFS did not sit idly by in reaction to the white muscle syndrome (WMS) incidents; then-Director of NMFS' Alaska Region, Steven Pennoyer, wrote in a 2 November 1994 letter to the EPA: "The National Marine Fisheries Service remains very concerned with the potential resources development conflicts presented in the industrial development of the Pribilofs." Another Alaska-based scientist, the Chief of NMFS Protected Resources Management Division, Steven Zimmerman, wrote in a letter to the EPA's Chief of Wastewater Management and Enforcement, on 14 April 1995: "The NMFS has been very concerned that the recent pace of development in the Pribilof Islands has been too rapid to measure its effects on the health of the fur seal population that depends on these small islands." It should be noted that the discovery of these dead seals were made by "Humane Observers" (Drs. Spraker and DeGhetto), who only observe the subsistence take of fur seal. The possibility that similar situations of caustic exposure may be affecting sea lions at processor outfalls throughout the Aleutian Islands is not known nor under study. Despite the death of so many fur seal and the indirect link to fisheries development, no one is currently observing whether sea lion, sea
otters, or seabirds are similarly impacted by toxic releases. Saint Paul Island is only the most recent of many coastal locations where groundfish processing has been developed under the guidance of public subsidy and incentive.

It is well known by fishers, fisheries observers, and NMFS resource managers that sea lion routinely forage on seafood waste at virtually every fish processing location in coastal Alaska. It is not known whether the proximity of processors to rookery/haulout sites contributes to or causes the frequency of sea lion foraging on seafood waste. It may be, because of the wide-ranging geography of sea lion rookeries and haul-outs, that sea lion would seek out and congregate at outfall zones regardless of where processors were located. Whether a different spatial arrangement of processors would alter the frequency of waste-foraging interactions, especially by mother/young pairs during the Fall (or 'B') fishing season or by juveniles during Winter, is not known or under study.

Again, it is a contention of this paper that pinniped ecology—specifically the likelihood of waste foraging interactions—has been poorly considered in the public policy-driven replacement of seafood processing activity from far offshore to near- or on-shore. The specific impacts to sea lions (or other animals, such as sea otters, or orca whales) from exposure to chemicals discharged into seafood processing outfall mixing zones have not been studied. EPA and NMFS documents acknowledge that interactions between sea lions and seafood wastes occur; both agencies have expressed the opinion that the potential toxic or otherwise harmful impact to exposed animals is minimal and not expected to be injurious. Both also acknowledge that little study of the subject has been done. At the same time, however, the FWS has initiated studies of seabird interactions with seafood waste using fishery observers.
The presence of sea lion at outfalls presents researchers with an opportunity to study that population at minimal cost. Tagging and tracking the whereabouts and health of outfall visitors would be useful in a number of ways. For example, to determine if sea lion from specific rookeries congregate at ‘nearest-neighbor’ processors (see Chapter 3 for further discussion on the opportunities presented by outfall foragers).

As discussed in Chapter 3, fresh injuries and scars on visiting sea lion were frequently reported by observers in the data examined here. This would conform to the findings of Zento-Savin et al. (1997), who found significantly higher levels of haptoglobin in Northern sea lion blood from Aleutian Island samples. Haptoglobin is an acute-phase blood protein that binds with hemoglobin. According to Loughlin (1997), writing in reference to sea lion: "Haptoglobin levels increase in association with tissue injury or other such stress (e.g., infection, trauma, inflammation). The higher levels found in the Aleutian Island samples suggest that higher levels of injury or trauma may exist there than in southeastern Alaska."

Despite the occurrence of WMS, the NMFS Observer Program has taken the opposite strategy than FWS (who are using fisheries observers to monitor seabird-fishery waste interactions). NMFS apparently believes that the information potentially gleaned from observing the population of sea lion who visit outfall zones is not useful, despite the fact that such data could be gathered at minimal cost because fishery observers are already on-site and trained to make marine mammal sightings. The data used in Chapter 3 to document the frequency, character, and threats of waste-foraging by sea lions are the same observer data (U.S. fishery observer Form 11, marine mammal sightings) which
are no longer collected at fish processing facilities under an explicit Observer Program directive. This observer attended January, 1993 fisheries observer training sessions during which NMFS staff specifically asked that no further marine mammal sightings be made by seafood processor observers (Mike Brown, pers. comm). These same sighting data are a high-priority task of fishery observers deployed to fishing vessels. As a result of this discrepancy, the harvesting sector of the groundfish fishery is observed for marine mammal sightings while the processing sector is not. NMFS' Platforms of Opportunity database (see Boucher and Boaz 1989), which catalogs marine mammal sighting data, is shortchanged by this policy. As a tool in examining the totality of mammal-fishery interactions within the U.S. Exclusive Economic Zone (EEZ) fisheries, this database is now incomplete. Thus, when NMFS reports of 'fishery interactions with marine mammals,' their reporting leaves out the single most frequent interaction. Interactions with processing operations, including waste foraging and general exposure to effluent, is selectively omitted from consideration and discussion. For example, within the Quarterly Report by the Alaska Fisheries Science Center (see U.S. Department of Commerce 1997b) is a report by M. Perez, titled "Marine mammal incidental take in domestic groundfish fisheries." Table 1 of that report shows the "Total number of marine mammal interactions reported by U.S. observers aboard fishing vessels of the domestic groundfish fishery in the U.S. EEZ, 1990-96, by species, interaction, and gear type." The omission of processing interactions is misleading. From my experience, there may be 'incidental takes' of sea lion occurring beyond those reported because the data collection system selectively documents only traditional fishing vessel interactions with marine mammals, overlooking more-
subtle forms such as behavioral conditioning from ‘feeding’ on waste, or chemical exposure.

Occasionally sea lion reside in outfall mixing zones for weeks or more at a time. Sea lion learn quickly how to accommodate human activities into their search for food. They are not hesitant to confront and directly interact with humans and machinery, and their approach is extraordinary to watch for its learned, cautious assertiveness. It is not unusual for sea lion to climb onto the decks of fishing vessels using the trawl ramp, and ‘elbow’ crewman out of their way to spilled fish.

**Northern sea lion are in decline only in habitat shared with Alaska groundfish fisheries, concurrent with those fisheries development**

A decline in the abundance of Northern sea lion was first documented during surveys of eastern Aleutian Island rookeries in the early- and mid-1970s (Braham et al. 1980). From the eastern Aleutian Islands, the decline of sea lion apparently spread westward to the central and western Bering Sea, and then eastward into the Gulf of Alaska. Because many scientists and industry observers suspect the cause(s) for the decline are related in direct or indirect way(s) to fishery activities, the need for data on all forms of mammal-fishery interactions is great. The U.S. federal agency responsible for managing ocean fishes, the NMFS acknowledged this need (1991): "Marine mammal interactions with fish and fisheries are a growing concern. Steller sea lions are listed as threatened under the ESA and it must be shown that the groundfish fishery will not interfere with them. Pollock provide food for sea lions, and some fisheries have occurred near rookeries; however, we lack data to show a cause-and-effect relationship between the pollock fishery and the decline of the sea lions." The
bottom line, biologically speaking, is that failing to abate the decline will result in the extinction of Northern sea lions in Alaska within 100 years, according to projections of the decline by scientists (NMFS 1995).

Avise (2000), in a recent text on the emerging field of Phylogeography stated: "Rookeries of the Stellar sea lion (Eumetopias jubatus) in Russia, the Aleutians, and the Gulf of Alaska differ markedly from those in southeastern Alaska and Oregon in a pattern suggestive of historical population isolation in separate glacial refugia (Bickham et al. 1996)." Loughlin (1997) distinguished a ‘western’ versus ‘eastern’ subpopulation of Northern sea lions using the phylogeographic approach (see also Dizon et al. 1992). In making that distinction, the strongest indicator for distinguishing the two stocks came from examining genotype (i.e., the analysis of mitochondrial deoxyribose nucleic acid, or mtDNA). Distribution, population response, and phenotype were also examined. The ‘western’ stock, which is by far the bulk of the total population, is composed of sea lions breeding west of Cape Suckling, at 144 W. latitude (though isolated groups of Northern sea lion can be found as far south as Southern California). An ‘eastern’ stock was identified as those occupying rookeries east of Cape Suckling, located mainly in southeast Alaska and Canada, and along the contiguous U.S. coast. NMFS subsequently re-listed the western population of Steller sea lion as ‘endangered’, while the eastern population remains ‘threatened’ under the ESA in 1997.

As the fishery thrives, Northern sea lion are struggling. The history and geography of Alaska groundfish fisheries correlates with the range and the timeline of decline in the western stock of sea lion. Range-wide in Alaska, according to Merrick et al. (1987) and Loughlin (1997), adult and juvenile sea lion
numbers fell from approximately 300,000 in the early 1960s, to 116,000 individuals in 1989. A 78% decline was found on trend sites (i.e., rookeries and haul-out sites with reliable census data since the late-1950s to 1990.) The accuracy of such counts is thought to be fairly reliable given that the return rate of individuals to original breeding sites, termed rookery fidelity, is approximately 90%. The decline was most severe in the eastern Aleutian Island region, where 10,802 sea lions were counted in 1985. By 1989, only 3,145 sea lions were counted on the same sites during similar sampling periods (NMFS 1992). The western subpopulation of Northern sea lion has declined from about 177,000 (excluding pups) in the early-1960s, to roughly 33,600 in 1994 (NMFS 2001).

At the same time, counts of the eastern Northern sea lion subpopulation (mainly rookeries in southeastern Alaska and Canada) reveal a stable or slightly increasing population. So while the western subpopulation has declined 81%, the much smaller eastern subpopulation has increased 23%. The reason(s) for the decline of the western group and the increase in the eastern are not understood. Figure 1.4 shows the population abundance of both western and eastern stocks of Northern sea lion at various times, according to available data.

Study objectives

This research examines fisheries waste foraging by sea lion within the Alaska groundfish fisheries. While waste foraging is common, it is poorly studied by the many public agencies involved. It is important and required under the ESA to determine the full range of impacts on marine mammals from the federally-permitted groundfish fisheries off Alaska. The ESA prohibits federal agencies from "funding, authorizing, or carrying out any projects that jeopardize the existence of or modify the habitats of endangered species" (Thorne-Miller 1991).
Figure 1.4: Number of Northern Sea Lion, 1960-1994, Western and Eastern Subpopulations (divided at 144 E Longitude. Source: after U.S. Marine Mammal Commission Annual Report for 1997, Table 4.
The ESA further requires that critical habitats be protected (Jacobsen 1980). And in fact, varied restrictions of fishing activity have been enacted to protect sea lion (NMFS 1995; NMFS 2001). Buffer zones around major rookeries have preserved foraging opportunities in those zones by restricting all traversing and/or fishing within a regime of three-, ten-, and twenty-miles perimeters. A prohibition of shooting firearms at sea lion was implemented in order to prevent one historically-recognized source of mortality. Approaching rookeries on land (within one-half mile) was also prohibited to prevent harassment stress and the possibility of trampling mortality to pups when adult sea lions flee into the water. Spatial and temporal regulations have also been enacted on fishing activity, such as in the Gulf of Alaska, where Shelikof Strait pollock-spawning grounds are off-limits to fishing.

Despite these measures, years of field-based observation by this writer have indicated that potential impacts to sea lion from fisheries waste foraging are not being adequately investigated, reported, or mitigated by federal managers of fisheries, marine mammals, fisheries development, or pollutant discharge. As stated above, currently sea lion interactions with processing wastes in processor outfall zones are explicitly not monitored by federal fishery observers. Thus, the extent and impact from such foraging is not known. NMFS should reconsider its policy of not documenting the interactions between waste discharges and sea lion. An unmonitored interaction can not be assessed or managed. Hoover (1988) recognized the general failure of fishery managers to monitor interactions in light of rapid fisheries expansion. Hoover's observations are still valid:

Marine mammal-fisheries interactions are complex and need to be considered at both the ecological and management levels. . . Currently,
commercial fisheries are expanding without the baseline and monitoring data necessary to detect fishery-related impacts on marine mammal stocks. . . . Lowry (1982) ranked Steller sea lions among the top three of 26 species of Bering Sea marine mammals likely to interact with fisheries, on the basis of the sea lion’s heavy reliance on species of fish of similar size classes to those sought by fisheries, their moderately diverse diet, and their tendency to use regular feeding areas without other regular or optional feeding grounds.

In this report, sea lion foraging on fisheries waste is described in terms of frequency, character, and two forms of potential threats (food conditioning and exposure to two chemicals discharged into outfall zones). This research is based on six years of field experience as a U.S. fishery observer during the 1988-to-1993 period, and additional years as a fisher. Marine mammal sighting data gathered by NMFS-certified fishery observers stationed on fishing vessels and at processors in the central and eastern Bering Sea and in the western and central Gulf of Alaska during 1990 and 1992, are used to count and characterize incidents of waste foraging. The frequency of foraging by sea lion in at fishery operations is reported for by both incident and by total individuals sighted, during each month of 1990 and 1992. The pattern indicates that while the total number of sightings greatly decreased from 1990 to 1992, however, the proportion of these sightings which reported ‘waste-foraging’ incidents increased. The data is inconclusive because of an assortment of confounders (see Chapter 3).

My initial impression from years of field observation was that waste feeding became more common at seafood processors between 1988 and 1993, apparently because foragable forms of waste were being discharged by processors into locations more accessible to sea lion. It appeared from those field observations that as processors, particularly floating operations with limited storage and treatment facilities, moved to stationary positions in the nearshore
environment, it presented sea lion with increased opportunities to forage. There are several coastal Alaska locations where resident individuals or groups of sea lion forage on a daily basis continuously for weeks during the groundfishery seasons. As said, it is not known whether the proximity to major rookeries is a determining factor in the incidence waste foraging. It is also not known whether the disposal of highly-foragable forms of waste, has led to food-conditioning and increased sea lion interactions with fishery operations. Given the learning capacity and assertive curiosity of sea lions, it seems likely that food conditioning would lead to more frequent interactions between sea lions and fishery activities. I believe food conditioning is occurring, even though the finding that total number of sightings at all fishery operations declined between 1990 and 1992, would suggest the opposite. This decline may reflect the decline in sea lion abundance, or the vagaries of observer performance compounded by a reluctance on the part of NMFS to accept mammal sightings at processors, or other reasons. At any rate, because of serious confounders in the sighting data, the impression that fisheries waste acts to condition sea lions to increasingly interact with fishery operations cannot be refuted or affirmed.

**Methods**

The general methodology used here to describe sea lion waste-foraging follows that described by Johnston (1991):

... the earth’s surface comprises a complex mosaic of separate areas, or regions, each with its unique assemblages of phenomena, both ‘natural’ and created by humans. It is the task of the regional geographer to analyze and promote the appreciation of those unique assemblages, by taking the disparate material of the various sub-disciplines of geography (plus where relevant, other academic disciplines) and synthesize it into a description and analysis of the whole.
In addition, Sherman et al. (1990) provided guidance in Large Marine Ecosystems: Patterns, Processes, and Yields, stating, "Three factors are paramount to a geographic analysis: Location; interaction; and change." Those terms roughly correspond to those used here to describe sea lion foraging on seafood waste: frequency, character, and potential threats.

Chapter 1 introduces the interaction from initial observations, detailing the decline in the abundance of numerous Bering Sea species, the changes occurring in the environment, and in the fishery and the waste it generates. This first chapter attempts to provide a background for readers unfamiliar with the groundfish fisheries off Alaska.

Chapter 2 places the interaction within the regional context of two Bering Sea developments: pinniped evolution and biogeography; and the history of groundfish fisheries development in Alaska. Understanding both developments is critical to understanding what may at first appear to be local or haphazard incidents of waste-foraging. Rather, waste foraging occurs because of a failure of land-use planning in siting seafood processors, and a failure of resource managers to regulate fisheries interactions with food-stressed sea lion.

Chapter 3 tallies and characterises from anecdotal descriptions of Northern sea lion foraging on fishery wastes, within the Bering Sea and Gulf of Alaska, during 1990 and 1992. The FOIA procedure is used to gather sea lion sighting data, in addition to approximately 300 pages of agency documents which discuss or document sea lion(s) foraging on or encountering fishery wastes.

A FOIA request was also submitted to the U.S. EPA Region 10 Office of Wastewater Compliance for waste discharge records from Alaska processors. Initially, the study plan was to correlate discharge levels provided by EPA with
sea lion observations from NMFS, in order to determine whether a relationship between waste quality and sea lion presence could be detected. However, neither waste discharge data (mandated under the Clean Water Act), nor sea lion sightings proved reliable enough to substantiate an association between the two variables.

Chapter 4 describes the physical properties and biological effects of two chemicals (caustic disinfectants and organochlorines) found in fisheries waste. It describes their pathways and partitioning in the environment, and in the bodies of mammals. Levels of and impacts from exposure to these compounds upon mammals in the Bering Sea, and elsewhere if relevant, are reviewed.

Chapter 5 summarizes the conclusions drawn from chapters 1 through 4. It also recommends a method for recording sea mammal foraging on fisheries waste. The attraction of sea lions to waste has led to interactions with other human activities. For example, handfeeding from docks and boats, exposure to fuel-spill contaminants, active feeding from fishing gear, climbing on docks and on vessel trawl-ramps are all interactions which are associated with waste foraging. Waste-foraging also increases the exposure of sea lions to various deterence efforts, including mis-directed shotgun blasts during propeller repair or during underwater welding of a ship's hull. Finally, a formalized method of 'repeat photography' developed by the U.S. Forest Service to document the status of and changes in forest conditions is proposed for use by fishery observers to monitor waste-foraging interactions with marine mammals.

**Bering Sea changes**

The Northern Pacific Ocean is in a state of pronounced and unexplained change. There have been drastic changes in the geography and composition of
fish and marine mammal species, and in key physical parameters of the marine environment. The lack of data, the complexity of marine systems, predator-prey energetics, and natural variation; all introduce uncertainty in understanding what is going on in the North Pacific. The popular idea that the large-scale harvest of pollock has led to food stress and thus declines of sea lions and other species fails to appreciate changes to the Pacific ecosystem prior to pollock harvest. The history of human-induced change in the upwelling region of the Bering Sea is older than recent development of the pollock fishery. The pollock fishery might be thought of as a late phase of the maritime fur/fish-trade. The depletion of whales, fur seal, otters, crab, salmon, and other species has sent the North Pacific into a complex cycle of change. It is a global pattern, called "fishing down" food chains according to Pauly et al. (1998), who described the change in marine fish communities that have occurred during the past 40-50 years. Global landings of bottom fish (species which tend to be larger, longer-lived, high-trophically positioned, and fish-eating) have declined, whereas more fishing effort is now being devoted toward short-lived, low-trophic level invertebrates, and planktivorous pelagic fish.

Pauly et al. (1998) attributed the global decline in total fish catch—as total fishing effort and public investment increased—to two political factors. The first factor is open-access fisheries policy. Basically, open access allows unlimited participation in a (seasonal) fishery with a set quota of how many fish can be taken. Open access creates a 'race for fish' characterised by competitive pressure to fish hard and fast. It often results in significant waste of unintended catch, and can induce fishing during severe weather or dangerous conditions. This "derby-style" fishing also inundates the market with fish during one period,
reducing both the price paid to harvesters and the freshness of the product in the off-season. The second factor is publicly-subsidized fisheries development which often replaces an existing though foreign capacity for harvesting/processing fish. The inevitable result is that the displaced fishing capacity moves on to compete in other fisheries even though few or no fisheries are under-developed.

Such replacement of foreign fishers with a domestic industry is exactly what has happened in the North Pacific groundfish fisheries. Both factors are at work in the development of EEZ groundfish fisheries off Alaska. In fact, the current over-capacity of Alaska fishing vessels and processors is resulting in companies migrating out of the eastern Bering Sea to the pollock fishery in the Russian EEZ.

Many U.S. federal and state policies whose goals are to support further domestic investment in fisheries have directed development into sea lion habitat. Many of these fisheries also depend on public subsidies for development of infrastructure, such as harbors, docks, and breakwater structures. Subsidies such as loan guarantees for fleet expansion, and for construction of air- and marine-port facilities, housing, sewer, and water supply systems have been completed at many locations. These programs have the explicit goal of localizing fishery development but ignore the ramifications of replacing an existing capacity with redundant operations.

This problem of displaced fishing capacity is not unique to the groundfishery off Alaska. The Associated Press (Missoulian, 10 March 2000, A9) reported that since 1994, 160 million dollars in disaster relief has been spent nationally by the U.S. government for marine fishing boat buyback and job-retraining programs.
According to that article, an additional $421 million is now being proposed for similar programs in order to soften the impact of depleted stocks, habitat destruction, and high levels of bycatch in various fisheries. A coalition of environmental groups called the Marine Fish Conservation Network has blamed the regional fishery councils charged with managing fisheries for failing to enforce existing regulations. The coalition also said the NMFS has provided poor oversight in reviewing regional fishery plans. Proposed legislation, according to the article, would require that the councils study entire ecosystem impacts and ensure that fishing gear and practices not damage habitats.

The United Nations Environment Programme recently joined with the World Wide Fund for Nature in reporting that government subsidies have increased the global fishing capacity to the point where, presently, $124 billion are spent each year to earn $70 billion (Seattle Post-Intelligencer 3 June 1997). The report stated "During the past four decades, the capacity of global fishing fleets has increased fivefold while the productivity of most of the world's major fishing areas has declined." At the World Trade Organization meeting in the Fall of 1999, in Seattle, Washington, U.S. Commerce Secretary William Daley called for an end to these subsidies (see commentary by Rassam 2000). Daley stated that 70% of the world's fish stocks are in danger of being overfished, in large part because of subsidies totaling roughly twenty billion dollars, according to Rassam (2000).

Though it is the most endangered pinniped, sea lion are not the only species in the Bering Sea suffering decline. Three other pinnipeds and at least five seabird species, all variously dependant on pollock, are also experiencing decreases in abundance. This is not to say that commercial pollock harvesting is
their collective problem. As said, the dynamics of marine ecosystems are complex, and many factors are unstudied. If compared to management of other fish stocks, such as Atlantic cod, it can be said that Alaska pollock allocation quotas are relatively conservative. In terms of biomass, there would appear to be sufficient forage fish available. However, the subtle and indirect impacts of fishing are difficult to comprehend. There may be subtle disturbances induced by fishing, such as localized depletion, or other disruptions in the availability of fish to some predators. As well, changes in conditions such as sea temperature may be driving species deeper and into new habitats, possibly out of reach of young sea lion foragers. Because of this complexity, all known changes to sea lion habitat should be monitored, including waste foraging.

Declines within five fish-eating (piscivorous) seabird populations have been documented in the North Pacific (Alaska Sea Grant 1993). Springer (1993) summarized the conclusions of a conference investigating the decline of Bering Sea seabirds and marine mammals, stating: "The evidence presented at the conference strongly supports the hypothesis that food limitation is the cause of the declining bird populations on the Pribilof Islands."

Forage fishes have undergone great variation in population levels. The herring biomass, important to both pinnipeds and seabirds, has fluctuated greatly, both increasing and decreasing during the period of pinniped and seabird declines. During the past twenty-five years, the period of sea lion decline, pollock biomass has undergone a fourfold increase (Wooster 1993). Again, the factors related to the availability of prey for pinnipeds and seabirds are not well known. For example, pollock are cannabilistic to the extent that older fish devour 50% of the first-year class of ‘recruits.’ Thus, a large amount of
older fish may hinder the availability of younger-class pollock, which are understood to be the main prey of sea lion and seabirds. A further complication is the fact that pollock younger than two years old are not easily estimated in biomass studies.

Another fish species undergoing dramatic change in the Bering Sea is the Arrowtooth flounder (Atheresthes stomias), which has increased greatly in abundance. NMFS biologists are concerned about an increase in this fish because Arrowtooth may pose serious competition with sea lion as predators of young pollock (see Merrick’s comments in Obeso 1994). Young pollock less than two years are the primary prey of sea lions, especially juvenile sea lion who are restricted in foraging range, skills, and their ability to dive to the prime foraging depths. As noted, juvenile sea lion survival is believed to be a major factor in the collapse of the sea lion population. As well, salmon sharks, a species which preys on pollock and is considered a competitor for fish which sea lion rely on, have also greatly increased in abundance.

It appears from studies measuring sea lion, and other declining wildlife, that these animals are prey-stressed. At a conference of mammal, fisheries, seabird, and environmental scientists convened to answer the question "Is It Food," the conclusion was reached that "Food availability seems to be the most plausible explanation for observed declines of pinnipeds and piscivorous birds in the region" (Dearborn 1993). A recent National Research Council report, cited in the newsletter Ecology USA (24 March 1997, 55), stated that the effects of fishing are the only factors with a high likelihood of causing the sea lion decline. NMFS, after maintaining for years that the level of groundfish fishing did not threaten the health of sea lion, changed this opinion under pressure of a lawsuit (Lord 2001).
In 1998, NMFS determined that the high levels of groundfish harvested in areas critical to sea lion—those near rookeries—may cause localized depletion of prey needed by sea lion, especially juveniles.

The total biomass of Bering Sea pollock is thought to be maintained at fairly high levels by the setting of conservative harvest quotas. This would appear, grossly at least, to indicate that an adequate prey base is available for marine mammal predators. However, historic and current harvests and/or climate change-induced alteration of environmental conditions may now be resulting in a disruption of available prey. For example, if water temperature warms, as it apparently has, then fish may retreat to colder depths. While adult sea lions can dive to depths of 200 or more meters, juveniles are limited to about 50 meters and are vulnerable to changes that make foraging more difficult.

Alternatively, the current harvest may affect local availability of prey. If harvest effort has moved nearer to shore, as it appears it has with the domestication of the pollock fishery, it may be that pollock biomass has been depleted and/or disturbed in nearshore foraging grounds. If harvests are conducted near processors and rookeries, prey may become less available to juveniles learning to forage, and to lactating sea lions who are limited time-wise by the need to nurse young. Rather than climate or environmental change, some scientists suspect that large-scale harvesting of fish is depleting or disrupting the availability of prey. Alverson (1991) suggested that historic harvests have altered the composition of fish species in the Bering Sea. Harvests of herring, flatfish (mainly yellowfin sole) and rockfishes during the pre-EEZ period may have caused pollock to become so abundant in the Bering Sea. In the absence of oily and more-nutritious prey such as herring, Alverson aserts
that sea lion may have been compelled to change their diet, and now may be suffering nutritionally from a reliance on the relatively-lean pollock.

Alverson (1991) also noted that the causal factors of the sea lion decline are probably numerous, and that these factors have likely fluctuated in importance over the thirty-year decline. The causes of the declining populations of pinnipeds and seabirds are not simple, and will most probably require the recognition and remediation of more than one factor. Capture in fishing gear, incidental shooting (NMFS 1995); reproductive failures due to diseases or contamination by organochlorines (DeLong et al. 1973); and the affects of environmental change (Niebauer and Hollowed 1993; Amerongen 1997) have all been described as potential contributing factors in these declines. This uncertainty is why it is important to recognize all threats to sea lion and all disturbances to their habitat. Waste foraging may or may not pose a threat to sea lion. At the least, however, waste foraging should be carefully observed by NMFS field personnel. Further study should determine how common, deleterious, or advantageous it is.

So while the decline in sea lion abundance is not disputed, the cause(s) are poorly understood. Natural population variation to this degree is considered an unlikely explanation for sea lion, who exhibit "K-selected" traits: slow development; delayed reproduction; few offspring; high maternal investment; long lives; and long generational periods. Such species rarely exhibit natural fluctuation of the scale documented in the sea lion population. Generally, ‘K’ species maintain a population size near ‘carrying capacity’ and have evolved in relatively stable environments. Populations of ‘R’ species, on the other hand, fluctuate widely in abundance, making up for their risk-prone instable

The lack of available food as a hypothesis in explaining the sea lion population decline is supported by some studies of juveniles and pups, but not others. Pup counts and the individual weights of pups were both found to be greatly reduced at one eastern Aleutian Island rookery (Ugamak) during 1997 (see remarks of Merrick, quoted in Amerongen 1997). NMFS (1995) acknowledged an earlier study which reported: "Juvenile sea lions in the 1980s were found to be significantly smaller by weight (15-20%) than those from the same Gulf of Alaska location in the 1970s (Calkins and Goodwin 1988)." In that same report, NMFS 1995 noted that 1-2 month old pups "... in the decline area are as large or larger than pups in areas not experiencing decline." NMFS further reported that: "... physiological studies of pups also indicate that pups are healthy (Castellini 1993; Rea et al. 1993)." Juvenile survival appears to be greatly decreased in certain locations. Pascual and Adkinson (1994) and York (1994) both concluded that a decrease in juvenile survival is a key factor underlying the decline of Northern sea lion. The failure of juveniles to survive was highlighted when NMFS' biologists tagged 800 sea lion pups near Kodiak Island in 1987. By 1994, only 30 had been re-sighted. Under expected survival rates, 100 would have survived (see comments of Merrick, in Obeso 1994).

Pinpointing the causes of the sea lion decline will be difficult. The present study does not suggest that foraging on fisheries waste is a major contributor to the sea lion decline. It is questioned here, however, whether certain groups of sea lions are being conditioned to increasingly interact with fishery operations, perhaps leading to later deterrence actions or inadvertant chemical exposures.
Exposure to two forms of chemicals may be impacting the health of small groups of sea lions that frequent waste outfalls. It raises these issues from first-hand field experiences not directly shared by the managers of fisheries, pollutants, harbor development, or mammals. Field-based fishery observers are in a unique position to observe day-in and day-out operations of the fishing industry; their experience should be fully utilized.

Because of a long and complex history of mammal and fish exploitation, and the possibility of climate change, an assortment of causal factors may be compounding one another in disrupting the North Pacific ecosystem. For example, there is a reported two-degree warming of waters in the North Pacific Ocean (Trillmich and Ono 1991; Amerongen 1997; or see the newsletter *Ecology USA*, 28 July 1998, 134). This warming is itself a mystery. It may be associated with the El Nino Southern Oscillation (ENSO). Species normally associated with more-temperate waters, such as the white shark, were observed in the Gulf of Alaska during the 1990s ENSO event. Warming seas would bring a cascade of changes, including perhaps a disruption of marine upwellings and reduction of nutrient loading, altering the movement of forage fish. Warming seas might drive fish to deeper, colder depths, resulting in longer bouts of maternal foraging and stress to juveniles who are limited in their ability to dive deeply.

Many environmental changes are being studied in the North Pacific Ocean. Variation over several decades termed "extraordinary" by Niebauer and Hollowed (1983), in ice cover, surface winds, sea-surface, and air temperatures have been documented in the Bering Sea. Average sea-surface and air temperatures during 1973-to-1975, for example, were two-to-five degrees Celsius below average around the Pribilof Islands. In 1976, a strong extra-
tropical effect from the ENSO made the Aleutian Low more intense, increasing ice cover and air flow. By 1979 and a resumption of non-ENSO patterns, sea and air temperatures were above normal, and ice cover had retreated to 15 percent less than the mean annual extent. A correlation was noted between strong first-year age classes of forage fishes with periods of warming. However, Higgins (1984) found, as did Ono et al. (1987), a decrease in foraging success of California sea lions during ENSO periods.
CHAPTER 2

Resource partitioning

In the study of dispersal and distribution of animals, it is important to see that the physical conditions lead, and that in a more or less definite succession the flora and fauna follow; thus the fauna comes to fit the habitat as a flexible material does a mold. The time is passed when faunal lists should be the aim of faunal studies. The study must not only be comparative, but genetic, and much stress must be laid on the study of the habitat, not in a static, rigid sense, but as a fluctuating or periodical medium.

C. Adams, 1901 (from Avise 2000,)

'Resource partitioning' is a term used in studies of community ecology to describe how functionally-similar species, such as the coyote and wolf, or the fur seal and sea lion, structure their use of the same limited resources to avoid direct competition. In differentiating resource use, either spatially, methodologically, and/or temporally, the niches of a habitat are compressed. This process of 'competitive niche differentiation' enables the co-existence of a greater diversity of species (Schoener 1986).

G.F. Gause's research from the 1930s was credited by Schoener (1986) as laying the groundwork for addressing a major ecological quandry of the early 1900s: how do natural systems maintain their diversity of species, or rather, by what processes do so many species coexist? Gause observed under laboratory conditions that species of paramecium which were too similar in their mode of predation will compete to the eventual extinction of one species. He found that species which differentiated their use of resources were able to coexist (although each population then experienced a slower growth rate). Gause concluded that competitive exclusion' of one species would occur unless there was at least one major ecological distinction in competing species, "such
as where they obtain most of their food" according to Schoener (1986).

The concepts of ‘resource partitioning’ and ‘niche differentiation’ are useful in understanding pinniped habitat use in the Bering Sea. For example, why do sea lions routinely forage on seafood processing wastes discharged into the nearshore environment, while their near-relative the fur seal, also reliant on bottomfish as prey and on coastal habitats for rookery use, generally do not? The answer lies in the biogeographies of each species, specifically, varying patterns of habitat use attuned to long-evolved reproductive functioning. Fur seal and sea lion vary their rookeries in terms of location, density, and period of use. These variables facilitate differing foraging patterns, especially by mothers and juveniles, and ultimately results in physical differences which reinforce niche differentiation.

Pinnipeds are not alone in partitioning marine resources to avoid competition. Resource partitioning also describes, perhaps figuratively, the process of divvying up who gains from marine resource development and who does not. Commercial interests in the human community have previously and continue to subdivide access to and allocation of fish resources, through instruments such as exclusive economic zones, quota allocation schemes, or ‘catcher-vessel operating areas’ near shoreplant communities restricted to local harvest.

This chapter reviews the development of both sea lion and the groundfish fisheries industry in order to understand why they now interact so frequently.

Otariid ecology: a landlocked biogeography.

The amniotic fluid of all mammals is remarkably similar to seawater; both fluids contain the same salts in almost exactly the same proportions. Amniotic fluid mimics the seas that nourished our ancient ancestors. Mammalian mothers reconfect it in their bodies in order to
brew for their embryos the best conditions to foster life. It is this ancestral sea that is lost when a pregnant woman’s waters burst shortly before the birth of her child. At birth, we humans reenact life’s transition from water to land as we are born from the ancient seas of our mother’s amnion to the dry land of our terrestrial existence.

Payne Among whales 1995

The sea is the earth’s constant womb. It gestates the embryos of more than two hundred thousand species, thus performing a function that relatively few marine females can accomplish in their own bodies.

Mammals not only succeeded with gestation, diversifying into many species, they grew larger and required abundant food. This nutritional requirement applied to babies as well as adults so that there came to be a great evolutionary demand upon parents to supply this food. For mammals, the requirement of warm-bloodedness (homeothermy) eventually obliged females to spend the bulk of their lives gestating and lactating.

This devotion enabled mammals to live in a broader range of environments than other vertebrates. The intelligence and cooperation needed for extended mothering eventually brought mammalian life to levels of higher sentient and finally self-conscious being. It was as if mother’s milk made such an impression upon the individual that each one, female and male alike, made attempts to communicate with other species members just to discover whether they would be as warm and nurturing as that first-known being. . . . Our class owes its uniqueness to mothering and lactation; indeed, this is why it is called Mammalia, after the mammae or mammary glands.

Elia 1988, The Female Animal

Marine mammals in their ‘true’ form are distinguished by two characteristics according to eminent wildlife biologist Victor Scheffer. They derive their food from beneath the surface of the sea, and are unable to interbreed with terrestrial mammals. "The polar bear in captivity," Scheffer (1973) noted in distinguishing them from the marine mammal classification, "will readily mate with the brown bear." The clarity of this distinction between marine and terrestrial fogs over in managing wild mammals inhabiting the maritime zone. Animals who rely on land for reproduction yet derive their food from the sea bridge many borders.

Recent descriptions of sea mammals recognize that, functionally, marine
mammals can not be easily categorized as either marine or terrestrial. Loughlin and Miller (1989), for example, called the polar bear an "equivocal" marine mammal. A clear distinction of what constitutes a marine mammal is not unequivocal, according to Reeves et al. (1992).

The fossil record indicates that all marine mammal forms have re-adapted to the sea from three terrestrial 'stem' ancestors: ungulates, otters, and bears. Scheffer (1976) described marine mammal evolution functionally, as adapting from these land carnivores into six basic forms: sea otters; walking seals; crawling seals; sirenians; toothed cetaceans; and baleen cetaceans.

A practical consequence of these forms is that they predispose interactions with human activities, such as pinniped foraging on seafood wastes. These predispositions can be seen in reviews of marine mammal-fisheries interactions. Loughlin and Jones (1983) listed the marine mammals likely to interact with Bering Sea fisheries. Uniquely, Northern sea lions were reported as interacting with every type of fishery category. (They also stated that insufficient data bases existed to fully assess the level of sea lion interaction with the fisheries.) Loughlin and Miller (1989) reviewed marine mammal interactions with Bering Sea fisheries. Again, sea lion were the only animal listed in every category.

The taxonomic Class 'Mammalia' contains three Orders composed partly of marine mammals. Marine mammal Orders include the 'cetaceans' containing 75 species of whales, dolphins, and porpoises. A second Order includes the 'sirenians,' containing the manatees, dugongs, and sea cows.

Cetacean and sirenian species are believed to have habituated to the sea roughly 60 and 50-55 million years ago, respectively, from "primitive hoofed animals" (Scheffer 1976). Both cetaceans and sirenians are fully aquatic and
never leave the water. Cetaceans have completely internalized their limbs and have vertebrae which extend their entire body, achieving an advanced ‘fusiform’ or torpedo-like shape. Propulsion is achieved by vertically undulating their flukes and through motion of the entire body, rather than mainly the limbs, shoulders, and hips. Sirenians have also internalized their hind limbs, but some use fore flippers to maneuver and manipulate foods and offspring. Sirenians and baleen whales feed almost exclusively on plants, likely a carry-over from their ungulate ancestry (Loughlin and Miller 1989).

The third Order which contains marine mammals is ‘Carnivora,’ and includes the sea otter, polar bear, and numerous pinniped species (a wide variety of Phocid or ‘true’ seals, in addition to the two Otariids—fur seal and sea lion, and the single Odobenid—the walrus).

Some scientists prefer to place pinnipeds in a distinct Order. However, recent descriptions generally do not (see Reeves et al. 1992). There is a century-long debate as to the origin of pinnipeds. One theory (monophylogeny) holds that the Odobenid, Otariids, and Phocids derive from one ancestral stem. Another, the dual-origin position (diphylogeny), contends that fur seals, sea lions, and the walrus evolved from an early bear-like ancestor, while the Phocid seals derived from an early otter. Berta and Wyss (1994) reviewed this debate.

Of the marine mammals, sea otters (*Enhydra lutris*) branched into marine creatures most recently, about 2 million years ago, from a land otter ancestor. They have flippers for hind limbs, but their front limbs are paws. Because sea otters are highly valued for their exquisite pelts, their population was severely extirpated from large portions of it’s range during maritime fur trading of the 18th and 19th centuries. Protection afforded in the 1911 ‘Treaty for the
Preservation and Protection of Fur Seals and Sea Otters,' co-signed by Canada, United States, Russia, and Japan, has been relatively successful in recovering both sea otters and fur seals. The Treaty was the first international agreement given wholly to conserving wildlife (Loughlin and Miller 1989), and was widely used as a model for other wildlife conservation laws.

The polar bear (Ursus maritimus) is one of eight ("well defined") living members of the Ursidae Family and is, according to Reeves et al. (1992), the most recently-derived variation. Though seasonally they may spend considerable time in the sea, and interact with or rely on marine animals (such as ringed seals, which hide their young from bears in snow lairs), the polar bear in the U.S. is managed by the Fish and Wildlife Service, an agency with limited management control over marine conditions or habitat.

Pinniped means "fin-footed" in Latin (Scheffer 1973), as all four limbs of these species are flippers. Although the fossil evidence is incomplete, it is believed that pinnipeds have been living in the sea for twenty-to-thirty million years. The pinnipeds are composed of three Families: Phocidae (‘true’ or ‘crawling’ seals, including 19 species); Otariidae (the ‘eared’ or ‘walking’ fur seals and sea lions, including 14 species); and the Odobenidae (also a ‘walking’ seal, including the single walrus species).

To understand how it is that sea lions are particularly at risk to foraging on seafood processing waste, and thus how processing locations might be planned to minimize their attractive value to sea lions, the distinctive characteristics of each Family must be understood. Pinnipeds can be usefully distinguished by adaptations which increase each species’ ability to move on land. While pinnipeds feed exclusively from the sea, they seasonally occupy
land or ice in order to breed, rest, molt, and nurse pups.

Key to the sea lion's 'landlocked' character are distinctions in marine mammal limbs (English 1976; Wyss 1989). As noted, the Otariids (fur seals and sea lions) and the single Odobenid (walrus) are termed "walking" seals (Scheffer 1973). The term is a reference to their ability to pivot rear flippers forward, and using well-developed fore-flipper joints, elevate themselves, and thus 'walk' (or climb) on rough and broken rock surfaces.

The importance of Otariid 'walking' limbs is that they allow fur seal and sea lion to inhabit rookery sites situated near the richest upwelling zones in the ice-free subarctic of the eastern and central Bering Sea and more southerly coastal zones. These rookeries are typically located on coastal shelf sites of columnar basalt substrate which feature broken and angular surfaces polished over time by the action of waves. Because of the strength of their fore-flipper shoulder joints, and the ability to turn forward their rear flippers, sea lion are able to lift their two-thousand-pound bodies up from the surface and move over these unlevel surfaces. There is a defensive need to quickly scramble, both onto these shelves to escape predation from the sea, and into the sea if a threat appears on land. The mass scramble of adult sea lions into the sea is a behavior used by biologists to conduct pup counts, by 'spooking' the older sea lions into the water (although this carries the risk of injuring pups in the process). As discussed in chapter 1, this ability to climb on hard, broken, and sloping surfaces facilitates the sea lion's interaction with certain fishery platforms, such as vessel trawl-ramps, docks, breakwater jetties, and navigational buoys.

Bruemmer (1983) reported on a situation that demonstrates how the sea
lion's ability to maneuver, combined with their aggressive curiosity, gets them into trouble with human-induced disturbances of natural habitat. The Auckland Islands (300 miles south of Australia) are inhabited by Hooker's sea lions, the rarest, least known, and geographically the most-restricted of the five sea lion species. There, researchers discovered a unique source of mortality to groups of pups. Rabbits released during European settlement of these Islands have riddled certain coastal areas with burrows. Hooker's sea lion pups investigate the burrows and wiggle down into them one after another, until the group dies an agonizing death due to starvation and suffocation when they find themselves unable to reverse their way out. 10% of Enderby Island pups die this way according to Bruemmer. These same New Zealand sea lions are also interacting with fishery activity, congregating with trawlers operating on the Auckland shelf. Not unlike their Northern cousins, "sea lions and trawlers are often seeking the same prey in the same area," reported Donogue (1997).

Phocid seals differ in fundamental ways from the Otariids. The physical structure of their shoulders and hips do not allow them to hoist themselves off the surface of their rookeries. Phocids tend to breed on seasonal ice. Thus, they move about by shuffling or sliding on their bellies and are termed 'crawling' seals.

As Cohen and Massey (1984) observed, "Life is organized around reproduction." Northern sea lion, relative to other pinnipeds, are 'landlocked' in their reproductive strategy. In describing the significance of lactation to mammalian evolution, Pond (1977) noted: "The lactation habit has important consequences upon the morphology, food gathering strategy and energy balance of the mother. . . . The fat, protein, water and mineral composition of
the milk has been related to the habits and habitat of the species." Indeed, distinctions in maternal foraging habits and habitats is the case with sea lions and fur seals. Otariids have partitioned Bering Sea habitats by differentiating foraging ranges related to the provision of milk to pups.

Sea lion are the largest Otariid in the Bering Sea because they provide pups with a diet that promotes hard-tissue development early on. This pattern of providing high-protein milk over a prolonged period dictates that sea lion mothers must raise their young throughout the Aleutian Islands, where foraging grounds are in abundance near rookeries. This contrasts with the situation of fur seals, whose rookeries are limited in the availability of nearshore feeding grounds. Corresponding to the clustered rookeries of fur seals, they have adapted a shorter period of onshore nursing coupled with longer offshore foraging by both mother and pup. This strategy has presumably developed to avoid direct competition with the larger sea lion, known to kill young fur seals when they confront them.

Pup body mass in Phocids is achieved by the rapid accumulation of a blubber layer—necessary insulation for pups which must soon forage for extended periods in the frigid open sea. Zimmer (1998) described the effects of frigid water and the need for a insulating blubber layer in whales: "A warm-blooded animal will lose heat to water twenty-four times faster than air." In contrast, sea lion have the thermoregulatory problem of being out of water for long periods, causing heat exhaustion to mature animals. Thus sea lion rookeries and haul-out sites are typically exposed to the cooling effect of waves and wind.

Differences in sea lion and fur seal maternal foraging ranges and nursing
habits correlate to each animal's rookery locations. Sea lions rely on land and nearshore foraging habitats to a much greater extent than other pinnipeds. The consequences are dietary, resulting ultimately in significant physiological differences. Sea lions inhabit rookeries throughout the Aleutian Islands and coastal mainland Alaska which facilitate nearshore foraging and a prolonged daily-regime of perinatal nursing. Northern fur seal, on the other hand, breed mainly (75%) on the Pribilof group of four Islands in the central Bering Sea. Conforming to this situation, fur seals depart their rookeries to forage far offshore in waters independent from their rookeries. This geography of foraging is important in understanding why sea lion are most impacted by seafood development in the nearshore environment.

Costa (1991) studied the energetics of foraging pinnipeds and characterised Otariid maternal foraging this way: "Otariids like the Steller sea lion, make trips of relatively short duration (36 hour average), feed nearshore and thus travel short distances to the feeding grounds, whereas northern fur seals feed 100 km offshore and make trips of 7 days duration (Loughlin et al., 1987)." Costa (1991) further explained the consequence of these foraging patterns:

... we find species that make short foraging trips have lipid-poor milk (low energy density), whereas species that make long foraging trips produce lipid-rich milk (high energy density). ... The increased energy density of pinniped milk does have a tradeoff in that it may limit the amount of protein or other essential nutrients available to the offspring. This is because the increased energy content of pinniped milk is achieved by increases in milk lipid content with negligible changes in its protein content. Thus the young are provided with more than enough energy to fuel metabolism, but may be limited in their ability to grow.

Costa (1991) noted that sea lions are "central place foragers" whose feeding patterns correspond with the predictions of central place foraging theory.
described by two University of Washington scientists (Orians and Pearson 1977), this theory predicts the optimal pattern of foraging from a central place, such as a rookery. According to the theory, when foraging longer distances, a parent providing sustenance to young should make few trips of longer duration, and return with greater amounts of food, compared to animals foraging short distances. The short-distance foragers should make many trips, each resulting in a relatively lower yield of food. However, as Costa’s research revealed, not only does the quantity of energy vary according to foraging trip duration, the nutritional quality does also. Costa (1991) wrote:

In contrast to seabirds, pinnipeds are able to optimize food delivery to their young, in a manner consistent with the predictions of central place foraging theory by adjusting milk composition in response to differences in trip duration. Lipid and therefore energy content of the milk of otariids has been shown to increase as trip duration increases (Trillmich and Lechner, 1986). Incorporating phocid milk composition data and a larger data set for otariids we find species that make short foraging trips have lipid-poor milk (low energy density), whereas species that make long foraging trips produce lipid-rich milk (high energy density) (Fig. 4).

The increased energy density of pinniped milk does have a tradeoff in that it may limit the amount of protein or other essential nutrients available to the offspring.

It appears that the penguin and otariid strategy promote lean growth early, whereas phocids defer lean growth until after weaning.

This foraging pattern provides Otariid pups, particularly sea lions, with a leaner but protein-enriched diet. This results in the early development of hard tissue. Fueled by a prolonged period of lactational dependance on protein-rich milk, sea lions achieve a physical size which is the largest of the seals. Large physical stature is important in competing both interspecifically and intraspecifically. The large size of male sea lion also allows them to endure a prolonged ordeal of fasting which occurs during the entire mating period.
Again, Costa (1991) analyzed the energetics:

The major difference between otariid and phocid reproductive biology comes after parturition. Most phocid mothers give birth to a pup and stay onshore continuously, suckling the pup until weaning. During lactation the mother does not feed and milk is produced from body reserves stored prior to parturition. Weaning is abrupt and occurs after a minimum of 4 days of nursing (in the hooded seal, Bowen et al., 1985) to a maximum of approximately 5 weeks (in the Weddell seal, Kaufman et al., 1975).

In contrast to phocids, otariid mothers remain with their pups only during the first week following parturition. After this initial perinatal period the female returns to sea to feed, intermittently returning to suckle her pup onshore. Depending on the species, the mother spends between 1 and 7 days feeding at sea, then returns to her pup, which has been fasting onshore, and suckles it for 1 to 3 days."

Fur seal and sea lion have evolved niche-dependent patterns which allow their coexistence, but constrain their ability to change if their habitat is altered. The reproductive biogeographies of Otariids carry consequences for planning land use in coastal Alaska. Sea lion foraging in the outfall mixing zones of seafood processors may be inevitable if these facilities are placed within the foraging range of rookeries, especially in Summer or early Fall when mothers are constrained to frequent bouts of nursing and when young sea lion are learning to forage and limited to shallow depth of dives. By mid-September, pups have learned to swim and accompany their mothers on foraging trips. Because of a limited foraging capacity, mothers with pups are restricted to nearshore foraging areas and may feed at outfalls during the Fall fishing season. The sea lion foraging strategy is thus a geographical disadvantage in avoiding interactions with groundfish processors situated near major rookeries.

Not only does the terrestrial nature of Otariid limbs and a nearshore foraging pattern place sea lions in the position of interacting with the fishery, their
learning capacity does as well. Sea lion are easily-conditioned and possess an aggressive curiosity; both traits greatly exacerbate the problem of waste-foraging interactions. Chapter 3 discusses sea lion learning in more detail.

**Alaska groundfish fisheries development.**

Reorganized, the history of the West is a study of a place undergoing conquest and never fully escaping its consequences. . . . Conquest basically involved the drawing of lines on a map, the definition and allocation of ownership (personal, tribal, corporate, state, federal, and international), and the evolution of land from matter to property. . . . Western history has been an ongoing competition for legitimacy for the right to claim for oneself and sometimes for one’s group the status of legitimate beneficiary of western resources. . . .

Conquest was a literal, territorial form of economic growth. Westward expansion was the most concrete, down-to-earth demonstration of the economic habit on which the entire nation became dependent.

P.N. Limerick *The Legacy of Conquest*, 1988

On March 10, 1983, President Reagan proclaimed that the ocean area from a line 3 miles off the coast of the United States and its island territories out to 200 nautical miles was the Exclusive Economic Zone (EEZ) of this Nation. This action gives our Nation jurisdiction over the vast living and nonliving resources within those 3.9 billion acres. The importance of the EEZ is emphasized when its size is compared to the total onshore area of the United States and its territories of only 2.3 billion acres. This new area may well be analogous to the Louisiana Purchase of 1803, which doubled the area of our country by extending its border west to the Rocky Mountains.

McGregor and Offield

*The Exclusive Economic Zone: An exciting new frontier*, 1983

The evolution of modern international Law of the Sea has been characterized by efforts of maritime powers to mold the law to accommodate their national interests. . . .

The mighty have always attempted to impose their will on the weak. This is the last frontier, of this universe, which unless we organize ourselves properly, shall be subjected to even worse colonialism than we have recently been subjected to in our countries.


**The demersal fisheries of the North Pacific**

The groundfish fisheries off Alaska target approximately ten fish species which inhabit the near-bottom realm, though mainly Walleye pollock. Pollock
alone accounted for 62% (by volume) of all groundfish species caught off Alaska, according to Kinoshita et al. (1998). The Alaska pollock fishery alternates, depending on environmental conditions, with Peruvian anchovy as the largest-volume fishery in the world.

Figure 2.1 depicts Alaska groundfish use by interest groups (after North Pacific Fisheries Management Council, undated brochure; also after NMFS 2001). It shows that during the 1979-1989 period, a drastic change occurred in terms of who harvested and processed Alaska groundfish. The change from a foreign to domestic fishery has resulted in critical geographical changes in where fishery activity occurs. When these fisheries were predominantly foreign, both harvesting and processing occurred far offshore. One reason for this was that foreign vessels were restricted from approaching within the U.S. territorial boundary of three nautical miles, and thus processors were legally unable to use the nearshore zone. With the ‘Americanization’ of the fishery, however, the harvest and processing of pollock and other groundfisheries has moved nearer to shore. Figure 2.2 illustrates the proportion of landings used in the domestic Alaska groundfish by ‘on-shore’ versus ‘at-sea’ processing sectors, in the 1986-1993 period. Two facts should be clear from Figure 2.2: domestic processing took over from that done by the foreign fleet; and on-shore processing has greatly increased in proportion to that of the at-sea sector.

It should be realized that while fishing boats must be ‘U.S.-flagged’ in order to participate in fisheries within the American EEZ, shorebased processors involved in these fisheries may be wholly or partly owned by foreign interests. And in fact, many shoreplants are owned by Japanese corporations. The U.S. General Accounting Office (1991) reported on the issue in response to a request by
Figure 2.1 Alaska Groundfish Use by Interest Groups, 1979-1989. Source: after North Pacific Fisheries Management Council, undated pamphlet.
Alaska Senator Frank Murkowski, stating: "... some degree of foreign ownership was common—128 of the 347 Alaska seafood processing facilities included in the study. Such ownership ranged from 5 to 100 percent." To an unknown extent, the objective of domesticating Alaska groundfish has effectively funneled foreign investment into the shore-based processing sector of the Alaskan pollock fishery. Americanizing these fisheries may have greatly hastened the pace at which fish processing moves into the nearshore environment because once the option of foreign participation in actual fishing was eliminated, the only option for nations such as Japan to participate was to invest in the onshore processing sector.

Pollock was scarcely harvested prior to 1960. About that time, a process was created by the Japanese for making a minced-fish paste from firm- and white-fleshed bottomfish species. Pollock are well suited to producing minced fish paste because it is an abundant fish with a particularly white and firm flesh. Surimi is a highly-processed product made by mincing pollock fillets into a paste, repeatedly washing the paste so that high-protein solids remain, and adding sugar and sorbitol gelling agents to achieve a crab meat-like texture. The paste is an intermediate product exported to Japan, where it is further refined into finished products such as simulated crab- or lobster-meat, fish patties, and sausage-type items. In 1982, 90% of the global raw material used to make surimi was, and still largely is, derived from the abundant stocks of Alaska pollock (Hotta 1982). Prior to the development of surimi processing technology, pollock was generally discarded when caught, except for the harvest of its eggs, known as "roe-stripping." The practice of roe-stripping, which included discarding the rest of the fish, was later prohibited in U.S. waters off Alaska.

The surimi process was a new method for using a previously unexploited
resource. Like prior technological innovations such as barbed wire and the plow--both instrumental in the expansion of economic activity into the unfamiliar grassland frontier of North America--adaptations in fishing gear/vessel technology have allowed fishing fleets to expand their range of farther from shore and the ocean surface.

Many of the innovations to equipment used in the Alaska pollock industry originate initially from whaling-era improvements. The addition of factories to fishing vessels is one example; another important innovation was the alteration of the steering mechanism, from a single center-mounted rudder in the stern, to dual side-located rudders and ‘bow-thrusters.’ This relocation of steering allowed for a whale carcass to be brought onto the ship’s deck from the rear, via the ‘stern slipway’ another innovation developed in 1925 (Ellis 2000). The slipway allowed a 100-ton blue whale to be brought onboard for processing, without (drastically) impeding the vessel’s ability to move forward. Importantly, it freed whaling vessels of the tether of shoreside processing, allowing distant and unexploited fishing grounds to be utilised. While the stern slipway revolutionized whaling, it was also important to bottomfish fishing in its adaptation as a trawl ramp. Through these ramps, trawl nets capable of holding 120 metric tons of fish are hauled aboard using winches and cables, and then dumped into factory bins below deck.

From 1986 to 1993, groundfish resource development ‘boomed’ along the Alaskan coast. The replacement of an entirely foreign industry operating offshore with a domestic capacity to harvest and process groundfish stocks was a primary objective of the U.S. Fisheries Conservation and Management Act (FCMA—also known as the Magnuson Act, after Senator Warren G. Magnuson of
Washington State). FCMA was the enabling legislation for establishment of a U.S. EEZ.

University of Washington historian Huntington has suggested (1992) that laws regulating the exploitation of Bering Sea wildlife have been motivated by proprietary concerns from the beginning of the maritime fur trade period. Russian administrators, for example, dictated that Aleut natives were prohibited from killing sea otters to reserve the resource for Russian interests. This partitioning of Bering Sea resources by a narrowing scale of self-interested groups continues to the present. Appropriation is at the heart of the rush to exploit Alaska fisheries.

EEZ designations represent a monumental realignment in the distribution of the globe’s marine resources, and as such, were a highly contentious issue to many members of the United Nations. Many "land-locked" and "geographically-disadvantaged" nations, as they were called, questioned why powerful coastal nations could so freely appropriate such large tracts of the global commons (see discussions in Wenk 1972; Schmidt 1989; and Vasciannie 1990). EEZs establish the right to exclusive use of natural resources from the boundary of the traditional ‘territorial sea’ to 200 nautical miles offshore of all U.S. States and Territories. Most of the globe’s most species rich habitat—the coastal shelf—has been effectively appropriated by EEZ designations.

Other public policies have continued to partition marine resources, often under the influence of a narrowing circle of interests. In the Alaska groundfish fisheries, for example, ‘offshore’ and ‘onshore’ interests have battled for the right to harvest shares of the pollock quota. Catcher-vessel operating areas (CVOAs) have been designated offshore of certain Alaska communities, giving
exclusive use of certain areas to fishing boats delivering to the processors in those communities.

Public policy is partitioning the pollock resource with one priority objective—to increase coastal Alaska community development. The result has been the re-location of fish processing to a variety of nearshore localities. In many instances these locations are directly adjacent to major fur seal and sea lion rookeries. Incidents of sea lion foraging on seafood waste illustrate one impact from this re-development of the pollock fishery. Further, waste foraging is not being either documented or considered in the marine fisheries planning process. The establishment of ‘Community Development Quotas’ (CDQs) was a policy directed toward developing remote Alaskan community economies. The CDQ program dedicated portions of the total groundfish quota to selected coastal communities for the explicit purpose of developing industry in those locations. One criteria in selecting CDQ communities was that they have no history of groundfish use, effectively insuring that areas free from seafood waste disposal become more attractive to marine mammal foragers.

The goal of boosting the economic base of coastal communities is itself not the problem; it is the rushed and poorly-managed implementation of those development policies. The problem is that development schemes such as the CDQ and CVOA programs are being implemented without a full assessment of their impacts to other natural resources. In the Alaska pollock fishery, there has been such a fierce rate of capitalization and resulting competition to exploit the resource that certain precautionary measures, such as thorough monitoring of all fishery interactions with sea mammals, are being disregarded.

Shima (1996) noted the relocation of groundfishing activity in his dissertation
"The fishing fleet appears to have moved closer to shore as a result of the domestication process. Catches in Steller sea lion critical habitat (defined in 58 FR17181) more than doubled (15% to 35%) when the Shelikof [Shelikof Strait, located north of Kodiak Island in the Gulf of Alaska] spawning aggregation was discovered in 1981 and by 1985, the percentage of pollock catches made within critical habitat was 80% (Fritz 1993b)."

One NMFS scientist with a clear view of the situation acknowledged that publicly-subsidized Alaska pollock fishery development has ‘boomed’ in the Pribilof Islands. He wrote in an internal NMFS correspondance (Zimmerman letter to Sechrist of the Marine Mammal Commission on 12 January 1995, p. 1):

When the Government pulled out of the Pribilofs in 1983 (Fur Seal Act Amendments of 1983), it did so with the expectation that the islands would develop economies "not based on fur sealing." With large infusions of funds from the Feds and the State, breakwaters were built on each island to create port facilities. These breakwaters were built over a number of years beginning in 1984. By the early 1990s, the breakwaters had been finished, the docks and other infrastructure improvements has been completed, and the airports on each island had been expanded. Up to that time both islands had been involved in the development of small processing operations. At some point in the early 1990s, critical mass was reached, allowing a boom to begin. Because the Pribilofs are much closer to the fishing grounds than Dutch Harbor, fishing and seafood processing industries gain a competitive edge by doing business there. In late 1992, the Unisea Barge moved from Dutch Harbor to Saint Paul. This seems to have signaled the beginning of the economic boom there.

In a joint letter from NMFS Alaska Region Director Steven Pennoyer and FWS Region 7 Director Walter Stieglitz, to EPA Water Division Director Charles Findley (respectively signed and dated February 4 and 8, 1994, p. 1), the amount of waste currently being dumped into the Pribilof Island nearshore zone from this development is acknowledged, as is the need for information:

As you may be aware, the Pribilof Islands are becoming a major fish processing center in the Bering Sea. Currently, three major shore based
facilities are planned or under construction on St. Paul Island. These will have an initial combined processing capacity exceeding one million pounds of crab per day, generating approximately 1.3 million gallons of effluent wastes per day. These wastes will be discharged into the nearshore zone. The plants are planning to process bottomfish in the future, with a much increased waste volume if fishmeal or by-product recovery facilities are not built. A majority of the Bering Sea crab processing fleet also regularly anchors in English Bay along the south side of St. Paul Island, discharging crab wastes into marine waters. We have no information on the volume of these discharges. All discharges of fish processing wastes to these waters are now authorized under the 1989 NPDES General Permit for Alaskan Seafood Processors (GP) . . . . The Pribilof Islands are among the most important wildlife habitats in the world. . . . The amount of oils and grease, cleaning agents, lubricants, and solvents which may be discharged under the current General Permit may exceed acceptable limits to wildlife, particularly in view of the very close proximity of the seal and bird rookeries to these discharges. . . . We currently know very little about the nearshore marine environment at the Pribilof Islands. The ability to assess possible impacts from seafood processing waste discharges (required under the GP) is dependant on data not currently in existence . . . "

While the Fisheries Conservation and Management Act greatly expanded the marine resource base under U.S. control, it also established a unique method for managing them: eight Regional Councils comprised of stakeholders and State fisheries officials who develop and implement Fishery Management Plans. It is important to understand the skewed representation of these Councils; first toward industrial development, and secondly toward localized Alaskan development. The North Pacific Fisheries Management Council (NPFMC) leans in it's representation to Alaskan interests. Alaska's governor, for example, recommends five seats of the NPFMC, while the Governors of Oregon and Washington each recommend three. (Fishery Plans and the members of the Fishery Management Councils are given final approval by the Secretary of the Commerce Department.) This imbalance, while it may be representational in
geopolitical ways, has exacerbated the pressures to replace established offshore capacity with nearshore segments. This has effectively heightened the competition between 'inshore' and 'offshore' interests. The offshore processing fleets are 'distant water fleets, originating mainly from ports in Oregon and Washington, while the nearshore processors are Alaska-based (though often foreign-owned).

Miles et al. (1982) analyzed the implications of designating 200-mile EEZs, stating: "The emergence of [EEZs], in which the coastal state exercises exclusive control over marine resources, scientific research, and acts of pollution, has produced two immediate and interacting effects. The first places great stress on national institutions and requires the formulation of new national and international policies for management of ocean resources and ocean space. The second, significantly affected by the first, intensifies the need for increased bilateral and multilateral consultations, and a new level of coordination to cope with impending changes in the patterns of use." If the placement of seafood processing and fishery service centers is any indication, it would appear that national institutions such as EPA, NMFS, FWS, and the Army Corps of Engineers are operating in a fragmented fashion which fails to effectively plan for or coordinate a response to changing patterns of use.

Partitioning has declined in scale over time, from declarations of EEZs at the international scale, to an intra-national struggle between distant-water fleets and industry located in coastal Alaskan. Alaska-based interests are attempting to limit the highly-efficient and large trawler/processor fleet from usurping all of the 2.2 million metric ton groundfish quota. Alaska interests are assisted by strong leadership in the U.S. Congress, by a larger voice on the NPFMC, and
by a legal requirement which prohibits foreign ownership of U.S.-flagged vessels while encouraging shore-based development by foreigners.

Pressure to develop the nearshore zone has come from strong leadership by the U.S. Congressional delegation representing Alaska. A predictable result is that fishery plans have tended to increasingly partition fish resources for exclusive use by local or Alaska-based interests. "The whole point [of the Community Development Quota program] is to give the people an opportunity to build an economy in rural Alaska," Dave Benton, director of the Alaska Fish and Game external and international affairs, told the Alaska Fisheries Journal (see Welch 1993).

Dave Benton reacted angrily to the issue of public subsidies in the groundfish industry (see Welch 1993): "I get a little torqued at people who have problems with CDQs and who say the program is some kind of giveaway to rural Alaskans. . . When those guys [offshore trawler/processors] start paying for the fish they're catching, then they can start telling the people in Western Alaska that they're not entitled to a portion of the fish." The biggest giveaway of all is alluded to in this remark; the fact that in the federal groundfisheries of the EEZ, there are no comparable fees to the timber 'stumpage' or grazing fees paid by other users of federal resources. Thus, other than a state landings tax, small federal permit fee(s), and some local landings taxes, the groundfishery is essentially a free-for-the-taking enterprise.

This partitioning of natural resources by industrial interests is not unique to the fisheries off Alaska. It is precisely what historians have described as epitimizing the settlement of the American West. Limerick (1988) and Cronon, Miles, and Gitlin (1992) both depict Western history as one of colonizing and
privatizing the resources of frontier regions. Both define resource appropriation as a fundamental character of the American frontier. Limerick (1988) focused on boundary-marking as the principal process of taking territory: "The history of the West is the story of how the American map came to have the boundaries it shows today. Colonialization, at its most basic level, was a struggle to define boundaries on the landscape. The first such boundaries were terrestrial..." As evidenced by the EEZ, CDQ, and CVOAs, making boundaries for the purpose of excluding competition is not an uncommon phenomenon in the groundfish fisheries of the North Pacific. Boundary making as an regulatory tool for management prescriptions, such as preserving foraging zones surrounding rookeries, is also commonly used.

Cronon, Miles, and Gitlin (1982) described six stages of transition from frontier to a larger nation-state: 1) species shifting; 2) market making; 3) land taking; 4) boundary setting; 5) state forming; 6) self shaping. These stages accurately depict the history of groundfishery development in the EEZ off Alaska. This phenomenon of boundary-making is one context for reviewing the larger picture of why seafood processing now occurs near sea lion rookeries.

**Three phases of Alaska groundfish fisheries development**

The development of the groundfisheries in Alaska has occurred in three phases: 1) foreign; 2) joint-venture; and 3) domestic. Each stage has built on and replaced the former, and each phase seems destined to achieve an increasingly-local interest and control in the resource. The pattern which resulted from this process is characterised by two features, both of which play a significant role in the frequency of waste foraging incidents: the re-location of processors (and to a lesser degree, harvest effort) into nearshore zones.
proximate to major sea lion rookeries); and secondly, an overcapacity of fish harvestors and processors.

As said, U.S. law prohibits foreign vessels from approaching American shores, and for other reasons including operational efficiency, foreign vessels remained far offshore Alaska for extended periods of time. Thus, prior to the mid-1980s when the accelerating domestication of the groundfisheries occurred, the harvest and processing of bottom fishes had a relatively minor impact on the coastline. Under the direction of U.S. public policy, however, the domestic capitalization of the Alaska groundfish fisheries was completed very abruptly. The groundfish catch by U.S. fishermen increased from 3.2% of the total 2 million-plus metric ton groundfish harvest in 1984, to 100% of the same approximate total in 1991 (NMFS 1996).

During the late-1970s and early-1980s, eight large fisheries in the U.S. EEZ region were either wholly unutilized or under-developed by American industry. Full utilization by American industry of the EEZ fisheries in the North Pacific was initially estimated to necessitate the creation of 43,000 new domestic jobs (Royce 1989). The American Fisheries Promotion Act of 1980 supported the expansion of the North Pacific fishery economy, providing grants for research and development, low-cost loans for fishing vessels, improved monitoring of foreign fishing, and increased funds for management.

The domestic Alaska pollock fishery developed rapidly from the mid-1980s to 1990--far more quickly than anticipated. In 1985 there were only twelve floating processors operating in the Alaska groundfishery (North Pacific Fisheries 'Delphi Project', State of Alaska 1985); currently, there are hundreds. In that Delphi Project analysis, Table 6.5 illustrated the 'Relative Shares in Alaska's Groundfish
Harvest' in 1983. In that year, foreign fishers caught 74% of Alaskan groundfish, 23% was caught by joint venture operations; and 3% by 'domestic' or American industry. In addition, within that analysis a panel of industry representatives was asked to forecast the degree to which these figures would change. Those sources predicted 1990 levels for the following sectors: joint ventures were expected to increase to 42%; the domestic sector was expected to increase to 19%; and foreign catch was expected to decrease to 39%. As of 1991, all sectors of the fishery had become fully Americanized.

The rapidity of this capitalization forced the NPFMC to halt new participation in the EEZ fisheries. "The free-for-all is over in the North Pacific," the Council declared in an informational pamphlet to industry (True North, an undated brochure made available to the public about 1991). The brochure went on to explain: "The 15-year fever of expansion broke in June 1992 when the North Pacific Fishery Management Council called a three-year moratorium on new entries into the federally managed fisheries off Alaska. . . . In the last fifteen years, an average of 900 new boats a year swelled the fleet that fishes within the U.S. 200-mile limit off Alaska. . . . there's enough capacity on the fishing grounds to harvest more than two and a half times the Total Allowable Catch."

The Alaska groundfishery is now overcapitalized in both harvesting and processing capacities. Seafood processing development has outpaced the ability of public resource managers to regulate the quantity, location, and amount of pollutant discharges. NMFS stated (1996):

At the same time, aggressive development policies resulted in the rapid displacement of the foreign fishery by the domestic fishery. . . . Unfortunately, the same fishery management process and regimes that were successful in meeting those two objectives not only allowed but encouraged fishermen and processors to
make a variety of decisions that substantially increased the difference between the actual and potential values of the Alaska groundfish fishery to the Nation. Specifically, these decisions resulted in excessive investment in harvesting and processing capacity, excessive bycatch of nongroundfish species, excessive discard of groundfish, reduced product quality and value, and more hazardous working conditions.

**Foreign phase: the viability of North Pacific fisheries is established**

North Pacific fisheries for demersal fishes began sporadically and on a small scale in the middle- and late-1800s, and again periodically in the 1920s, mid-1940s, and 1950s. Modern efforts to harvest bottomfish began in earnest in the early 1960s, originally as distant-water fisheries using factory-equipped trawlers from numerous North Pacific Rim nations, including Japan, North and South Korea, China, Russia, United States, Canada, as well as from Poland, Norway, and others. Bakkala, King, and Hirschberger (1981) reviewed the history of the early fisheries, mainly the Japanese effort in the Bering Sea, recognizing three phases (mid-1950s; 1958-1963; and post-1964). The latter post-1964 stage focused on pollock. Significant efforts targeting demersal fishes by Soviet fleets began in 1960. During this foreign phase, the fisheries for numerous demersal fishes, including yellowfin sole, herring, rockfish, pollock, and others were proven economically viable by foreign fleets exploiting grounds in the North Pacific.

Following World War Two, new technologies made control of offshore areas a concern of the industrial coastal nations. First, offshore drilling platforms allowed the prospect of exploiting the seabed beyond shallow nearshore areas. Secondly, fleets of 100-plus meter factory/trawlers began to develop long distance fisheries located far from their home-ports. These fleets were at-sea for extended periods. The size of these vessels allowed them to remain on the
fishing grounds, far offshore, even when weather was severe. Factory trawling is a technology which allowed exploitation of fish stocks beyond the traditional nearshore and small-scale fisheries. They are in use in various fisheries around the world, and have been blamed for decimating fish stocks in many locations, including the cod fishery off the Northeast United States. Distant-water vessels are equipped with processing capacities for producing surimi or quickly freezing whole or head/gutted processed fish. These vessels are of ocean-going size (300 feet or larger) and capable of catching and processing many metric ton of fish per hour. The highly productivity of factory trawler fleets was achieved by combining processing capacity with the use of a ‘trawl’ net. Cone-shaped ‘trawl’ nets can harvest as many as 120 tons of schooling fish from the bottom or middle water columns. Serviced with crew changes, mail, food/water, and fuel by supply ships from their home countries, these fleets are largely self-contained and rarely ventured near shore.

Joint venture phase: Americans catch while foreigners process

The nationality and location of groundfish processing activity began to change during the second stage, the ten-year (1979-1989) ‘joint-venture’ transition of the groundfishery from mainly foreign to exclusively domestic. This period occurred directly as a result of the U.S. policy, but prior to the time when the American industry was capable of fully harvesting or processing the entire ‘total allowable catch.’

The joint-venture period resulted from a U.S. fisheries policy known commonly as ‘fish and chips.’ During the latter part of the joint-venture stage, foreign participation in the groundfisheries of the U.S. EEZ was limited to processing, and was dependant on the degree to which foreign companies
contracted to buy fish from American catcher vessels for processing on their motherships. Thus, U.S. policy encouraged American fishers to participate in the Alaska groundfisheries, while giving American industry time to develop its own processing and other infrastructure necessary to service a fully-domesticated groundfishery. In 1988, for the first time, American fishing vessels caught the entire pollock allocation in the U.S. EEZ. Of that 1988 catch, 61% was delivered to foreign vessels for processing.

The strategy of phasing out participation by foreign fishing boats while retaining foreign at-sea processors was economically successful and proved to be a smooth transition to a wholly-American industry. NMFS reported (1996): "The development of the domestic fishery required substantial increases in domestic processing capacity. Much of the increase in at-sea and on-shore processing capacity was financed by foreign investment. It was the increase in domestic processing capacity that resulted in the displacement of the joint-venture fishery."

The Bering Sea can be thought of as an economic crossroads of the Pacific Rim region. It is the frontier of economies interacting and expanding from Asia (Japan, North and South Korea, China, Thailand, Philippines and others), Russia, and North American nations (U.S., Canada, and Mexico). 'Joint venture' business arrangements occur commonly in this continental and cultural margin. Fish harvest and processing from the North Pacific provide a base for significant portions of the Northwest U.S. economy. It further reversed what had been an imported product (though limited), to one that was exported, effectively reversing the trade imbalance with Asian economies by more than 1.5 billion dollars annually. Of the groundfish from the Northwest U.S. (Oregon
and Washington) and from Alaska, 77% are exported to Japan—by far the largest market for U.S. groundfish products. Three other Pacific Rim nations rank second, third, and fourth, respectively, as markets for western U.S. groundfish: the Republic of Korea, Canada, and China (Kinoshita, Grieg, and Terry 1998). As evidenced by these figures, the economic incentive for domesticating the groundfisheries off Alaska was significant.

**Domestic phase: groundfish processing moves nearshore**

As intended, the declaration and implementation of a U.S. EEZ triggered a major change in the management of Alaskan groundfish. The U.S. was relatively late in proclaiming an EEZ (see Miles et al. 1982; Pontecorvo 1986; Evans 1989); many other nations proclaimed 200-mile economic zones much earlier. In order to protect its offshore whaling industry, for example, Peru established a 200-mile EEZ in 1947. In 1952, Chile and Ecuador followed suit, for the stated purpose "in order to permit the conservation, development and use of those resources" (Evans 1989). These countries have a long history of marine resource use. A prominent marine upwelling occurs near the western coast of central South America, where the northerly flow of the Humboldt Current deflects off a mid-continental protrusion. As in the Bering Sea, a plume of nutrients from the colder bottom layer is forced upward, producing a large anchovy biomass. The Humboldt Current and this particular upwelling is greatly influenced by the El Nino Southern Oscillation (ENSO) phenomenon. ENSO redirects the current offshore, reducing the upwelling and the availability of nutrients (Suplee 1999). Because of these changes in current, great fluctuations occur in the Peruvian anchovy fishery. (For a description of El Nino's affect on fisheries, see Houghton et al. 1990, or Niebauer and Hollowed...
1993. On the Peruvian anchovy fishery, see Sherman and Alexander 1989.)

The effect of ENSO is reflected in fish harvest levels. Weber (1994) reported the ten largest single-species fisheries of the world as harvested in 1970, during the 1980s, and in 1992. Harvest of Peruvian anchovy (*Engraulis ringens*) was far and away the largest of any in 1970, at 13.1 million tons (mt). Ranked second that year were Atlantic cod (*Gadus macrocephalus*) and Alaskan pollock, at 3.1 mt each.

During the 1980s, the anchovy harvest declined severely, probably because of ENSO, and possibly exacerbated by years of intense fishing pressure. In 1984, for example, Peruvian anchovy yielded just 94,000 tons, less than 1% of 1970 level. South American cultures have fished the waters off Peru for at least 6,000 years. Archeological records indicate these fish-based cultures periodically underwent dramatic changes, quite possibly from fluctuations in the availability of fish.

In 1980, Alaskan pollock was the world's largest fishery at 4.0 mt. That year, Atlantic cod had dropped in rank to number six, at 2.2 mt.

By 1992, Peruvian anchovy was again topping the list at 5.5 mt., while Alaskan pollock followed at 5.0 mt. By then, Atlantic cod, in a widely-publicized conservation failure, had become too depleted for viable commercial effort. (The New England Fisheries Management Council has been criticized for allowing cod fishing to continue long after stocks were in obvious and serious decline. The Atlantic cod experience has had a lasting impact on the degree to which every regional Council adheres to scientific advice. U.S. taxpayers are presently bailing out the New England cod fishing industry.)

Under the terms of the 200-mile EEZ, the U.S. gained 3,107,000 square
miles—far more than any other nation (Hollick 1974). According to Weber (1994), the U.S. EEZ accounts for a full 10% of the total ocean area capable of being designated as an EEZ. The second largest national EEZ is that of France (because of it's extensive Island Territories); at 2,100,000 square miles it accounts for 7% of the total EEZ acreage. Australia and New Zealand follow in rank, each with 6% of the total acreage. Indonesia is next with 5%. Russia and Japan have 4% each. Brazil, Canada, and Mexico have 3% apiece, each with less than 1,000,000 square miles.

American-based industry was building vessels and processing capacity at a rapid pace during the late-1980s and early-1990s, thanks in large measure to government policies and subsidies. An on-going third stage then is the wholly ‘Americanized' pollock fishery (achieved in 1990-91).

NMFS (1991) reported in their Annual Report on marine resources that the domestic Alaska pollock fishery increased in total value (ex-vessel values) from $86 million in 1988 to $255 million in 1990. The change from foreign to domestic processing activity accounts for the greatly elevated value.

As stated, Bering Sea groundfish resources are being further partitioned at a more local scale by interests operating in the North Pacific region. A legal and political struggle for shares of the groundfishery quota is going on between ‘inshore' interests (i.e., those delivering to shore-based processors) and ‘offshore' catcher-processors (i.e., ‘distant-water,' mostly self-sufficient vessels). At stake is the extent of each sector's participation in the $520 million pollock fishery (ex-vessel value, according to the Alaska Fishermen's Journal, January 1993). Of this total, in millions of dollars, $387 are derived from the Bering Sea; while $133 come from the Gulf of Alaska. At issue is whether the offshore fleet
of factory-trawlers, who harvested 72% of the pollock quota in 1991, will preempt the harvesting opportunities of the smaller vessels which supply processing facilities near- or on-shore. In the early 1990s, a battle ensued over a plan by the NPFMC to limit factory trawlers to a certain portion of the total groundfish quota. Factory-trawler interests protested the passing of Amendment 18, the "Inshore-Offshore" segment of the Alaska Groundfish Fishery Plan. Amendment 18 allocated 65% of the quota to factory trawlers, and 35% to boats delivering to nearshore processors. Offshore trawler interests, mainly from Washington and Oregon, asserted this would amount to an economic reward to the mainly Japanese-owned shore based processing segment of the industry. Distant-water interests complained that Amendment 18 would result in a $209 million loss to the nation. In approving the Plan, however, then-U.S. Commerce Secretary John Knauss said, "In a fishery of this magnitude and value, this potential loss to the nation is inconsequential compared to the Council's legitimate objective of avoiding preemption of one sector by another." Knauss also stated: "I strongly urge the Council not to resubmit Amendment 18 again, because in my judgment, it will distract the Council from its major responsibility to develop a market-based allocation system for the long term. . . . I hope the Council will avoid any further efforts to select winners and losers in the pollock fishery when there appears to be no economic gain to the nation from such efforts" (Alaska Fishermen's Journal 1993, 30).

Harvest sector.

Fishing vessels discard two types of wastes: fish parts from simple 'head and gut' processing; and periodically, large amounts of whole-fish from inadvertant
'bycatch' (undersize, damaged, or undesirable fish). Typically this discharge is done while traversing, and a moving vessel leaves behind a relatively light trail of wastes. However, even small amounts of parts or whole fish may stimulate (and condition) mammal presence and lead to interactions with fishing gear. Historically, gear interactions are known to be a source of high mortality to sea lions, either by actual capture of the animal (Perez and Loughlin 1991), or through deterrence efforts such as indiscriminate shooting (Alverson 1991). Incidents of sea lion being shot are now presumably far less in the groundfishery than prior to 1990 because of the presence of fishery observers, although this assumption may be erroneous if fishers are shooting marine mammals when observers are not present.

**Fishing gear types.**

Three types of gear are used in the Alaska groundfisheries. The dominant gear is the conically-shaped trawl net, capable of holding up to 120 tons of fish. Trawl nets are towed at varied depths (midwater or bottom), with the aid of 'doors' or 'wings' attached to the side of the net's opening. These doors serve to hold open the mouth of the net as it is pulled through the water. Computer navigation, radar, and range finders help determine where exactly to tow the trawl. To get the fish aboard, the net is lifted off the bottom and dragged up a ramp at the rear of the vessel using cables and large winches. The net is then hoisted above openings on the deck and emptied into processing holds. The fish are then delivered to a processor, or held for on-board processing.

'Fixed gear' is generally a long line with baited hooks or trap-pots attached which is 'set' on the seafloor. A common form is "hook and line" (also called a "longline"), which is a weighted line with thousands of baited hooks attached to
the line by one-meter-long 'gangions.' Longlining typically involves a rigorous daily-cycle of baiting, setting, and retrieving. High-value species such as Pacific halibut, Pacific cod, and sablefish (i.e., black cod) are often caught with longline gear as capture-induced damage to the flesh is less than when fish are compacted into a trawl net. Both Orca whales and sea lions will actively feed from longline gear as it is being retrieved off the bottom, doing great damage to the catch. Prior to an increasing sensitivity of fishers as to the impact of fishing on the environment, and the placement of fishery observers, this is often when these predators would be shot.

"Pot gear" is another type of fixed gear. Crab pots, for example, consist of baited nylon-webbed pots fixed to the bottom either individually or in a series attached to a weighted line.

Trawl gear is the principal type used in the fishery for pollock. Because so many bottom-dwelling species are caught both deliberately and indiscriminately using trawl nets, they are managed under one regional Groundfish Management Plan, developed by the NPFMC. The Councils rely on fisheries management and research information provided by regional NMFS offices and the Councils own committee of advisors to develop these plans.

Processing sector.

The EPA manages seafood processing waste disposal in the nearshore zone under the ‘National Pollutant Discharge Elimination System’ (NPDES), a program within the Clean Water Act. Seafood processing in Alaska was estimated in 1994 to generate over 3.75 billion pounds (1.7 million metric tons) of solid waste annually. Pollock processing contributed 59% of this total (not including the discard of ‘bycatch’) (EPA 1994b). Because surimi is made from only pollock
Figure 2.3 Typical Waste from Walleye Pollock fillet processing (1993 photo by author)
fillets, over 80% of each individual pollock is refuse. The exception is at major shoreplants, where much of the waste by-products are often made into fish meal, an ingredient used to supplement non-human food and fertilizer products. The EPA (1994b) reported that of the total 1.7 million metric tons of solid waste from all Alaskan seafood processing, pollock contributes 59%. Pollock processing waste is composed mainly of unused fatty tissues such as skin and organs. Wastes from pollock viscera was reported by EPA (1994b, see page 2.21) to contain a wet weight fat content of 40%, whereas the average from seafood waste was generally less than 3%.

The quantity of waste associated with the pollock fishery is substantial for a number of reasons. First, the total volume of the pollock harvest is huge; simply the amount of waste volume from unused processed tissue is large. Other factors contribute to the amount of waste, such as high amounts of 'bycatch' (e.g., damaged or inadvertently caught sizes or species) in the pollock fishery, because of indiscriminate gear and the unfamiliarity of American industry with the global fish market. Many fish which are now caught but unused could be packaged and sold in numerous markets. The practice of the surimi industry in the early-1990s was to focus exclusively on turning pollock fillets into paste. A prohibition of the discharge of usable bycatch fishes as waste was implemented in the late-1990s and this regulation has greatly reduced waste volumes.

The discard of undersize, damaged, or nontargeted fish is important in the issue of why sea lion feed so frequently on seafood processing waste. Most forms of groundfish fishing, though especially trawling, catch substantial amounts of non-targeted organisms. Bycatch when discharged whole or as fish-parts is significant as an attractant of sea lions because of it's quantity, and it's quality as
a foragable waste. Floating processors often do not have the facilities for treating the waste with a grinder. Nor do they have the room to store retained bycatch, which is often processed into ‘fish meal.’ At the major shoreplants, waste from processing is typically ground into effluent (particles are ground to less than .5 inch), however, lapses in the grinding of all waste also occurs.

The waste from bycatch is in addition to the amount of waste generated from disposal of unused portions of processed fish. In 1994, the Alaska Department of Fish and Game (Gay 1996) estimated the annual discard of un-utilized fish caught in the groundfishery at 750 million pounds. NMFS (Kinoshita et al. 1998) reported in their annual *Economic Status of the Groundfish Fisheries off Alaska, 1996*: "Based on estimates of the discard rates for 1992 through 1995, discards would have been about 16% of total catch."

Figure 2.3 shows typical pollock fillet waste from seafood processors. Figure 2.4 shows sea lion approaching an eastern Aleutian Island shoreplant in the midst of effluent. Figure 2.5 shows sea lions foraging in the outfall zone of that site.

**At-sea versus shore-based processing**

Managing the waste discharged by this fishery is not easily accomplished because of the large volume and the mix of fish which are often captured. The operational practices of processors also make managing them difficult. These difficulties highlight the importance of comprehensive site planning of seafood processing facilities. The EPA, in permitting Alaska seafood processors to discharge wastes into public waters, attempted to locate seafood processing activity. In 1994, a total of 388 processors were operating in Alaska; 136 were shore-based and 252 were floating processors (EPA 1994b). EPA (1994b, see
Figure 2.4 Sea Lion Approaching Eastern Aleutian Island Shore Plant Amidst Waste Discharge (1993 photo by author)
Figure 2.5 Sea Lions Foraging in Shore Plant Outfall Zone (1993 photo by author)
map on page A: 2-13) noted that "several facilities occupied more than one location during the year" and that 173 floating processors could only be located as "various Alaskan waters." A lack of data, inconsistent or incomplete record keeping, and the highly transient nature of processors all contributed to the inability of EPA to track the locations of some floating processors. Figure 2.6 shows a floating processor in a remote bay of the Aleutian Islands, in addition to a shoreplant at Akutan, Alaska.

All sectors of the groundfishery (i.e., four types: boats which only fish; factory-trawler vessels which both catch and process; processor-only operations including at-sea 'floating ships; and on-shore plants) discharge wastes in forms that are attractive to foraging sea lions. Depending on the type of operation, fish parts, whole fish, and/or effluent (wastewater often high in both particulate and lipids/oil) are all discharged. The type and location of disposed waste, and whether an operation is stationary or moving, are key factors in determining whether waste attracts and retains sea lions to outfalls.

Because of the volume and character of waste discharges, processing vessels anchored seasonally in isolated bays have great potential to attract sea lion with their wastes. Waste and bycatch at such facilities is often simply dumped over the side of the ship in a solid form. Congregations of sea lions reportedly feed off these wastes, as shown in chapter 3. Typically, such floating processors are in very remote locations, and are formally unmonitored for waste disposal; the only person present who is not employed by the operation is the fishery observer.

Kinoshita et al. (1998) reported on the size (by tonnage) of each processing sector in NMFS' annual economic analysis of the Alaska groundfishery: "Catch
Figure 2.6 Two Types of Pollock Processors: Floating Processor Receiving Fish From Fishing Boat in Isolated Aleutian Island Bay (Top — 1993 photo courtesy of John Varner); Shore Plant at Akutan, Alaska (Bottom — 1993 photo courtesy of John Varner)
for at-sea processing increased from 106,200 t in 1986, to 1,659,000 t in 1992, and decreased to 1,445,000 by 1996 (Table 17). The catch for on-shore processing increased from 61,500 t in 1986, to 621,000 t in 1992 and was 608,000 t in 1996."

In contrast to the often-isolated nature of floating processors, shoreplants are larger facilities associated with coastal villages. Large shoreplants often grind unused fish and fish-part wastes to one-half inch particulate, and may use filters to reduce waste. The grinding of waste aids in natural decomposition and dissemination across the sea floor by tides and current. Piles of accumulated waste, especially large amounts of whole fish, are known through dive surveys (EPA 1974; EPA 1994b) to degrade water quality by depleting available oxygen. Also, the smaller the particle size of waste, the less food value it has for sea lions. Major shoreplants may also barge fish wastes to offshore dumping zones in order to avoid polluting local bays.
CHAPTER 3

Waste foraging frequency and character

Waste disposal probably is the most inadequately documented of all the use patterns in the North Pacific.

Miles et al. Atlas of Marine Use in the North Pacific Region 1982

The amount, quality, and spatial distribution of fishery wastes discharged by the Alaska groundfish industry provides sea lion with ample opportunities to feed. Wastes lucrative as food, such as the discard of undersize and non-targeted fish, or fish parts from pollock fillet processing, are disposed of at sites throughout the entire range of the Northern sea lion's eastern sub-population. During the 1990 to 1992 timeframe of this study, sea lion were being lured to outfall zones by these wastes. In the field at that time, it appeared to this observer that sea lion were being conditioned by seafood waste to increasingly interact with fishery activities. Often these subsequent interactions were more harmful than simply feeding on wastes. Though the period studied is by necessity limited to only two years, incidents of sea lion foraging on fisheries waste are described here in terms of frequency in order to determine if the trend of waste-foraging is changing. The character of seafood waste foraging is described to understand whether behavioral changes beyond sheer frequency are occurring.

The attraction of sea lion to wastes appeared similar to that documented in 'garbage bear' situations across the American and Canadian West. The experience in Yellowstone National Park (YNP) of food waste disposal conditioning black and grizzly bears is reviewed for relevance to the sea lion situation. The central issue presented in this chapter is whether waste-foraging changes the foraging behavior and the physical well-being of sea lions.
Given also that NMFS has stated that "feeding" wild sea lion is prohibited as a "take" of those animals (NMFS pers. comm. 1993), the importance of documenting foraging interactions is important to planning where seafood processing should be allowed. In 1993, at a groundfish shoreplant in the eastern Aleutian Islands, the issue arose of whether dockside hand-feeding of fish to Northern sea lions was illegal. Fishers and dock workers were entertaining themselves by handfeeding fish to sea lions congregating around the processing dock area in search of food. Rather than a rare event, such activity is not unusual, occurring at most if not all processors. From years of observing sea lion at all forms of fishery operations, it appeared that behavioral conditioning was occurring because the frequency of such foraging seemed to be increasing.

There are known instances where sea lion were 'trained' to respond to such feeding. For example, in Lost Harbor of Akun Island, Alaska, one fisher and one particular sea lion were known for a well-rehearsed trick: the fisher would lean out over the side of the vessel with a fish dangling in his mouth, prompting the sea lion to leap high out of the water and take the fish. Incidents of hand-feeding, combined with the normal discard of waste debris and effluent, appeared to retain sea lions to outfall discharge zones. In response to these situations, NMFS declared that hand-feeding fish to sea lion was illegal. A memorandum from NMFS (pers. comm. 1993) stated:

... NMFS regulations prohibit "feeding" marine mammals in the wild as a "taking." In 1991, NMFS amended the regulatory definition of "taking" to include "feeding or attempting to feed a marine mammal in the wild." "Feeding" is defined as "offering, giving, or attempting to give food or non-food items to marine mammals in the wild. It includes operating a vessel or providing other platforms from which feeding is conducted or supported. It does not include the routine discard of bycatch during fishing operations or the routine discharge of waste or fish byproducts from...
Data gathered

To describe waste foraging interactions and determine how frequently they occurred in 1990 and 1992, Northern sea lion sighting and seafood waste discharge data were collected for groundfishery operations in the U.S. EEZ area between 51N and 60N latitudes, east of longitude 180W. Over eight months in 1995 and 1996, in consultation with NMFS and the EPA, agency records were searched. The Freedom of Information Act request procedure was used in order to insure that the data gathered was complete. It is important when making a FOIA request to precisely describe or identify needed documents. My familiarity with NMFS and EPA record keeping was helpful in discussing potential sources of data with agency personnel, and in specifying the following three records:

(1) Sightings of Northern sea lions collected during 1990 and 1992 by NMFS groundfishery observers (and to a lesser extent, by NMFS staff biologists during research cruises). Sighting data are maintained by the NMFS National Marine Mammal Laboratory (NMML) in Seattle, Washington, within the Platforms of Opportunity Program database (see Boucher and Boaz, 1989, for a description of database parameters). As requested, a computer readout of 1990 and 1991 sightings was provided by NMFS. Because only 1990 and 1991 data sighting data were in the NMFS computer at the time of my request, I personally reviewed and retrieved data for 1992 from the original sighting forms (11A and 11US) during a 1995 visit to the NMML library in Seattle, Washington. Four data per Northern sea lion sighting incident were collected: Number of sea lion observed; narrative description of behavior; date; and location by latitude and
(2) Records received from or originating in any public agency or sector of private industry which discuss or mention marine mammal interactions with groundfishery wastes were also collected. Specifically requested were internal memoranda, anecdotal field reports, and interagency consultations which might contain references to fisheries-waste foraging by sea lion.

(3) From EPA (Region 10), National Pollution Discharge Elimination System weekly-test records from 1990-1993, at all groundfish processing facilities, of 'Total Suspended Solids' and 'residual chlorine.' EPA data was limited to shoreplant facilities; thus, floating processor data concerning the amount of discharged fish wastes, including whole-fish, were unavailable because of NMFS confidentiality restrictions applying to data collected from vessel logbooks.

Results of search

From 1990 marine mammal sighting data, 380 sighting incidents (of 2067 individual sea lion) were provided by NMFS. From 1992, 197 sightings (of 527 individual sea lions) were obtained by the author in a search of the original (paper) sighting records. The author’s search of paper records was necessary because 1992 data had not then been entered into the computer database and NMFS personnel did not have the time to do the hand search. An invitation from NMFS (R.V. Miller pers. comm. 1995) to do the search at the NMML in Seattle, Washington was accepted. A total of 2594 individual sea lions were sighted during these two years, mostly by fisheries observers aboard fishing vessels or at seafood processors. Figures 3.1 through 3.4 summarize sighting data of sea lion for the years 1990 and 1992.

Foraging at fishing vessels and processors is common

These data reveal sea lions were often reported either foraging at or feeding
Figure 3.1 Incidents of Northern Seal Lion "feeding" as a Proportion of Total Sightings, by the Month in 1990 (top) and 1992 (bottom).
Figure 3.2 Northern Sea Lions Foraging at a Floating Processor in the Western Aleutian Islands (top); Sea Lion feeding (bottom) (1993 photos courtesy of John Varner)
Figure 3.3 Number of Individual Northern Sea Lions Observed Foraging by Behaviors and Months in 1990. (From NMML Platforms of Opportunity Database)
Figure 3.4 Number of Individual Northern Sea Lions Observed Foraging, by Behaviors and Months in 1992. (From NMML Platforms of Opportunity Database)
from fishing gear/waste. Foraging behavior is defined here as actual "feeding" from waste or gear, or following and attending fishing or processing operations in what was described as apparent attempts to find food.

Obtained from EPA and NMFS were approximately 300 pages of narrative records, mainly interagency correspondance and internal memoranda discussing mammal interactions with waste. Events at Kodiak Island (1990), the Pribilof Islands (1990-1994), Lost Harbor (1987-1991), and Akutan Harbor (1993) were reviewed in these documents, and these are described.

Confounders found

The original problem statement of this research asserted that fish wastes high in dense amounts of large particles (especially foragable waste such as fish parts or whole fish) are attractive as forage, and will retain sea lion to outfall mixing zones. A positive relationship between foragable waste and sea lion attendance at outfalls was posed as an initial hypothesis. Testing this relationship, however, required that data of a certain quality be available. Unfortunately, it became evident after reviewing the data with EPA and NMFS that both waste discharge and mammal sighting data are not reliable nor specific enough to establish relationships between the variables of attendance in outfall zones, feeding from gear, and the quality of seafood waste discharge.

It was also initially proposed to study the time period of 1990-1995. However, a couple of problems with this timeframe arose. First, as noted, NMFS requested in January of 1993 that observers placed at seafood processors discontinue gathering marine mammal sighting data. Because NMFS suppressed the collection of sighting data at processors, 1993, 1994, and 1995 had to be omitted from consideration. Secondly, because so few data from
appear in the database, that data appears to be missing and lost. Thus, 1991 was also eliminated from this analysis. The result is that no reliable correlation between waste discharge quality and mammal sightings can be obtained using current records (as discussed with R.V. Miller of NMFS, pers. comm. 1995, and Florence Carroll, EPA Wastewater Compliance Officer, pers. comm. 1995).

Sighting data are used in this study even though they have many problems. The subjective interpretation by the observer in their narrative descriptions of 'feeding' and/or 'foraging' behavior is a confounder of these data. Observers in 1990 and 1992 were not asked to collect data regarding specific fishery-mammal interactions, such as waste foraging, with the exception of deterrence efforts by the fishing operation in reaction to mammal presence. Because of this subjectivity in interpreting waste foraging, conclusions drawn from sighting data regarding behavior are not systematic but anecdotal. As anecdotes, however, they point to specific issues which marine mammal and fisheries managers should address during observer training and in collecting fishery interaction data.

Analysis of sighting data offers insights into how these interactions actually occur, potential consequences, and point to future management/mitigation activities. Sighting data is capable of identifying the change over time in the

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1 As a U.S. fisheries observer from 1988-1993, I gathered many marine mammal sightings from varied platforms. A familiarity with how often and when sightings might be expected leads me to suspect that 1991 "A" season (January through June) sighting data are misplaced or lost. Richard Ferrero of NMML (pers. comm. 1995) stated the nineteen sightings of 1991 were the full extent of data in the computer, and that all that year's sea lion data had been entered. My experience on longline vessels, which fish throughout the year, and often suffer gear interactions with mammal predators, suggested that these are platforms where sightings are regularly made, especially during winter. The nineteen sightings of 1991 were from one period only (September and October), and occurred in a density similar to that period in 1990 and 1992. I had hoped in my search of 1992 paper records to find misplaced records, but did not. Correspondence with NMML as to a possible explanation resulted in their re-search, by a University of Washington intern, of the entire POP database. No further 1991 sighting data were found. Because the bulk of sighting occurs in the Winter months when groundfishing activity peaks, 1991 was not included in this analysis. This problem of missing 1991 data opens the entire POP database to integrity questions.
frequency of waste foraging. It should specifically correlate waste quality and quantity with mammal presence and behavior. The degree to which waste-foraging leads to feeding from gear should also be examined; gear interactions are a major source of incidental take of mammals by the fishery. The degree to which sea lion presence at outfalls triggers predatory interactions with Orca whales should also be addressed. Fishery observer data and the Platforms of Opportunity database are now largely unutilized for these purposes. Behavior codes in the main marine mammal sighting database (the Platforms of Opportunity database—see Boucher and Boaz 1989) are inadequate to address either waste foraging or gear interactions.

Marine mammal sightings in the early 1990s were gathered opportunistically and unsystematically. Some observers, for example, might emphasize sightings as part of their duties, recording mammal presence every day the animals are present rather than just the initial day of sighting. Observers are also poorly trained in interpreting what constitutes a 'take' of sea lion. For example, deliberate and inadvertent 'feeding' is not specifically observed as a 'take,' even though—as said—it technically may be an illegal 'take.' It is not known if the presence of sea lions at processors was routinely not recorded by observers prior to 1993. Daily reporting of incidental take on form 10US allows a series of answers relevant to fishing gear interactions, but none specifically involve interactions with seafood processing. Instances of caustic chemical exposure are also difficult to categorize. Although one category titled "lethal removal--not entangled or entrapped" might conceivably include impacts associated with waste foraging, the form was not devised to record more subtle interactions or impacts. This category was likely intended to encompass incidents such as the
mammals with firearms (a serious concern in the early history of the fisheries, and possibly yet). Also the sighting report forms (variably labelled Form 11, 11US, and 11A) are completed per daily incident, not per individual. It is not known what behavior is noted or omitted on these forms if some individuals behave differently than others, or if there are numerous behaviors by the same individual. Behaviors are described in narrative free form, and many report no predominant behavior. It is not unusual on the 1990 and 1992 sightings that "no specific behavior noted" was reported. The perception of the observer is critical in determining whether an interaction may have somehow injured the animal.

**Sea lions--'garbage bears' of the sea**

The emphasis of this Chapter is to document the presence of sea lions in outfall mixing zones, and to search for patterns which indicate that behavioral conditioning toward increased foraging at fishery operations may or may not be occurring. While the learning potential of sea lions is well documented in captive animals, the literature on wild populations is lacking. There is, however, plenty of anecdotal evidence that conditioning is occurring.

Data discussing the behavioral impacts of waste foraging are more abundant for the varied species of bears. While such a comparison is a stretch, I believe it is relevant because bear species and sea lion are related in terms of a common ancestor. More importantly, the trophic position, foraging habits, and physical condition of bears and sea lion are similar enough that a comparison is helpful to understanding sea lion foraging at waste sites. Both animals are upper-level and opportunistic predators, wide-ranging in diet, and whose foraging ranges are being usurped by human activities. Two differences in the two animals are that sea lion behavior is modified by the prey-relationship they have with orca (killer)
whales, and the fact that grizzly bears are omnivorous, rather than the solely
carnivorous nature of sea lions. With the limitations in mind, the literature on
waste foraging by bears is examined briefly below to discuss their response
patterns. At least, the example of ursids will help frame the discussion of
behavioral responses of waste foraging by sea lions.

Jonkel, Stirling, and Robertson (1976) reported the attraction and retention of
foraging polar bears to Cape Churchill area village dump sites in Manitoba,
Canada. Waste foraging at Cape Churchill led to routine interactions between
humans and bears, with many bears being injured or killed by gunfire. In the
Canadian Province of British Columbia, geographer J.S. Marsh (1972) studied
bear-human interactions, highlighting bears attraction to garbage.

Perhaps the best-studied garbage foraging situation is that of grizzly bears in
Yellowstone National Park. Brothers Frank and John Craighead studied the
situation extensively between 1959 and the closure of the YNP dumps in the
early-1970s. They reported (1972): "Food disposal areas (Figure 2) have
attracted grizzlies for over 80 years. They have shaped and are integrally
meshed with grizzly bear ecology in Yellowstone. Except for the nature of the
food, they are ecological equivalents of the spawning salmon runs that attract
and concentrate Alaskan brown bear (Ursus arctos middendorffi) during the
summer months. Yellowstone garbage sites concentrate the grizzly bears during
a 3-month period from June through August." An interesting conclusion of the
Craighead's from the YNP situation was that garbage foraging does not
necessarily decrease human-avoidance behavior by bears in non-dump
situations. Waste foraging did not appear to suppress YNP bear's wariness of
humans. Such a finding may be directly applicable to sea lions; the idea that
waste foraging will lead inevitably to greater interactions between sea lions and fisheries. "Feeding at these dumps does not normally develop grizzlies into garbage-seeking animals, make them dependant on humans (Leopold 1970) or create incorrigible animals," wrote Craighead and Craighead (1972), suggesting an ability of grizzly bears to vary their fear-response behavior depending on the situation. They reported:

We have obtained no evidence that the Yellowstone area has two distinct populations of grizzlies—'wild living' animals inhabiting the wilderness country and 'garbage-addicted' grizzlies inhabiting the dumps and developed areas of the Park. On the contrary, thousands of man-hours spent observing grizzlies at open-pit dumps and hundreds spent observing these same color-marked animals and monitoring radio-instrumented bears in wilderness country divulged not two distinct populations but two distinct behavioral patterns. Many of the grizzlies that feed at the isolated, open-pit, garbage dumps exhibit less fear, and greater tolerance of man at these areas than at other areas. The same animals that ignore human scent at the dumps are quickly alerted by it in the backcountry. From hundreds of encounters that we made with grizzlies when they were half a mile or more from the dumps, we observed that in most instances, they were alert and wary and would generally flee when they heard us or got a scent. Tolerance of man while feeding on artificial food at the dumps is definitely linked with specific sites. It is not a general toleration of humans or of human scent, although in rare instances the on-site conditioning may alter behavior in other locations. Animals that feed at garbage dumps, presumably where the humans scent is strong, ignore it there but not elsewhere. We have little evidence that garbage feeding changes their behavioral patterns toward humans under quite different circumstances. Troublesome grizzlies normally develop their behavioral patterns toward humans under quite different circumstances.

The Yellowstone garbage dumps provide grizzlies with an abundance of palatable food, congregate them for an unnaturally long period of time and alter some of their behavioral patterns. Feeding at these dumps does not normally develop grizzlies into garbage-seeking animals, make them dependant on humans (Leopold 1970) or create incorrigible animals. This does not imply that the garbage dumps are beneficial and should be kept open: it does mean that eating 'unnatural' versus 'natural' food does not, in itself, significantly alter the behavior of Yellowstone's grizzlies toward human beings.
The long-term YNP field work by the Craigheads (and varied study team members) was summarized in 1995 by Craighead, Sumner, and Mitchell in *The Grizzly Bears of Yellowstone: Their Ecology in the Yellowstone Ecosystem, 1959-1992*. They described the interaction of bears and garbage in terms directly applicable to the issue of sea lion foraging on fisheries wastes:

**The Role of Garbage**
Garbage was not only a massive food source, but was predictably available every year. As such, it raised the total food base within the Yellowstone Ecosystem and provided nutritional stability unmatched by any of the other food categories. It is clear that human food wastes were important as an independent food resource. Less clear, and a subject of considerable controversy, are the effects of garbage-feeding on the behavior and health of a bear population.

**Garbage Habitation and Human-Conditioning**
Bears at the Trout Creek ecocenter became conditioned to feed on garbage. This habituation, however, did not preclude their feeding on a wide range of natural foods (see also Rogers 1976). Some researchers have concluded that bears also become conditioned to human scent at garbage disposal areas (Cole 1971, Herrero 1976). Our detailed observations of garbage-habituated grizzlies in Yellowstone provided no evidence to support these claims. We found that grizzlies habituated to feeding in campgrounds and developed areas in the near presence of humans lost their timidity and did become human-conditioned. Those that fed at isolated dumps such as Trout Creek did not (Craighead and Craighead 1971). Rogers (1989), in a study of black bears at garbage dumps, stated, "Human smell on garbage apparently does little or nothing to habituate bears to human presence." Moreover, Gunther (1995, [in press]), in a review of bear management problems over the 20 years following dump closures, concluded that garbage dump use by bears was not a major factor in rates of human injuries, but roadside feeding and poor campground sanitation were. Thus, current evidence suggests that bears become human-habituated in the presence of people, not from the presence of garbage alone.

Because of the close and natural association between bears and humans, it is extremely important to the future management of bears that we determine more precisely how individual animals become human-conditioned.

With the inevitable increase in human numbers in the future, and a corresponding increase in garbage disposal, we need to know more about the social and physiological aspects of garbage-feeding. To what extent
does garbage-feeding offset the loss of bear habitat? Can dumps serve the biological needs of bears? If so, how and where should they be located?

The observations and questions of researchers studying refuse-feeding bears are relevant, and in specific ways are comparable, to the situation of waste-foraging sea lions in the North Pacific. Like Yellowstone grizzlies, sea lions are aggressive mammal predators with wide-ranging diets, apparently prey-stressed, and under pressure from human usurpation of habitat and forage resources. And like the wild bears of post dump-closure YNP, the disposal of waste is occurring commonly throughout sea lion foraging habitat. Mace and Jonkel (1983) and Craighead, Sumner, and Mitchell (1995) reported of "boneyards" in bear habitats of Montana. These sites were used by ranchers to dispose of dead stock animals, and were regularly visited by bears. Jonkel (pers. comm. 2000) stated this practice undoubtedly led to instances of interactions with, and predation on, livestock. These sites were located in both remote locations and also immediately adjacent to pens of cattle and sheep. In one case on the outskirts of Ronan, Montana, Jonkel was asked to determine the best method for preventing grizzlies from walking through a residential area. He found the bears were visiting a small cattle processing operation, where the processing waste was being stored outside in open containers (Jonkel, pers. comm. 2000).

It is important to raise these issues as they relate to bears, because there is currently a lack of data (and interest) regarding sea lion foraging on seafood waste. In fact, fishery managers in the North Pacific seem intent on ignoring the issue. The Alaska seafood industry, particularly the highly-mobile floating processors which locate seasonally in small isolated bays, often dispose of
fish or fish parts in sites and forms similar to 'boneyards.' It should come as no surprise that sea lions will take advantage of these dump sites. The questions which need addressing are numerous. To what extent does fisheries-waste feeding condition sea lions to further interactions with human activities? Does waste foraging lead to increased sea lions interactions with fishing gear? Does waste foraging expose sea lions to incidents of deterence, or to toxic or caustic pollutants? Do fisheries wastes provide nutritional benefits to prey-stressed sea lions? As the Craigheads argued regarding bears, might wastes be deposited in areas off-limits to fishing and other human activities, augmenting the food supply of sea lions? Probably not, the precariousness of the grizzly bear population in YNP is far more dire than that of Alaskan sea lion, and required more direct manipulative measures. These issues can not be addressed without a deliberate effort to collect data about waste-feeding sea lions.

**Selected comments from sea lion sightings**

Marine mammal sightings are an opportunity for fishery and marine mammal managers to focus field observations on selected issues and potential problems. Currently, fisheries observers are given little direction as to what exactly to look for, what to describe in observing fishery interactions with mammals. Readers should realize the narrative comments drawn from sightings and quoted extensively below, are to a great extent a product of individual initiative. Thus, there is no systematic way to categorize these comments. NMFS could do far more in the way of directing observers as to what to pay particular attention to. The use of a detailed and itemized survey for recording the various specific fishery interactions, or the use of cameras to document individual sea lion identities and behaviors seem to be obvious opportunities for collecting valuable
data. Much data is no doubt lost because of this lack of direction. For example, do sea lion(s) who reside in outfall zones suffer greater incidence of injury or mortality? Are yearling or juvenile sea lions who visit outfalls with their mothers later becoming habitual visitors as adults? Tracking resident sea lion individuals and groups using existing hide coloration and markings is feasible, and could be used to gauge the persistence and consequences of repeated visitation by known individuals. There has been, in my knowledge, no effort to document the identification of animals frequenting fisheries discharge outfalls. The comments selected below are quoted to show the perceptual value of sighting data, in addressing particular behaviors or specific problems. The value of the comments should make NMFS managers reconsider the current practice of not collecting sightings at processors; early detection of potentially dangerous interactions are not possible without them.

1) Does behavioral conditioning result from foraging at fishery operations?

The learning potential of sea lions is well known, partly because of the experience at aquariums. Ronald Schusterman, a psychologist and long-time student of pinniped intelligence, stated: "They [sea lions] can perform complex learning tasks that only the highest mammals, such as apes and dolphins, can perform" (Gentry 1987).

Numerous sightings indicate that behavioral conditioning is occurring. It appeared during my experiences in the fishery to occur routinely at pollock processors which were discharging 'foragable' forms of waste. As noted previously, at one floating processor location in the eastern Aleutian Island location of Lost Harbor, off Akun Island, observers reported the routine presence of one large sea lion. Observer Miriam Khan wrote of this animal being trained
perform circus-like behavior at a floating processor on 4 April 1992:

... this animal was huge. I believe it is the sea lion that the Arctic Enterprise people call "Omar." He took a few preparatory inertial building thrusts before making the 1.5-2 meters out of the water to grab fish from the Samoan deckhands mouth and hands.

Again, on 19 April 1992, Khan reported from Lost Harbor of fifteen sea lion "feeding voraciously on fish heads and gut waste. They were diving and coming up with large chunks of gut and heads and the water was churning with their activity. I believe Omar was among these animals."

' Omar' has been repeatedly recognized as a "resident" visitor to the Lost Harbor waste site. How many other resident animals are there? Where did Omar go when Lost Harbor was closed to fish processing? Is the population of sea lions which forage at waste sites a small group of repeat visitors, or is it an array of many animals who may or may not visit again? Observer sighting data could easily portray what is going on in outfall discharge zones. According to unsolicited observer data, identifiable animals are not only repeatedly visiting the same processors, they appear to be repeatedly visiting different waste sites.

Observer Mike Johnson reported on 11 March 1993: "Two animals were resting on surface near vessel while vessel was at anchor in Lost Harbor, Akun Island. One was nearly 8 ft. long while the other was about 7 ft. long. One had a dark spot on his right flank about 4 inches across and appears to be the same animal that is frequently sighted at Trident Plant in Akutan."

From Lost Harbor, observer Benjamin Wang reported on 19 March 1993:

Big sea lion w/ cataract in one eye and fish hook w/ line hanging out of it's mouth jumped onto stern ramp @ 0800, stayed on the ramp pretty much all morning. Only had one canine in lower left of jaw - old battle ax of a sea lion. Knew it was a sea lion from brown color, visible ears and long pectoral fins. . . . Heard from other observers that this individual sea lion had been seen @ Akutan.
From another processor, observer Ted Jackson (1 February 1992) wrote:

During my stay at this plant, I observed two groups of usually five per group. They were obviously Steller sea lions (visible ears, thick necks and light to dark brown in color.) Usually they were feeding near the discharge pipe (underwater) at the end of the dock, consequently, I was able to see them closely. I feel that most of these animals (if not all) were permanent residents here. I saw them nearly everyday from Feb. 1st until my departure April 4th. During the times when the plant was not processing, they could be seen swimming across the bay to the far shoreline. The two groups rarely were more than 100 meters apart but did not seem to mingle together.

The data from sightings indicates that not only are there numerous 'resident' sea lions feeding on refuse, but numerous situations where the same animal(s) will return accompanied by other sea lions. For example, observer Robert Alsord reported (8 January 1992) of such a case at one site, and the possibility that waste feeding may lead sea lion to further interact with fishing gear:

These sea lions . . . would feed on the livers from processed P. cod . . . When the processing discards slowed down they would bite the guts out of fish on the ground line. However, this was rare. They would get their fill and leave on their own.

I believe that several of these sea lions were the same ones as last nite. There is no distinct markings on any of them to I.D. later with. The same bull seems to be here from the nite before. If that is the case he is bringing friends to feed also, they only eat the livers and once in a while on fish off the fishing gear if they don't get livers fast enough. They stay alongside for about a set, feed and then leave. It seems that they know we won't bother them and they make no aggressive moves toward the fishermen, like the ones around Kodiak will. [from 9 January 1992]

Similarly, this author reported as an observer on 7 March 1992, that two sea lion were "swimming about as line is retrieved (no feeding), directly next to boat." A day later (8 March 1992), I reported that two sea lions were "swimming along ship's gear, feeding from line, following boat. . . . (1) was 9+ ft., (2) was 11+ feet
long flippers, pointed external ears, lite tan, with dark scars on back - these animals appear to be the same two as observed earlier (03/07) at the Akutan Island locale, approximately 8.15 miles distant in NMFS area 511. . . Both the captain and I believe these two mammals are the same as reported then. [They] actively fed off line, [were] clearly visible, came to within several feet of ship’s rail, taking fish directly from longline, sometimes getting entire fish, other times just the stomach." Later, that same day (8 January 1992), in NMFS area 519, I reported that eleven sea lions were "feeding along discharge chute and on line."

Observer Randy Bearce saw repeated visitations by apparently the same sea lions, but in an opposite sequence; first feeding on gear and then, the following day, feeding on discarded waste. Beginning 5 May 1992, he reported two sea lions were "feeding off the line." On 6 May 1992, Randy wrote that two sea lions (fitting the same description as the day before) were "feeding off discard chute." He further noted: "I saw them the next day [7 May 1992] feeding off the discard chute. They were with the boat most of the day (12-18 hrs.) I did not spot them on the 8th, but one of the crew members said he saw them."

Another observer, Mark Cunningham, wrote (3 August 1992) of one sea lion "swimming beside boat, curious about the line coming in." On 9 August 1992, Mark sighted another single sea lion, stating it was "feeding off longline. Appears to be same sea lion seen on 8/3."

These anecdotal reports prove little by themselves. They do point out that sea lion foraging on waste is a predictable event. These reports suggest that in the siting of processing facilities, proximity to rookeries and correlation with seasonally varying foraging ranges may need special consideration. Tagging animals might allow managers to determine visitation patterns. As noted, neither
systematic nor cursory investigation of sea lion foraging on seafood waste is currently being done by NMFS.

Related to the issue of conditioning is the habit of sea lion visitors who lift their heads high from the water while in close proximity to boat, looking directly at fishers, and 'barking.' Could it be this sequence of behaviors serves to prompt fishers to interact with the sea lion, perhaps by hand feeding them fish? Notably, in only one of the following cases—all from May of 1992—was there more than one animal sighted. For example:

Observer Clint Dickey stated on 3 May 1992 that: "The boat was tied up at the spit in Dutch Harbor. . . . As I continued to watch, the mammal swam to within 20 yards of the boat and bobbed up and down as if looking at me. I was leaning out the window. . . . The head and neck protruded out of the water."

On 7 May 1992, observer David Hine wrote of one sea lion who was: "barking at ship during haulback."

Another single sea lion was observed by Dan Hopkins on 15 May 1992: "swimming around vessel searching for food - would bark - crew said they also saw it last night."

Michelle [unidentifiable last name], an observer, stated on 16 May 1992: "one sea lion, swimming near boat, watching haul, barking at gaffers in haul station."

Observer R. Varon reported similar behavior on 18 May 1992: "Female, about 5 ft. long, . . . what looked like a red rash on her neck. Swam alongside boat, barking and peering out of the water at us. Uninterested in the fish on the line coming up." Again that same day, Varon sighted a second single sea lion: "Different animal than this morning, but same behavior - barking at the boat and swimming alongside. . . . Uninterested in line or fish." The next day (19 May 1992) Varon reported: "Same behavior as 2 females yesterday - swimming alongside, barking at the boat."

Sharon Davis observed a sea lion 19 May 1992: "swimming alongside vessel making vocalizations . . . animal was not observed feeding at the discard chute"
Observer Randy Myers, on 21 May 1992, reported one sea lion "would swim right outside picking window, diving and barking"

Observer David Murphy saw the same behavior on 22 May 1992: "He barked and would always respond when imitated. Swam around boat for about an hour - when the net came up he took off."

Another single sea lion was observed by Kevin Busscher (23 May 1992) "swimming around vessel and making a belching noise"

On 24 May 1992, Lee Rocke observed two sea lion who "inspected fish coming up on line, swam around boat, occasionally raised head and entire neck vertically out of water for a better look at boat." On the 27th, Rocke wrote of one sea lion who was "... raising head and body as high out of water as possible in order to see more of our deck." The next day, Rocke wrote: "This animal raised it's head and neck high out of water and appeared to try to look out for a possible [way] up onto the deck. It showed little interest in our fish but was quite interested in the people and in the roller area... this was not the same animal as the one last night as it did not have the circular patch behind it's right shoulder."

On 28 May 1992, observer Randy Myers described one sea lion who "approached very closely to the picking window... would bark occasionally."

On 29 May 1992, observer Michael Nelson reported one sea lion who was "circling boat - didn't see animal feeding on fish - very close to vessel, about one meter at times - barking loudly"

2) Does foraging on discarded waste lead to injuries and mortality?

Observer sighting data indicates few instances of observed deterence efforts injuring sea lion, although deterence efforts to keep sea lion from preying on fishing gear are not unknown in my experience. NMFS recognized (1992b; 1995) deterence from fishing gear as a potential factor in the sea lion decline. The threat of deterence injury was especially great prior to the deployment of observers. Shooting or otherwise injuring sea lion is now explicitly prohibited by law, however, the effectiveness of such regulations is only as good as the ability
to monitor and enforce it. There is likely some sentiment in the fishing community that would react to being 'observed,' by increasing injury to mammals preying on gear during unobserved periods. The presence of firearms on fishing vessels is very common, even necessary for security reasons. Given that observers are not present 100 percent of the time, it is not known to what extent deterence injuries yet impact sea lions. This means that if there is widespread conditioning of sea lions to more frequently interact with fishery activities, this makes an increasingly growing population of sea lion more vulnerable to deterence injury. Reducing the opportunity of deterence-induced injuries should be pursued by enforcing regulations restricting waste discards, so to avoid rewarding sea lion visitation with large chunks of forage and potential deterence injury.

An example of the use of guns to deter sea lions was noted by observer Shawn Farry, on 17 April 1992, who reported seven sea lions "feeding on discards and taking fish off line right at roller." Farry remarked that the "closest approach was less than one meter," that the roller man "hit one male with the back of the gaff," and that "shots were fired in air." John Watson noted (5 March 1992) six sea lions were "feeding on processing discards" and that one "had an injury above right front flipper - appeared to be a surface cut, maybe by a propeller, skin hanging off, so fairly recent, but not bleeding." Chris Brigham sighted one sea lion on 8 April 1992 which was "feeding on discard" and that the animal had a "fresh wound on right side of belly." On 3 May 1992, observer David Robinson sighted two sea lions, noting that the "Large male had recent gash wound on right shoulder, looked to be healing nicely." Both were "feeding mostly on waste from port scupper. They were with us for a long time. Some
In the same area on 5 May 1992, Lewis Van Fossen reported: "Big bull . . . had a large wound in the upper-right portion of his back above the right fore-flipper. He was taking fish from the line." Lewis noted a second injured sea lion on 21 August 1992: "Big light brown sea lion. Was feeding outside discard chute. . . . This particular individual was a male with small wounds on head, on small of back above hindquarters, and on belly. Wounds were small, didn't look serious. Departed when crew stopped sorting to deploy the net. Came back and went straight to the discard chute like he really knew his business."

The presence of identifiable animals, including those injured, should be a required component of sightings, and should be systematically examined by fishery managers. It would give a rough indication of whether sea lions foraging at fishery operations are in poor or good health, and perhaps whether incidence of injuries are increasing. The above incidents of injured animals does not comprise a comprehensive list.

3) Do waste and gear foraging confer nutritional benefits to sea lions?

Craighead, Sumner, and Mitchell (1995), in their studies of garbage-feeding YNP bears, observed:

"With the inevitable increase in human numbers in the future, and a corresponding increase in garbage disposal, we need to know more about the social and physiological aspects of garbage-feeding. To what extent does garbage-feeding offset the loss of bear habitat? Can dumps serve the biological needs of bears? If so, how and where should they be located?"

These same questions are relevant to sea lion foraging on fish waste. It is likely sea lions are less constrained by habitat fragmentation than the grizzly bear population of YNP, and thus may have greater options in deciding where to feed. However, this may not be true if the restricted foraging range of mother
juvenile sea lion are taken into account.

It appears from the database as a whole that most sea lions who visit fishery operations are intent on feeding. They are often reported to be quite selective in what they eat. What they appear most interested in are the livers and other internal fatty-tissues of various fish. For this reason, waste disposal at seafood processing facilities may constitute a greater attraction than might be expected, as the waste or effluent discharged from them is to a great extent composed of livers and other internal organs.

One behavior, repeatedly noted, demonstrates the selectivity of sea lion foraging. It is the predilection of sea lions to bite only the belly from fish caught on longline gear. You might imagine the frustration this brings to fishers, who are ultimately interested in only the meat but must throw away all damaged fish.

Observer Joe Rigney commented (8 August 1992) on this habit:

"Sea lion pulled a Pacific cod off the line, but only ripped out the fishes guts. The gaffer was feeding the animal several flatfish to try to keep the sea lion from feeding off the line. The animal ate several whole fish (15-20 fish), then, when its appetite appeared partially satiated, it seemed to only be interested in ripping out the guts of the flatfish. I have noticed on several occasions over the last 2 years this activity of feeding on only the abdomen of fish thrown over by the fishing industry. I personally believe the sea lion is mostly interested in either the stomach or the liver, but I have not verified any pattern."

4) Do sea lion visits to fishery operations lead to killer whale predation?

The anecdotal evidence for this is slim, however, during the Spring of 1990, it was compelling enough of an issue for NMFS to request that observers carefully monitor the presence of sea lion at seafood processors of Kodiak Island, Alaska. Unfortunately, this effort was discontinued in the Summer of 1990, and no analysis has been done on the data collected (Richard Merrick, pers. comm.)
During 1992, two sightings relating the presence of killer whales and sea lion visitation to fishery operations were reported.

Observer Juli Anderson sighted five sea lions on 13 April 1992, reporting:

"Mate had called me from factory, had seen 3 killer whales headed our way. But when I got to bridge, they had left. While scanning seas, I saw sea lions approaching stern as net # 534 was being set out. Closest approach - 2 meters. . . . Only stayed 3 to 5 minutes, headed off after net was down."

A more intriguing observation was made 30 December 1992 by Sandra Sloat:

"4 or 5 sea lions feeding around starboard discard chute. One animal on three different occasions came up the stern ramp to hang on the gate. Once it went over the stern gate and helped itself to a fish before returning down the ramp to the water. People on the boat responded by running for their cameras. So did I but I don't think anyone was fast enough to get a picture. They also lowered the stern gate halfway to give the animal a better chance to make it on deck. I was told there was a pod of approximately seven killer whales in the area. I didn't see these but I did see the sea lion hanging on the stern gate from the bridge about 110 feet away. Animal was about seven feet long. No attempt at deterence what-so-ever."

The intriguing aspect of Sandra's sighting is the possibility that a sea lion would use a fishery platform to escape the threat of predation by killer whales. I personally have witnessed many sea lions climbing on stern ramps, however, never have I seen or heard of a sea lion "hang on" to, and actually climb over a gate. These gates are a substantial barrier to sea lion, as they are made of heavy iron sheets about 3 to 4 feet high. The association between sea lion visiting fishery platforms and the presence of killer whales is another example of an issue which NMFS should be monitoring using marine mammal sighting sources, especially fishery observers. Given the persistent visitation by sea lions at fishery operations, it is very possible that not only do sea lions associate fishing activity with food, but killer whales may associate sea lions with fishing
activity. One simple way to initially analyze this issue would be to compare over time the incidence of killer whales and sea lions sighted absent of each other, with sightings in which both are noted. If sightings of sea lion associated with killer whales increased, it might be theorized that the association between the two is changing, and that possibly, killer whales are learning to associate fishing activity with sea lions (and other food). For a brief period in 1990, this association of sea lions at Kodiak, Alaska, processing outfalls and killer whales was briefly observed by observers. Observers are not now specifically instructed to look for this association, so it may be that the presence of both sea lions and killer whales is discounted. Technically, however, one would understand from the Platforms of Opportunity database instructions that such data is collected. Page eight of the document describing the database (see Boucher and Boaz, February, 1989) instructs the following under the section labeled "COMMENTS": "This section is one of the most important parts of the record. . . . In addition to details of the animal's appearance, note the kinds and numbers of other associated animals (fish, birds, squid, mammals, etc.) and their behavior." The interaction of fishery activities with the observed mammal should also be documented.
CHAPTER 4

Taking place in a sea of hormones

Embryogenesis normally takes place in a sea of hormones (steroid and nonsteroid) derived from the placenta, the maternal circulation, the fetal adrenal gland, the fetal testis, and possibly from the fetal ovary itself.

Wilson, George, and Griffin 1981

Every woman's womb is a micro-ocean, the salinity of its fluid resembling that of primeval waters; and every micro-ocean restages the drama of the origin of life in the gestation of every embryo, from one-cell protozoan through all the phases of gill-breathing and amphibian, to mammalian evolution.

Borgese 1975

It rested in an upper chamber of the womb as a translucent sphere no larger than a grain of crystal sand. There it had lain, this gleaming blastocyst, without motion and without change, through August, September and October.

Suddenly in early November it quickens; the cells resume their splitting; the pearly embryo is prompted to continue on a course towards the final form: an Alaska seal. The horn of the uterus enlarges at the site of the blastocyst like a weak spot in a toy balloon. The swelling grows to a nesting chamber. By mid-November the cluster of cells will be well along on the track towards the ancient tetrapod, the four-limbed creature that, depending on its heritage, will be an amphibian, a reptile, a bird, or a mammal, such as a seal.

A fur seal had been drowned in a fish net off the Oregon coast, on the bottom in 240 feet of water. The carcass was delivered to his laboratory in Seattle, and he carefully removed a perfect foetus only thirteen ounces in weight. Its ears were flat like a puppy dog's, and on its front flippers were miniature claws — vestigial structures that would have disappeared before birth.

Scheffer 1973

People love to think that we're different from other animals, and certainly different from insects. But at the cellular level, we are fundamentally the same. If we design a compound to be toxic to an insect cell, why does it surprise us when we find out that the same compound is toxic to a human cell? We've always thought the issue was mass—that these things could be toxic to an insect without having significant effects in a much larger human. But how big is an embryo?

Guillette 1995

Whereas the previous Chapter examined the potential for fishery wastes to
alter sea lion behavior by conditioning their attendance at waste sites, physiological changes from exposure to chemicals in that waste are discussed here. Marine mammal predators near the top of the food chain, such as the killer whale, sea lion, or polar bear are considered 'sentinel' species for certain pollutants. Arctic marine mammals store large amounts of energy in their blubber. Blubber is instrumental for survival where animals must endure long periods of seasonally-sparse food sources and very cold temperatures, as insulation against a frigid sea and to provide sustenance during prolonged on-shore nursing or fasting (Oftedal, Iverson, and Boness 1987; Silverin 1995). In meeting the energetic demands of the arctic, the reproductive strategy of sea lion places them at particular risk of exposure to nearshore waste discharges by the seafood industry. Because the degree of sea mammal exposure and the composition and fate of fishery wastes are not known, the threats posed by wastes can not be fully assessed here, or by any of the variously-involved agencies endowed with the ability and responsibility to study environmental impacts from fishery development.

However, data from initial field observations and in the literature, point to two potential contaminant threats from discharge of groundfish fishery wastes. This Chapter examines why foraging in outfall mixing zones may put sea lions at risk to two chemical injuries. 1) Disruption of fetal development and later physiological functioning by ingestion of synthetic persistent organic pollutants (POPs). POPs have two especially troubling characteristics for arctic marine mammals: they mimic the action of endogenous hormones and disrupt the endocrine system; and they sequester in fat. 2) Oxidization of tissue/organs by exposure to wastewaters containing caustic detergents and disinfectants
routinely used to clean holding tanks and factory surfaces.

**Persistent organic pollutants and endocrine disruption**

It is now recognized that numerous endocrine-disrupting chemicals have been released into the environment in large quantities since World War II (Table 1). Some of these chemicals bind to intracellular receptor proteins for steroid hormones (4) and evoke hormonal effects in animals (5), humans (6), and cell culture (7, 8). They thus interfere with the functioning of receptors whose normal role is to mediate the effects of the endogenous steroid hormones (9). Laboratory experiments have demonstrated that exposure of fetuses to endocrine-disrupting chemicals can profoundly disturb organ differentiation (10, 11) because they act as hormone agonists or antagonist.

Colborn, Dumanoski, and Myers 1993

Mammals may transfer organochlorine residues from maternal depot fat to offspring through lactation . . . . In marine mammals the process may be particularly important, since relatively large amounts of depot lipid are mobilised for production of lipid-rich milk, usually over a short period. Thus, although marine mammals may transfer organochlorine residues from mother to pup during foetal development (Anas and Wilson 1970), probably much more is transferred during lactation (Addison and Brodie 1977).

Addison and Brodie 1987

Many of the chemicals suspected to disrupt animal endocrine systems are chlorinated organic compounds, including the two most widely dispersed and most potent: polychlorinated biphenyls (PCBs); and dichlorodiphenyl trichloroethane (DDT). PCBs and DDT belong to a class of chemicals called organochlorine compounds (OCs), and are characterised by three important traits: semi-volatility; environmentally persistence; and lipophilicity (i.e., soluble and stored in fat). Tanabe et al. (1994) researched Pacific Ocean pollution, stating: "marine mammals are among the organisms most vulnerable to the long-term toxic effects of persistent organochlorines." This is true for a number of reasons, related to the toxicology of persistent organic pollutants, the biology of marine mammals and demersal fishes, and the ecology of the subarctic.

**Chemical pathways**
Atmospheric transfer of volatile compounds

Because they are semi-volatile, OCs readily convert from a fluid to an aerosol and move into the atmosphere (Hargrave et al. 1988). Wania and Mackay (1995), Simonich and Hites (1995), and the Arctic Monitoring and Assessment Programme (AMAP 1997) describe this process of redistribution from temperate to arctic zones via the 'global distillation' effect. From sources in warmer industrial climates, OCs evaporate into the atmosphere, circulate to the polar zones, condense in the cold air, and are deposited on land (or water) by precipitation. In the cold, they persist because of an otherwise stable chemistry. Through this process, chlorinated organic pollutants circulate to the arctic and subarctic; thus, polar environments are considered a 'sink' for OC contamination (Iwata et al. 1993; Simonich and Hites 1995; AMAP 1997).

High levels of these chemicals were found in the northern latitudes by Tanabe et al. (1983), who wrote: "Geographically, all specimens taken from the northern hemisphere had much higher concentrations of PCBs and HCHs than those taken from the southern hemisphere. . . The geographical variation in concentrations of chlorinated hydrocarbons in marine mammals are most likely attributable to the different degree of contamination in their ambient water. . . The latitudinal distribution of chlorinated hydrocarbons in surface water well accounts for their geographical variation found in marine mammals." Once in polar environments, OCs adhere to microscopic particles in the air, to particles afloat on the surface of water, eventually settling in bottom sediments of water bodies.

Bioaccumulation of lipophilic OCs

In addition to accumulating in bottom sediments, because organochlorine
compounds are lipophilic (i.e., they sequester and store in fat), they 'bioaccumulate' in the fatty tissue of animals. Once stored in fat, OCs are released in the maternal fluids to the young. The composition of milk, and the maternal foraging strategy necessary to achieve it, are key to understanding the threat posed to sea lion by prolonged foraging on seafood waste. Spatial and temporal patterns of maternal foraging/nursing bouts vary in the marine mammals sharing Bering Sea habitat.

The research of Jacobson (et al. 1984) and Rogan and Ragan (1994) pointed out that milk is the primary route of lipophilic, bioaccumulated pollutants to the young. In the gray seal, for example, Addison and Brodie (1987) reported that by the time of weaning a pup receives 95% of it's DDT and PCB body burden from it's mother's milk. It would be difficult to exaggerate the importance of milk fat in the transfer of OCs through the food chain and the bodies of mothers to offspring.

Bonner (1984) acknowledged the importance of lactation: "The essence of mammalian organization is the link between mother and offspring implicit in the process of suckling and rearing the young. . . . Although seals, sea-lions and walruses all can, and often do, spend long periods in the water, all must resort to the land (or to ice) to bear their young and suckle them." The dependance of Otariid seals on a prolonged period of land-based nursing carries drawbacks, however, making them vulnerable to certain predators and to overheating stress, for example. What marine mammal biologist Victor Scheffer (1973) wrote of fur seals, is in the case of fishery interactions even more true for sea lions: "Fur seals, in adopting the habits that have enabled them to live gracefully in two worlds, aquatic and terrestrial, have dug for themselves a deep evolutionary
groove out of which it is increasingly impossible for them to climb." Prolonged lactational dependancy, during which milk is the sole source of nutrition, is a key element in a distinctly sea lion reproductive pattern including wide-ranging rookery site locations and seasonally-variable patterns of social structuring. Of the pinnipeds in the Bering Sea, sea lion pups have the longest period of lactational dependancy (Costa 1991).

Because OCs sequester in animal fat, these chemicals predominate in the livers, head and stomach parts, the skin, and subcutaneous fat. These same body parts are typically the ingredients which compose seafood waste. While no literature was found that describes the toxic chemical load of seafood waste, OCs are likely present in much greater concentrations in seafood processing outfall mixing zones than in either ambient ocean water or specimens of individual prey. Sea lion also visit seafood waste discharge zones more frequently than any other marine mammal observed at Alaska fishing boats and processors. This combination of factors make sea lion particularly vulnerable to OC contamination.

Organisms feeding or dwelling near the bottom are subject to heavier OC exposure because these compounds adhere to particles such as sediments. For this reason, demersal (i.e., near-bottom dwelling) fish are used as 'bio-indicators' of persistent organic contaminants in fish species. NMFS' toxicologist Usha Varanasi (1992) discussed this issue in reporting high concentrations of OCs in demersal fish livers from urban/industrial locations, in temperate climes such as Seattle, Washington, and San Diego and Los Angeles, California. Sea lion normally feed extensively on bottomfish species.
**Caustic chemicals and oxidization**

A second threat in seafood waste arises from caustic chemicals used in the sanitation of processors, and to a lesser extent, in the cleaning of fishing vessels. Though poorly studied, oxidization of tissues and organs by chlorinated disinfectants and/or detergents have been documented in both wild and captive marine mammals. Thorough sanitation is a necessary (and legally-required) procedure in any food harvest and processing operation. In the groundfish fishery as a whole, potent cleaning agents are used on a regular basis; at seafood processors during a procedure called 'washdown' their use is intense and highly concentrated in wastewater. Washdown is prompted by processor testing for Escheria-coli bacteria. It involves the abrupt shutdown of an entire facility, and a complete scrubbing with chlorinated cleansers of all surfaces in contact with fish or their slime. From personal experience, the volume of chlorine and other cleansers used during washdown is impressive; simply the fumes in an enclosed factory room bring tears to one's eyes. More to the point, the wastewater flushing into outfall mixing zones during washdown also contains considerable amounts of chlorine residue. No one to my knowledge has examined the issue of their impact on animals in the discharge zone.

In my experience, fish processing emissions dense with particulate appeared to lure sea lions to outfall zones. Dense discharges of wastewater occur when the filter system of processors become plugged with debris, further signaling the need for washdown procedures. Thus, cleaning wastewaters often occur suddenly and immediately following the time when sea lion are most likely to be foraging in outfall zones.

Chlorinated detergents and disinfectants may burn the tissue and organs of
animals occupying outfall mixing zones. The potential impact to marine mammal eyes or mucous membranes are particularly worrisome. Exposure to chlorinated and caustic cleaning agents also occurs at fishing vessels. An example of marine mammal exposure to the use of chlorinated substances as a deterrent from a fishing vessel was reported in the *The Mail Buoy* (5 September 1998, Volume 2, page 5), a publication of the Association for Professional Observers. Liz Mitchell reported "Another observer reported a fisherman throwing bleach in the water to deter killer whales. It was enough to drive the whale(s) away temporarily, which to me says that the whale came in contact . . ."

The skin as a route of chlorinated chemical intake has been reported by many investigators, including Casarett (1975) and Reif et al. (1996). Anwar (1997) studied human exposure to OCs used in greenhouse agriculture, reporting: "Pesticide uptake occurs mainly through the skin and eyes, by inhalation or by ingestion. The fat-soluble pesticides and, to some extent, the water-soluble pesticides are absorbed through intact skin." Toppari et al. (1996) also suggested that dermal or subcutaneous intake of OCs may be a concern: "It should not be overlooked that the exposure via routes other than food, such as air, drinking water, and particularly the skin (e.g., detergents) may be highly significant. Current knowledge on actual exposures is rather limited . . ."

California sea lions are easy to train and are commonly displayed in marine aquariums. They are familiar to aquarium visitors as the seal adept at balancing items on it's snout, climbing ladders, etc. Because of their use in aquariums, there is some familiarity with sea lion exposure to chlorinated water. King (1983), writing under the topic of sea lion pathologies, noted that "In captivity, conjunctivitis and corneal cloudiness may be induced by too much chlorine in the
water; in the wild similar conditions occur as a result of a scratch while in a dirty rookery." Conjunctivitis is an inflammation of the mucous membrane. Corneal cloudiness would presumably decrease the ability of sea lion to see prey at bottom depths with poor lighting.

Despite the experience with captive animals, and despite agency mandates to understand the full impact of permitted activity, it is neither known nor under study what impact chlorinated cleanser discharges have on the eyes or mucous membranes of sea lions who commonly forage in outfall zones. It is not known whether injuries result, or whether damage to sea lion eyes, for example, may impair functioning, such as foraging success.

Beyond oxidization, two further problems with caustic cleaners are related to additives in industrial detergents known as 'surfactants' (e.g., alkylphenol polyethoxylates). Surfactants contain both hydrophilic and hydrophobic molecules which concentrate at the interface of air/water or oil/water. By adhering to the surface layer, surfactants relax surface tension. In this way they facilitate cleaning by releasing adhesion between surfaces.

In the environment, however, alkylphenol polyethoxylates breakdown into weakly estrogen-like chemical substances, including nonylphenol and octylphenol (Lewis 1991; Soto et al. 1991; Ahel et al. 1994; Purdom et al. 1994; White et al. 1994). Thus, the discharge of surfactants into outfall mixing zones adds to the load of xenoestrogens (hormone-like substances which are obtained from the environment, rather than internally from the endocrine system), which may already be present from the discard of fatty fish organs. There is indirect evidence that organisms may uptake estrogenic detergent residues at sewage discharge zones (Gray and Mirza 1979; Harding et al. 1981; Giger et al. 1984;
Folmar et al. 1996), however, few studies address the topic specifically at seafood processors.

As well as being weakly estrogenic, there is a synergistic effect between surfactants and organochlorines. Once surfactants are released into the outfall zone they alter the physical behavior of OCs by causing them to adhere to the surface film of water. Shigenaka (1990) reported: "In both this study and the previous effort (Oloffs, Albright, and Szeto, 1972), the authors suggested that the presence of surfactants, such as industrial or domestic detergents, in sewage outfalls or near cities, may cause behavior of chlordane compounds there to differ substantially from that in other more removed natural waters." It was noted by Shigenaka that in water without surfactants, between less than 1 to 13.8 percent of chlordane was found. In the presence of surfactants, however, between 71.4 and 82.9 percent remained in the water, rather than evaporating or sinking to bottom sediments.

A concentration of organic pollutants on the sea's surface has been reported even in the absence of surfactants. For example, Fuller and Hobson (1986): "In addition to partitioning between the soluble and various particulate components of natural waters, PCBs also partition between surface films and subsurface waters. Thus, for example, Raybaud found . . . the surface film exhibited PCB levels of 46 to 121 ug/l, whereas water from 40 cm below the surface contained only 0.1 to 0.21 ug/l . . ." Other researchers such as Reif et al. (1996) have also recognized that surface water contains higher levels of chlorinated compounds.

The adherence of OCs to the water surface is troubling in terms of the potential for uptake by sea lions in outfall zones. As evidenced by photos of sea lion foraging in outfall zones (see Figures 2.4 and 2.5), animals visiting
processors are at eye and snout level in the surface layer. Surface adherence, when combined with the ability of OCs to readily evaporate and be inhaled, or to enter the body via the skin and mucous membranes, increases the possibility that OCs may be ingested while sea lion are in outfall mixing zones.

**Toxic tide on Lukannon beach (now spelled Lukanin)**

I met my mates in the morning (and oh, but I am old!)
Where roaring on the ledges the summer ground-swell rolled;
I heard them lift the chorus that drowned the breakers' song—
The beaches of Lukannon—two million voices strong!

The song of pleasant stations beside the salt lagoons,
The song of blowing squadrons that shuffled down the dunes,
The song of midnight dances that churned the sea to flame—
The Beaches of Lukannon—before the sealers came!

Rudyard Kipling, *The White Seal* 1948

The colours and sounds of St. Paul Island all tell of a detached little world that has lived through centuries of time without the clever help of man and his institutions and devices — the kind of world that will forever pull at heartstrings and cry, 'Turn back, turn back . . . this is the mother source.'

V.B. Scheffer, *The Year of the Seal* 1976,

The mother source indeed. Saint Paul Island, the place of which both Kipling and Scheffer wrote, is one of the Pribilof group of four Islands in the central Bering Sea. The Pribilofs are sometimes referred to as the Galapagos of the North to describe their importance to wildlife. In the opinion of two scientists familiar with arctic marine resources, the Pribilofs are " . . . among the most important wildlife habitats in the world" (joint letter from Pennoyer of the NMFS and Stieglitz of the FWS, in February of 1994, to the Water Division Director for EPA Region 10).

In the early-1990s, a series of chemical exposure incidents occurred on the
Pribilof Island of Saint Paul; Lukanin was one of three rookeries affected. These incidents highlight the potential impact to marine mammals from waste discharges at seafood processors recently developed in the nearshore environment. Documents which describe these incidents are quoted for two reasons: the disease suspected to have resulted from seafood waste exposure has never been reported in marine mammals, and secondly, as internal agency memoranda obtained under FOIA, these materials would not otherwise be publicly available.

As described in Chapter 2, the pollock fishery in Alaska (particularly the processing sector) has relocated, moving from far offshore to coastal habitats critical to sea lion. This relocation has been guided by public subsidy and a public permitting process, but without complete environmental impact assessment, despite reports from scientists in the field that impacts are occurring. The situation in the Pribilofs indicates that seafood development is occurring in the Alaska groundfishery too rapidly for effective resource planning and management.

In a joint letter from NMFS and the FWS (Pennoyer and Stieglitz letter of February 1994, to EPA's Findley), the extent of waste disposal in the Pribilofs was explained:

As you may be aware, the Pribilof Islands are becoming a major fish processing center in the Bering Sea. Currently, three major shore based facilities are planned or under construction on St. Paul Island. These will have an initial combined processing capacity exceeding one million pounds of crab per day. These wastes will be discharged into the nearshore zone. The plants are also planning to process bottomfish in the future, with a much increased waste volume if fishmeal or byproduct recovery facilities are not built. A majority of the Bering Sea crab processing fleet also regularly anchors in English Bay along the south side of St. Paul Island, discharging crab wastes into marine waters. We have no information on the volume of these discharges.
Some type of discharge from seafood processing facilities is suspected by investigating veterinary pathologists to have resulted in the deaths of 300 or more fur seal pups. The pups were apparently burned by a caustic substance through the skin to their internal organs, only on the side of their body which contacted the surface of their rookeries. This occurred only on the three rookeries surrounding Saint Paul Island processors, the nearest located more than a half-mile away from the developed area. Pups affected by what was termed "White Muscle Syndrome" were found on rookeries proximate to St. Paul Island outfalls. These same rookeries were experiencing declines in their fur seal populations, whereas rookeries further away from the outfalls were not.

WMS was found in 1990 by two veterinary pathologists employed as 'humane observers.' Humane observers oversee the subsistence hunt of federally-protected seals by Pribilof natives. In addition to overseeing the hunt, autopsies of dead seals found on beaches were performed. A NMFS memorandum (28 August 1990, from William Fox to Steven Pennoyer) explained what was found:

During this summer, these pathological studies resulted in the discovery of a new syndrome which appears to be causing significant pup mortalities at rookeries located near the village of St. Paul. This condition, known as "White Muscle Disease," is recognizable by the numerous white lesions which are found throughout the muscle tissue and internal organs.

Over the past four years the Humane Observer, Dr. Terry Spraker, has sampled dead pups from rookeries at two locations: Reef Point and Northeast Point. These rookeries are located approximately twelve miles apart; the rookery at Reef Point is located in proximity to the village of St. Paul while the rookery at Northeast Point is quite remote from any human activities. . . . Twenty-seven per cent of the animals necropsied at Reef Point exhibited gross lesions characteristic of White Muscle Disease. None of the pups from Northeast Point contained any such lesions. After discovering this pattern, additional rookeries were sampled. The incidence of White Muscle Disease appeared to taper off with distance from the Reef Point area.
In a 1994 Position Paper (dated December 8), NMFS again described the findings at St. Paul Island:

We have found evidence that the three rookery areas closest to East Landing (Lukanin, Kitovi and Reef) are experiencing environmental impacts that have not been observed elsewhere on the island. Specifically, a condition known as "white muscle syndrome" was observed in 1990 in fur seal pups from only these three rookery areas. This syndrome has never before been reported from marine mammals anywhere in the world. The etiology for this syndrome is unknown, but the most likely cause is from ingestion or absorption of chemical oxidizing agents such as those found in solvents and cleaning solutions.

During the past summer (1994) we observed and sampled 23 fur seals that had a tar-like substance on their ventral pelage. The veterinary pathologist who sampled these animals believes that fur seals are contacting the substance onshore rather than at sea. Of the 23 seals, all but three or four were found at Lukanin and Kitovi, the rookeries most immediate to East Landing.

During these processing periods, and during that of the bairdi crab fishery in October/November 1994, a large number of fishing and support vessels were observed in very close proximity to the islands. On St. Paul, approximately 40 large vessels were observed immediately offshore of the Northeast, Reef, Lukanin and the English Bay (Zapadni) fur seal rookeries. This offshore fleet consisted of very large factory processors, catcher-processors, fishing vessels, freighters and large fuel barges. All of these moved frequently and freely around the island to obtain the most advantageous operating conditions and to avoid the effects of bad weather.

During the February 1994 opilio crab fishery, one vessel wrecked on the shoreline of St. George island near marine mammal and seabird habitats. Another vessel wrecked on the reef that fringes the complex of very large fur seal rookeries that occur on the southeast tip of St. Paul island. All fuel and other materials aboard the vessel broke up. Significant quantities of fuel, oil, pallets of paint and batteries were removed from the vessel on St. Paul. This vessel was subsequently towed to sea and sunk with the permission of the EPA.

It is not definitively known what caused the WMS in the seal pups. As stated above, caustic oxidizing agents are suspected. Dr. Spraker and colleague Dr. DeGhetto wrote (letter of 14 May 1991 to Loughlin) to NMFS of their conclusions:

During July-August 1990, 354 fur seal pups were necropsied from two
rookeries (Northeast point and Reef) on St. Paul Island, Alaska. The number of pups that have been necropsied during the same time frame from these two rookeries has been approximately 95-110 animals, for the last five years. This year the overall mortality increased by nearly 3.5 times. One of the primary reasons for this increase was a new syndrome characterized by multifocal necrosis of skeletal muscle and myocardium with varying degrees of mineralization and pulmonary edema. This condition has been called white muscle syndrome (WMS). Pups from Northeast Point did not have any evidence of WMS . . .

The cause of this multifocal necrotizing myopathy and cardiomyopathy was not determined. The epidemiology, gross lesions, histopathology, and laboratory work suggest that the etiology is not an infectious agent or trace mineral problem. The possibility of a toxic substance is extremely high. The source of toxin could be from many places, but the distribution of the occurrence of the condition suggest that the tide and/or ocean waves carried the substance and deposited it on the beaches. The areas of the rookeries that were extremely rocky did not have pups with this condition. Areas of rookery that were more flat and covered with dirt had the problem. The suspected toxins could have been absorbed via the skin of the flippers. Vitamin A and E are transmitted to the neonate via milk. Further work including checking livers for organochlorines and necropsies in the summer of 1991 will be done.

An undated and unsigned note attached to the above report (these materials were obtained using FOIA and thus are raw materials; it was presumably written by Dr. Thomas Loughlin of NMFS), stated: "Although we do not have an etiology for this syndrome, Terry Spraker feels it is associated with a toxin that could have been deposited on the rookeries on the southeast side of St. Paul Island. Cleaning agents that are corrosive in nature, and could release free radicals resulting in the oxidization of cell membranes, are the most likely cause." It should be emphasized that it is not known conclusively what caused the outbreak of WMS. The U.S. Marine Mammal Commission (1995 Annual Report to Congress) stated: "Although the syndrome has not recurred and its cause was never identified, some sort of oxidizing compound or chemical dumped into the waste treatment system was a possible factor in the occurrence of the incident."
Florence Carroll, a NPDES compliance officer with EPA Region 10 in Seattle, Washington, was asked by the author if additional information was available as to the cause of WMS in the Pribilofs. Florence Carroll responded (pers. comm. 1995) that she had been told it was then suspected that the causal agent may have been a caustic substance used to cure newly-poured concrete associated with the development of new seafood processing facilities.

The problem of endocrine disruption

As stated, marine mammals bioaccumulate OCs, PCBs, and other lipophilic compounds in their fat reserves. Risebrough (1979) demonstrated that over a lifetime, male seals show a gradual increase in OC levels. Female seals also gradually accumulate OCs, until their first pregnancy, when levels abruptly drop (Addison and Smith 1974). It may be that maternal fluids are the primary—if not the only—means of eliminating some organochlorines from the body (Siddiqui and Saxena 1985). Because many OCs are not readily metabolized; burning fat through exertion may only re-concentrate such lipophilic chemicals into remaining fat stores. Because the primary means of eliminating OCs from the body is through lactation, high amounts of chlorinated organic pollutants are transferred to the fetus and nursing pups via maternal fluids such as milk (Addison and Brodie 1987).

This transfer of OCs via maternal fluids coincides with periods of hormonally-orchestrated physiological development. In a normal scenario, minute amounts of hormones are released into the blood by the endocrine glands where they find and bind to appropriate cellular receptors, activating the biological processes associated with those cells. Estrogen receptors, for example, are found in cells throughout the body, including in the uterus, breasts, brain, and liver. Wilson et
al. (1981) reviewed the process of how hormones dictate sexual development. Hormones determine how well the nervous system, immune system, and reproductive system develop and function throughout an animal's lifetime (Wickizer et al. 1981; Schwartz et al. 1983; Rogan et al. 1988; Dewailly et al. 1992).

Organochlorines, polychlorinated biphenols, and other similarly-structured chemicals have been shown to block, activate, disable, or otherwise occupy cellular receptors uniquely structured for hormones which are normally released by the endocrine system (Mueller and Kim 1978; Fry and Toone 1981; Gray 1992; Peterson et al. 1993). The work of Green et al. in 1939 may have been the first published evidence of this process. Colborn et al. (1993) reported that the disruption of normal endocrine functioning by many chemical compounds may lead to intergenerational problems, with the potential to affect the reproductive success of entire populations. Toppari et al. (1996) explained that many animals are vulnerable to endocrine disruption because cellular receptors are "highly conserved between species," meaning that the endocrine system evolved early and thus is structured and functions similarly in many animals. Often the consequence of this disruption is damage to fetal development, resulting in impaired sexual or nervous-system organs, reduced immune system functioning, or abnormal behavior associated with reproduction. A large and growing body of research has demonstrated the reproductive impairment associated with high levels of OCs in various animals (Short et al. 1989; Olsson et al. 1992; Tanabe et al. 1994; and Reif et al. 1996). Eggshell thinning in birds (Fry and Toone 1981), deformed sexual organs in reptiles (Arnold et al. 1997), decreased fertility in fishes (Leatherland 1992; Swackhamer and Hites 1988) are
all suspected of being induced by OC contamination. Compromised immune systems have also been linked to high levels of OC contamination by Grossman (1984). In marine mammals, diseases in porpoises (Subramanian et al. 1986; Subramanian et al. 1987), and in whales (Martineau et al. 1987) have been attributed to xenoestrogenic impacts.

What is not clear is whether mammals ingest, absorb, or are oxidized by pollutants from fishery wastes in the outfall mixing zones of seafood processors. The potential for this to occur is not specifically discussed in the literature from wildlife biology, marine mammal science, or toxicology. No studies have determined whether contaminant uptake by marine mammals occurs from fisheries-waste discharges, though a growing body of research points to endocrine-disruption impacts to varied aquatic species from sewage and industrial waste discharges. Bortone and Davis (1994) documented hormone disruption (in this case, masculinization of females) only in fish directly downstream of paper mill discharges. This masculinization was evidenced by elongated anal fins in females (normally a trait of males.) Fish from the contaminated Great Lakes also exhibit endocrine-disruption impacts (Leatherland 1992). Marine bays influenced by urban and industrial waste disposal have been examined, revealing significantly higher incidence of lesions in fish from contaminated versus nonpolluted areas (Myers et al. 1994; Varanasi et al. 1992).

From these findings, and from personal observations on fisheries platforms, it is presumed here that marine mammal exposure to toxins, and to some extent chemical uptake, does likely occur in the outfall zones of seafood processors.

Bright et al. (1995) described a localized source of OCs in an arctic
The elevated PCB concentrations in sediment from upper Cambridge Bay occurred at the end of the embayment close to the discharge from the hamlet dump. This study provides for the localized elevation of various organochlorines in abiotic and biotic compartments of an arctic coastal environment, based on riverine input of contaminants introduced through aerial transport from distant sources, as well as local shore-based inputs.

**OC levels in sea lion and other marine mammals**

Sea lion have been reported to carry relatively high levels of OCs compared to marine mammals from similar areas, although the data is limited. In 1992, for example, Varanasi et al. stated:

> Interestingly, in Steller's sealions (Table 5.7) the concentration of CHs [chlorinated hydrocarbons] observed were substantially greater than the concentrations detected in harbor seals, when both species were sampled from relatively pristine waters in Alaska. Such differences could be explained, in part, on the basis of differences in the migration patterns of these animals. Harbor seals have a limited range of migration and may show levels and profiles of CHs similar to those observed for the Alaskan marine environment, whereas the CH profiles in sealions may reflect sources far from the site of capture. The relative proportions of PCBs, DDTs and other CHs in harbor seal tissues resemble those in fish and sediment sampled in an Alaskan site, whereas the pattern in several of the sealions is similar to that observed for certain sites in southern California where fish, invertebrates and sediments show relatively high proportions of DDTs compared to other sites in our field surveys.

Varanasi et al. (1993) further reported: "Although for most species the number of samples available is limited at present . . . gray whales that strand in urban areas of Puget Sound have much lower levels of toxic contaminants in their tissues than do Steller sea lions sampled from environmentally pristine area in Alaska." Gray whales feed by baleen filtering of bottom sediments in order to
procure their prey of benthic invertebrates. Varanasi et al. (1993) offered no interpretation as to why sea lion and gray whale might differ in OC levels, nor from where sea lion might be accumulating their large stores of OCs.

Bacon, Jarman, and Costa (1992) reported levels of organochlorines and polychlorinated biphenols in pinniped milk from four regions: the arctic (Pribilof Island fur seals); the mid-latitudes of the northern hemisphere (California coast); Australia; and Antarctica. All four regions contained milk samples with detectable levels of DDT and PCBs. Bacon et al. (1992) reported: "The data presented in this study suggests that seals and sea lions from the arctic (northern fur seals) and California (California sea lions) have higher levels of OCs and PCBs than those from either the Antarctic (Antarctic fur seal) or Australia (Australian sea lion). The high levels show a correlation between pinnipeds feeding in "contaminated" ecosystems. Though the northern fur seals breed in relatively pristine waters in the Bering Sea, they spend a significant amount of time feeding in more southern contaminated waters. . . . This geographical variation could be explained because highly industrialized countries that produce and use many chemicals in question are located in the mid-latitudes of the northern hemisphere rather than in the southern hemisphere." Northern fur seal as a sentinel species for sampling arctic pollutants are not an ideal specimen because of their migratory pattern. Bacon et al. (1992) acknowledged this when they wrote:

The relatively high levels of DDT and its metabolites reported for the northern fur seals seems related to their migratory and feeding patterns. The northern fur seals studied breed on St. George Island in the Bering Sea, a relatively pristine environment with no large point-source input of chemicals. They feed on squid and pollock from this area (Antonellis et al. 1984; Costa et al. 1986). During the winter months these seals migrate to more southern waters off the western United States. The levels reported
for organochlorines in these northern fur seals are similar to those reported for seals and sea lions feeding in the California current. The levels for chlordane appear very similar between these two regions.

The assumption that St. George Island, of the Pribilof group, contains "no large point-source input of chemicals" may be incorrect in light of the data presented above (although for the purposes of Bacon et al. in studying PCBs and DDT, the statement may be true). Because the foraging range of Northern sea lion is more limited than that of fur seals, it would have been more representational of local environments to have sampled sea lions. Thus, like so many other studies, the findings of Bacon et al. (1992) are inconclusive as far as evaluating Bering Sea contaminants.

Increased abortions or premature births in California sea lions was correlated with high body burdens of OCs by DeLong et al. (1973) and Gilmartin et al. (1976). While their findings did not rule out the effects of other pathogens and stresses, DeLong et al. (1973) summed up their findings: "Premature pupping in California sea lions has been noted on the breeding islands since 1968. Organochlorine pesticides and polychlorinated biphenol residues were two to eight times higher in tissues of premature parturient females and pups than in similar tissues of full-term parturient females and pups collected on San Miguel Island in 1970." Hook and Johnels (1976) found a strong correlation between blubber residues of PCB and the presence of reproductive problems in mature female seals. Risebrough (1979) reviewed the issue of contaminant-induced reproductive problems in marine mammals, stating: "High levels of various organochlorine compounds have been accumulated by populations of several species and may be causally related to three different kinds of reproductive
abnormalities that have been observed: premature births along the California coast, birth defects in Puget Sound, and a reduction in fertility in the Baltic."

More recently, Reijnders (1986) determined experimentally if dietary intake of fish containing differing amounts of PCBs affects reproductive success, and further, whether this accounts for the depletion of seals observed in the heavily-polluted Wadden Sea. Fish from the Wadden Sea, containing an average daily intake per seal of 1.5 milligrams of PCBs, were fed to one group of female seals. A second female group received a much less contaminated North Atlantic fish, providing a daily intake per seal of .22 milligrams of PCBs. Three male seals alternated mating with the groups of females. Of the twelve ovulating females fed the higher PCB fish, four carried pregnancies to term while the rest suffered miscarriages. In the group fed lesser amounts of PCBs, ten of twelve conceived successfully at full term.

Colborn et al. (1993) identified over forty compounds which exhibit an ability to disrupt the endocrine system. The most potent are the pesticide DDT and the polychlorinated biphenols (PCBs) used as a coolant in electrical insulators. Other compounds, generally weaker in their estrogenic effects, are found in many commercial and household products. As noted, these include the metabolites of detergent and certain health-care additives (such as dental sealants), and widely-used plasticizing agents added to many consumer items, including drinking-water containers and the lining of cans of food. Colborn et al. (see Our Stolen Future, 1996) provides an interesting description of how plasticizers were simultaneously discovered to be estrogenic by two different research teams (see Soto et al. 1991, and Krishnan et al. 1993).

In addition to potency, the timing of chemical exposure during periods of early
fetal development is a critical factor (Wickizer et al. 1981; Schwartz et al. 1983; Rogan et al. 1988; Dewailly et al. 1992). It is through the disruption of the endocrine system's normal provision of hormones in minute quantities that OCs may be affecting numerous animal populations, including humans (see Bern 1992; vom Saal et al. 1992; Colborn et al. 1993; Dewailly et al. 1993; Sharpe and Skakkebaek 1993).

**OC levels in humans**

Organochlorine contamination and reproductive problems are not restricted to marine mammals. All the fish fed to the seals in Reijnders (1986) forementioned study were initially harvested for human consumption. Wickizer et al. (1981) reported PCBs of more than 2 milligrams per kilogram (fat basis) in human milk samples from eleven Michigan counties, nine of which bordered or were near Lake Michigan. While Wickizer et al. did not correlate PCB levels with eating fish, they did speculate that this relationship existed. Schwartz et al. (1983) followed up on this speculation by examining PCB levels in human ambilical cord serum, maternal serum and milk from 242 maternity patients reporting moderate, and from 71 who reported no consumption of Lake Michigan fish. They reported (see Schwartz et al. 1983):

- PCB body burden increased at each additional level of contaminated fish consumption. All four exposure groups exhibited higher maternal serum levels compared with non-exposed controls.
- Both fish consumption and maternal age were significant predictors of PCB levels in maternal serum, yielding a multiple R of .39 (Table 3). Only fish consumption predicted neonatal milk levels.

Dewailly et al. (1993) found that OC levels in the milk of Inuit women of northern Quebec, Canada, were five times higher than from white women in
southern Quebec "because fish and sea mammals are major components of their traditional diets." They further reported:

The mean PCB concentration in the milk fat of Inuit women is greater than that recently reported for the general female populations of various countries (13). This surprisingly high organochlorine body burden in Inuit women may bear public health consequences. Because of the ability of these compounds to cross the placental barrier and to bioconcentrate in milk fat, fetuses and breast-fed babies constitute the most heavily exposed group, as well as the most susceptible. In the United States, a study conducted in the Great Lakes basin (14) investigated the children whose mothers were exposed to relatively low doses of PCBs. This study reported adverse neurodevelopmental effects in exposed children, which correlated with the estimated maternal exposure and presumably with in utero exposure. In laboratory animals, PCBs can interfere with reproduction and possess carcinogenic, teratogenic, and immunotoxic properties (15).

The defining action of estrogen is cell proliferation. This trait leads many to postulate that cancers of reproductive organs may be associated with OC-triggered changes in cellular processes (see, for example, Dewaily et al. 1999; Davis et al. 1997; Dees et al. 1997; Zava et al. 1997).

There is by no means total agreement among scientists on the severity, or even the possibility, of an endocrine-disruption problem. Safe (1997) presented an opposing view from the researchers cited above, stating: "Although overall exposure to estrogens is a known risk factor for development of breast cancer, current data do not support a role of organochlorine compounds such as PCBs and DDE as etiologic agents." Addison (1989) reviewed the association of high OCs and reproductive failure in four marine mammal populations, concluding that there is no firm evidence relating OCs to marine mammal reproductive problems. The idea is especially contentious because the level of such chemicals in the environment and in animals has been shown repeatedly to be
decreasing since the ban on DDT was enacted in the early-1970s. However, it should be kept in mind that xenoestrogenic disruption of endocrine functioning is a long-term problem and the impacts are not necessarily observable immediately.

The criticisms of the endocrine-disruption theory that I have reviewed downplay or outright dismiss the growing body of evidence that xenoestrogenic compounds disrupt the physiological development of mammals. Various other scientists challenge the idea that synthetic OCs are capable at current levels in the environment of causing reproductive dysfunction. For example, Cooper (1995) asserts that the risks of OCs are "overstated," and that the call for the 'virtual elimination' of chlorinated chemicals from the Great Lakes region (called for by the International Joint Commission in 1993) is unrealistic. In the 13 May 1996 edition of Ecology USA, Kenneth Olden, director of the National Institute of Environmental Health Sciences, was quoted to rebuff the assertions of Colborn et al. (1996): "There is absolutely no evidence that environmental agents with estrogenic or hormone-disruptive activity—at the level to which humans are exposed—are causing disease." Additionally, according to Olden, plants and medicines already expose people to estrogenic substances at levels that dwarf their environmental exposure to chemical agents. "And individual variability in estrogen levels," stated Olden, "far exceeds anything that one could possibly obtain from an environmental exposure."

Naturally occurring phytoestrogens are found in many plants, prominently soybeans and others such as red clover—notorious to ranchers as a cause of abortions in sheep. Toppari et al. (1996), however, reported that "Phytoestrogens may not bioaccumulate or biomagnify but they are readily
metabolized and excreted (260)." The scientific debate surrounding the issue of endocrine disruption is changing rapidly because of advances in research. Cunningham et al. (1997) reported a recent advance which challenges the notion that natural and synthetic hormone-like substances behave alike: "it is demonstrated that natural (e.g., estradiol) and some xenoestrogens (e.g., methoxychlor metabolite) are characterised by a lipophilic region that is absent in nonestrogens as well as in phytoestrogens. It is suggested that this region affects binding to specific receptors and may, in fact, differentiate harmful from beneficial estrogens."

Regarding the assertions of Colborn et al. (1996), Elizabeth Whelan of the American Council on Science and Health, an organization funded by food, drug, and chemical industries (according to a report in Sierra January/February 1997), stated: "It's innuendo on top of hypothesis on top of theory." None of these refutations of the endocrine disruption theory specifically challenge the laboratory evidence, nor the many wildlife problems documented in the field, both of which point to some sort of hormonal disruption to physiological development.
CHAPTER 5

Pacific discharge

Planning is like saving. If it's postponed until it's needed, it's too late.

Coleman 1983

Most of the problem is related to pollution. Virtually the entire NEPA process was skirted in the Pribilofs, and there will not be much incentive to slow down the process by adhering to other laws. Most of the outfall lines on St. Paul were permitted under a general permit from the Corps of Engineers (COE). The only one that went through any public review was the Unisea line which was built much shorter, and discharges in much less water depth, than the permit application described. All NPDES (Clean Water Act Section 402) permits for both islands were issued under a 1989 general seafood processing permit, again with no public review. Once the permits were given, COE and EPA showed no interest in attempting to determine the effects.

Zimmerman 1994

The best disinfectant is sunshine.

U.S. Supreme Court Justice Brandeis

The attraction of food processing waste to large foraging predators is well known in many species. The predicament of sea lions foraging at processing outfalls is not unlike placing beef processing waste dumps and ranch 'boneyards' in grizzly bear habitat. Any plan to manage Alaska Groundfish fisheries is inadequate without a thorough and ongoing analysis of fisheries waste discharges and waste foraging by Otariid seals.

Incidents of waste foraging are an opportunity for a more systematic collection of data aimed at answering specific management issues. The work of Frank and John Craighead studying the YNP grizzly bear population illustrates this. For example, are the same sea lion individuals routinely visiting outfalls to forage on waste? Is the total number of individual waste-foraging incidents increasing? Why are processors excluded as platforms for marine mammal
sightings by fishery observers, and does this exclusion limit the Platforms of Opportunity database as a tool for completely assessing fishery interactions with marine mammals? It is evident that land-use planning for seafood processing at numerous village seaports undergoing fishery development has failed to anticipate or monitor impacts from processing waste discharges. Based on the data gathered here, the contention that local land-use planning can be an effective agent in protecting habitats and their species (Press et al. 1996; Schonewald-Cox and Bayless 1986) would be proven true in the isolated, industrialized Bering Sea. Not only are sea lion being impacted by waste discharges, but federal marine sanctuaries, National Wildlife Refuge lands, and designated 'Wilderness' resources in the Aleutian Islands are being exposed to waste deposition and other intrusions from fisheries.

The management of a fishery interaction as complex as sea lion foraging on seafood waste is made more difficult by numerous factors. The geographic isolation of the fishery stymies monitoring regimes. The relocation of groundfish fishery activities have changed because of political pressure, not sound resource planning. The groundfish fisheries economic "boom" has occurred on the virtual edge of the developed world, a resource frontier truly. The monitoring and mitigation of fisheries development impacts requires but lacks baseline information and interagency coordination. Further complicating things is the fact that sea lion foraging on seafood waste cuts across jurisdictional boundaries and is addressed in a disjointed way. Jurisdiction over the various and intertwined issues is cumbersome and confusing. For example, most of the Aleutian Island chain was designated 'Alaska Maritime National Wildlife Refuge' in 1913 (Morgan 1983). Thus, this is a management situation where the Islands are
protected but the nearshore aquatic zones are not; where EPA manages what comes out of a pipe, and the Army Corps of Engineers manages how that pipe is built; where NMFS manages fisheries in the federal EEZ, and the State of Alaska manages nearshore (i.e., less than three miles) fisheries. This is an arena where NMFS manages certain marine mammals (whales, seals, and sea lions) and marine sanctuaries, and where the Fish and Wildlife Service manages other mammals (walrus, sea otter, polar bear, manatees, and dugongs) and Alaska Maritime refuges.

The complexity of managing waste foraging has been compounded by the rapidity of fisheries development, a direct result of public policy. Much as declaration of the U.S. EEZ effectively replaced the foreign with domestic capacity to fish the Bering Sea, we now see domestic inshore interests battling against domestic offshore interests to secure as much participation in the pollock fishery as possible. This heated economic environment has created an urgency by vessels and processors alike to establish a history of using the resource, and a feeding frenzy not dissimilar to sea lions at the outfall during fillet waste discharge.

Management assessments and policy from numerous agencies appear to have disregarded the lessons of the Pribilof Island incidents of white muscle disease. The opportunity to use the NMFS Observer Program to better protect public resources has been overlooked. This former observer wonders what would have happened had a fisheries observer discovered the three hundred dead fur seal pups, rather than the mammal pathologists who did. Have there been other similar cases which went undetected? Again, NMFS Observer Program requests that observers at seafood processors not make sightings of
marine mammals. Observers were placed in the fishery expressly to monitor the incidental take of protected marine mammals by the fishery. In explaining why observers were initially necessary in 1989, industry was informed by NMFS: "The main impetus for the observer program is concern over incidental takes of Steller sea lions and the need for reliable information" (Alaska Fishermen's Journal, January 1989). On fishing vessels, both marine mammal sightings and documentation of waste discharges are priority duties of observers. At processors, NMFS policy dictates that observers document neither. Thus, while injuries from chemical exposure are quite possible, the only monitoring of such subtle exposure to mammals in outfall zones is on the form recording incidental take. Why distinguish between a sighting and an incidental take given that a take may often be so subtle that the difference is indistinguishable. Determining a take of such subtle quality requires a difficult interpretation by an often inexperienced observer. Sightings are much more clear cut. It is recommended here that the form for sightings and incidental takes be merged. Given the sublethal nature of chemical injury, it should surprise no one that subtle injuries which actually comprise a 'take' may go undetected.

Currently, the structure of resource management segregates resources into single issues and attempts to manage one animal, condition, or activity in isolation of the whole. As a result, management may fail to respond to and account for subtle dynamics initiated by one topic or area affecting another. The topic of groundfish fishery and interactions with seafood processing is a prime candidate for testing the so-called 'ecosystem management' concept.

The scope of most natural resource research and management is too narrow to detect changes in ecosystem-wide patterns. The long-term work of Estes et
al. (1998) did, however, in documenting an apparent switch in Orca whale predation on increasingly-scarce pinnipeds (mainly sea lion) to sea otters (see article by Kaiser 1998). The resulting sea otter decline has stimulated an increase in the population of their principal prey (sea urchins), and a diminishment in the food of urchins (nearshore kelp forests).

The coastline as a jurisdictional divide for resource management is too simplistic and outdated, persisting perhaps in lieu of a feasible alternative. Griffis and Kimball (1996, 708) articulated the ecosystem approach, as envisioned by the U.S. National Oceanic and Atmospheric Administration (NMFS' parent agency). In regard to the need for fisheries management to complement land-use planning, their comments could pass for a summation of the waste-foraging interaction: "The history of coastal and marine resource management provides illustrations of how this discontinuity of ecosystem and human boundaries can lead to serious ecological, social, and economic problems. For example, decisions about land-use patterns in coastal zones or management of fisheries resources are based on limited information, weak predictions, inaccurate perceptions, and/or disregard of ecological boundaries and dynamics have been, and will be, flawed because they deal with only parts of the system."

Charlotte Kirkwood is a land-use planner for the Pribilof Island community of Saint Paul—the site of 300+ fur seal pup mortalities and a rapidly developing processing capacity. She stated in a 24 October 1994 letter:

Our experience also indicates that regulations, in and of themselves, do not provide the necessary management tools unless they incorporate basic ecosystem research, monitoring and enforcement. In the same manner, we have also found that individual monitoring and research programs do not afford responsible management unless they are
integrated into a multi-disciplinary and interagency consolidated program. Too often we have noted that specific, individual programs do not and cannot explore relationships and interactions.

Management assessments of waste foraging

Presently, public resource policy and assessments regarding sea lion foraging on fisheries wastes downplays the potential for harm to sea lion.

NMFS prepared a "Final Recovery Plan for Steller Sea Lions" in 1992, which did not address the topic of fisheries-waste foraging, but did briefly discuss pollution as a potential source of the decline. It reported: "Although studies of chemical pollutant loads are incomplete, the relatively low level of industrial activity in the central portion of the species range would suggest that pollution has not been a cause of the decline." The Plan in my estimation understates both the general level of pollution in the arctic and the localized sources of pollutants and interactional impacts from the hundreds of floating processors and shoreplants discharging wastes to nearshore waters throughout the range of sea lion.

A formal Biological Assessment was prepared for the EPA (1994a) in part to examine whether discharges are a threat to protected species. It stated:

Steller sea lions and designated critical habitats are not likely to be adversely impacted directly by seafood process waste or sanitary discharges. NMFS has established sea lion protection areas around major haulout and rookeries in Alaska where vessels are prohibited within 5.6 km (3 nm) and trawling is prohibited within 18.5 km (10 nm) of these areas. Critical habitat has also been established for Steller sea lions which includes three major foraging areas and all major rookeries and haulouts within Alaskan State and Federal waters. In addition to the protective measures stated above, the proposed general permit is expected to exclude seafood processing activities from the areas stated above...
There is a presumption which the numerous assessments of fishery interactions with marine mammals share. It is that designated 'critical habitats' are sufficiently complex in size and time to prevent harm to sea lions from any or all fishery activities. In my experience, NMFS managers are selectively monitoring fishery interactions with mammals because of this presumption. In restricting data to fishing vessels, the databank for assessing overall impacts from the fishery is limited. Future reviews of 'incidental takes' will not be able to review the issue of sea lion interactions with processors. Partly, this bias toward managing the harvest sector is based on the time when the fishery was predominately foreign and only operated offshore. At that time, what constituted an 'incidental take' consisted of shootings from boats and gear interactions, such as entrapment. Much of the information necessary for managing the contemporary domestic pollock fishery is not known because the geography of the fishery has changed. This fact makes a full accounting of all the varied fishery interactions important.

Recently, in U.S. District Court in Seattle, Washington, it was determined that NMFS had violated the ESA in how it has managed the North Pacific groundfishery (Janis Searles, pers. comm. 1999). As reported in Ecology USA (26 July 1999, 135): "The court noted that NMFS failed to take the measures recommended by its own scientists to protect the Steller sea lion. The Court also found the agency failed to prepare a comprehensive environmental impact statement assessing the impact of this massive fishery on the North Pacific ecosystem. Trawlers from Washington, Oregon, and Alaska net hundreds of millions of tones [sic] of fish from sea lion critical habitat, the areas most essential to sea lion survival." Waste foraging incidents are a consequence--a
predictable interaction once aware of sea lion biology and fisheries methods—of developing the groundfishery in sea lion critical habitats.

EPA (1994b) issued a National Pollutant Discharge Elimination System permit for seafood processing in the Alaska Region, as required under Section 7(a)(2) of the ESA. EPA is required by the Clean Water Act to make 'biological assessments' of any potential impacts to biological resources, and to evaluate ocean disposal as part of their general permitting of any waste discharge. EPA (1994b) noted that although no studies have been done, accounts of waste foraging are not uncommon:

As discussed above, there are no documented studies relating seafood processing waste discharges with marine mammal concentrations. However, there is anecdotal information from the National Marine Fisheries Service indicating a very strong attraction to processors by sea lions both at sea and shorebased. As seafood processing moved onshore, observations of sea lions were made in Kodiak Harbor.

EPA re-assessed waste discharges in light of the ‘White Muscle Syndrome’ situation in the Pribilof Islands (1995a, 13). They reported:

...some contact with waste discharges may occur during foraging periods and during travel to and from rookeries or haulouts. Although there have not been extensive studies on the effects of seafood processing wastes on Steller sea lions or other marine mammals, processing discharges are not expected to contain pollutants at toxic concentrations (EPA 1994) . . .

Prompted by the WMS situation, EPA (1995b. 14-15) reviewed the potential for waste impacts, concluding:

Seafood processing wastes do not contain significant quantities of toxic pollutants that may bioaccumulate in aquatic organisms, and therefore do not pose a long-term threat to the health of aquatic organisms or humans. Solid wastes have not been observed to accumulate and persist in the vicinity of seafood processing waste discharges in the Pribilof Islands. Disinfectants used during food processing are potentially toxic constituents that will be discharged from the seafood processing facilities. However, it is expected that the concentration of disinfectants will be
reduced due to dilution with other wastewaters prior to discharge and that these constituents will not be present at toxic concentrations following discharge.

The issue of whether sea lions are exposed to chemicals after being attracted by processing wastes to outfall zones cannot be substantiated or refuted without data. At this time, it is not known how often or when sea lions are present in waste zones because NMFS fails to collect sighting data, and EPA has failed to conduct studies of its own. It is also not known how long or whether the same sea lion occupy outfall zones; such baseline information is necessary to assess whether marine mammals might be intaking OCs from the ambient water of outfall mixing zones in amounts detrimental to their health.

A report was commissioned by the North Pacific Fishery Management Council to review the Biological Opinion of 3 December 1998 by NMFS that the pollock fisheries in Alaska "could plausibly be expected to jeopardize Steller sea lion recovery and adversely affect critical habitat." Authored by a panel of scientists (Bowen, Goodman, Northridge, Swain, and Swartzman 1999), it was called the Independent Review of the Scientific Bases for the 3 December 1998 Biological Opinion Regarding Interactions between Steller Sea Lions and Bering Sea and Gulf of Alaska Pollock Fisheries. Published in April of 1999, the report is wholly oriented toward harvest and prey availability to both fishers and sea lions; there is no discussion of the interaction of garbage-feeding sea lions and or fisheries dump sites.

Local levels of organic pollutants and the potential for episodic sea lion exposure to a variety of chemicals in waste are not examined in the recent Draft Supplemental Environmental Impact Statement released by NMFS (2001).
Instead, because of the regional focus of the assorted studies, the eastern Bering Sea was characterised from sediment and fish samples as having "very low" levels of organic contaminants. Such broad portrayals of pollutant levels do not assess local sources of persistent organic pollutants nor the potential for uptake of elevated POP levels from the ambient water of outfall zones. "In the few biological samples analyzed for PCBs, the total PCB concentration ranged from 2 (in starfish) to 11 ng/g (in flatfish)" NMFS (2001) reported. This region-wide review of contaminants also fails to account for the Alaska groundfish fisheries contribution of caustic cleaning agents, paint and oil residues, and the release of OCs which are in fatty fish parts and effluent to local environments such as bays. Regarding the presence of sea lion in outfall zones, NMFS (2001) said nothing at all. There is only one reference alluding to waste foraging in the entire 3300 pages of the Draft Supplemental Environmental Impact Statement: "All fish waste is biodegradable. . . Many observations have documented large chunks of waste being consumed by opportunistic predators soon after discharge. The opportunistic predators include species of invertebrates, fish, birds, and marine mammals." "Large chunks" is an inadequate description of the composition of fisheries waste discharges; chunks larger than .5 inch are illegal under the Clean Water Act permits at some processors.

In contrast to the lack of NMFS interest in sea lion foraging on processing waste, FWS has begun to systematically record (using fishery observers) instances where seabirds are consuming processing wastes. NMFS (2001) characterization of fish processing waste as "large chunks" is simplistic and unacceptable given the expertise at NMFS. What about caustic cleaning
discharges—do they burn the eyes of attending sea lion? A significant portion of processing waste is bottomfish livers and other fatty fish parts, known to sequester OCs. No discussion is found regarding sea lion or seabird consumption of large amounts of fish livers in the NMFS Draft SEIS (2001).

Recommendations

The NMFS Observer Program should monitor, in coordination with FWS, EPA, State of Alaska, and the Army Corps of Engineers, all interactions associated with groundfish fishery waste discharges. In particular, waste foraging by protected species, such as sea lion, should be systematically observed. A legally-defensible method for documenting changes to the environment has been developed by the U.S. Department of Agriculture Pacific Northwest Region (U.S. Forest Service in collaboration with J.E. Todd 1982). The Camera Point Management System is used by the Forest Service to monitor changes in a myriad of environmental conditions, including fuel-load levels, timber activity and regulation compliance, historic structure deterioration and renovation, air-quality in scenic viewsheds, wildlife habitat conditions, and others. It is a highly adaptable method which could be easily and quickly used by fishery observers, using disposable cameras if necessary, to document waste discharges and marine mammal interactions at both fishing vessels and processors. During the early 1990s, in my experience, observers at shoreplants and shoreside processors were under-utilised in terms of their time and task load. It is highly feasible that systematic observations or cameras could be used to identify individual sea lion which are routinely visiting outfall mixing zones. Determining the composition and health of sea lion visitors to outfall zones would yield interesting results. While many exhibit distinguishing
marks, such as color variation and/or scars, tagging at specific locations could augment the use of cameras for identification purposes.

I say that it touches a man that his blood is sea water and his tears are salt, that the seed of his loins is scarcely different from the same cells in a seaweed, and that of stuff like his bones are coral made. I say that physical and biologic law lies down with him, and wakes when a child stirs in the womb, and that the sap in a tree, uprushing in the spring, and the smell of the loam, where the bacteria bestir themselves in darkness, and the path of the sun in the heaven, these are the facts of first importance to his mental conclusions, and that a man who goes in no consciousness of them is a drifter and a dreamer, without a home or any contact with reality.

Donald Culross Peattie, *An Almanac for the Moderns*, 1935

The aesthetic indictment of industrialism is perhaps the least serious. A much more serious feature is the way in which it forces men, women, and children to live a life against instinct, unnatural, unspontaneous, artificial. Where industry is thoroughly developed, men are deprived of the sight of green fields and the smell of earth after rain; they are cooped together in irksome proximity, surrounded by noise and dirt, compelled to spend many hours a day performing some utterly uninteresting and monotonous mechanical task. Women are, for the most part, obliged to work in factories, and to leave to others the care of their children. The children themselves, if they are preserved from work in the factories, are kept at work in school, with an intensity that is especially damaging to the best brains. The result of this life against instinct is that industrial populations tend to be listless and trivial, in constant search of excitement, delighted by a murder, and still more delighted by a war.


The Arch of the Sky
and mightiness of storms
Encompass me,
And I am carried away
Trembling with joy

Inuit Song
REFERENCES


Briggs, J.C. 1988. The North Pacific Connection, In Biogeography and plate...


Costa, D.P. 1991b. Reproductive and foraging energetics of pinnipeds:


Danzo, B.J. 1997. Environmental xenobiotics may disrupt normal endocrine function by interfering with the binding of physiological ligands to steroid receptors and binding proteins. Environmental Health Perspectives 105 (3): 294-301.


transport of organochlorines to the Arctic Ocean. *Tellus* 40B: 480-93.


the Southeastern Bering Sea. Alaska Sea Grant College Program. Fairbanks: University of Alaska Press, 3-16.


Lowry, L.F. 1982. *Documentation and Assessment of Marine Mammal-Fishery*


exciting new frontier. U.S. Government Printing Office pamphlet No. 1987-192-

biologically active xenobiotics. Environmental Health Perspectives 101 (7): 386-
7.

Environmental Health Perspectives 75: 25-7.

Merrick, R.L. 1995. The relationship of the foraging ecology of Steller sea lions
(Eumetopias jubatus) to their population decline in Alaska. Ph.D. diss.,
University of Washington.

young-of- year Steller sea lions in Alaska waters. Abs. tenth biennial conf of
Nov '93 Galveston, TX. (photocopy reviewed at NMML library).


Miles, E., S. Gibbs, D. Fluharty, C. Dawson, D. Teeter; with W. Burke, W.
Kaczynski, and W. Wooster. 1982. The management of marine regions: The

Miller, G. 1996. Ecosystem Management: Improving the Endangered Species


Moore, K.L. 1983. Before we are born: Basic embryology and birth defects. 2nd

Nostrand.

Morgan, J.R. 1987. Large marine ecosystems an emerging concept of regional
management. Environment 29 (10): 4-9 and 29-34.

Morgan, J.R. 1989. Large marine ecosystems in the Pacific Ocean. In
Bioamass yields and geography of large marine ecosystems, eds. K. Sherman


exposure to chemical contaminants in English sole (Pleuronectes vetulus), starry flounder (Platichthys stellatus), and white croaker (Genyonemus lineatus) from selected marine sites on the Pacific coast, USA. Environmental Health Perspectives 102 (2):200-15.


Obeso, V. 1994. Research team heads into the sea lion rookeries to study decline. The Dutch Harbor (Alaska) Fishermen, 8 April, p. 5.


Oliver, S. (Nutchuk), with Alden Hatch. 1941. Son of the smoky sea. New York: Julian Messner, Inc.


Peattie, D.C. 1935. *An Almanac for the Moderns*


Mammals.


58-61.


Risebrough, R. W. 1979. Pollutants in marine mammals: A literature review and recommendations for research. MMC report MMC-77/12, NTIS PB-290 728. 64


Alaska Sea Grant Rpt. 93-01. University of Alaska, Fairbanks, AK.


U.S. Environmental Protection Agency-Region 10. 1989. Permit of authorization to discharge under the National Pollutant Discharge Elimination System for Alaskan seafood processors.
U.S. Environmental Protection Agency Region 10. 1989. Permit of authorization to Trident Seafoods Corporation to discharge under the National Pollutant Discharge Elimination System (Akutan Shore Plant specifically).


