

Quantifying the impact of derelict fishing gear on the marine fauna of Puget Sound and the Northwest Straits

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Abstract

Derelict fishing gear--lost or abandoned commercial and recreational fishing nets, lines, pots, and traps that sit or float underwater--can remain in the marine environment for years. Unseen and largely unquantified, this marine debris can trap and kill marine organisms. Since 2002, a project removing derelict gillnets from Puget Sound and the Straits of Georgia and Juan de Fuca has documented the capture and mortality of marine taxa. Specimens collected during gear recovery are enumerated and identified to the lowest possible taxon as nets are pulled onboard and/or using osteological characters in the lab. Of the 481 gillnets recovered from throughout Puget Sound and the Northwest Straits, most were recovered from the San Juan Islands and northern Puget Sound; they were recovered from high relief rocky and boulder habitats, were relatively small in size ($\leq 7,500 \text{ ft}^2$ in area), were of relatively recent construction, were in relatively good condition, were open to some extent (*i.e.*, maximum suspension $> 0 \text{ ft}$), were recovered from between 45-70 foot depths. Of the 7539 marine organisms documented in recovered derelict gillnets, 74% were dead upon net recovery (marine mammals-100%; birds-100%; fishes-96%; and invertebrates-71%). Invertebrate mortality was documented in 34% of recovered gillnets; vertebrate mortality was documented in 30% of recovered derelict gillnets. Mortality, particularly for invertebrates, was more likely in the San Juan Islands, northern Puget Sound, and the Strait of Juan de Fuca and in areas of boulders and high relief rocky substrate. Derelict gillnets captured and/or killed at least 27 species of marine invertebrates, 18 species of marine fishes, 7 species of marine birds and 3 species of marine mammals. This information will be used to help prioritize removal of derelict gear and refine estimates of mortality for species of economic and conservation concern.

Introduction

Derelict fishing gear is recreational or commercial fishing nets, lines, pots, and traps that is lost or abandoned in the environment. During the 1950s, most of the world's fishing industries replaced nets and gear made of natural fibers such as cotton, jute and hemp with those made of synthetic materials, such as nylon, polyethylene and polypropylene (USOAP 2004). Unlike natural fiber, synthetic fishing gear is functionally resistant to degradation in the water, and, once discarded or lost, this gear may remain in the marine environment for decades (USOAP 2004). Such gear can get caught on rocky and coral reefs or float on the ocean surface and pose a hazard for navigation as well as for commercial and recreational divers. Derelict gear can degrade marine habitats by inhibiting access to habitats via multiple layers of gear, suffocating habitat by trapping fine sediments, and contributing to habitat destruction (Morton 2005, UNEP 2005).

Discarded or lost fishing gear remains in the marine environment, negatively impacting economies and environments worldwide (UNEP 2005), and it may be having a worldwide impact on the sustainability of already stressed fisheries. A recent Asia-Pacific Economic Cooperation report deemed derelict gear to be degrading the Pacific Rim's economic and ecological resources (APEC 2004). The U. S. Commission on Ocean Policy recognized marine debris in general as a significant threat to marine fauna, warranting an entire chapter in its "Ocean Blueprint for the 21st Century" (USCOP 2004). In response to the report, an interagency marine debris coordinating committee was re-established to reduce marine debris from all sources, but with a particular focus on derelict fishing gear.

One consequence of derelict fishing gear in the marine environment is the entanglement and killing of target and non-target fishery species long after the gear has been lost or abandoned, a

process is known as “ghost fishing” (Breen, 1990). Quantifying marine resources lost due to “ghost fishing” can often be difficult, but studies have shown that losses can be a non-trivial portion of target populations. In some cases, catch rates can approach zero after a relatively short time. In shallow water, nets may lose their effectiveness as they get weighed down by accumulated catch, become more visible due to caught organisms and bio-fouling, and generally break down (Kaiser et al. 1996, Erzini et al. 1997). Catch rates of commercial species in lost nets can remain substantial over time, particularly in deeper water and if nets are suspended by the habitat (Humborstad et al. 2003, Santos et al. 2003, Sancho et al. 2003).

Derelict fishing gear also poses a threat to non-target fish (Stewart and Yochem 1987), turtles (Carr 1987, White 2004), seabirds (Schrey and Vauk 1987; Piatt and Nettleship 1987), whales (Volgenau et al. 1995) and seals (Hofmeyr et al. 2002, Page et al. 2004, Boland and Donohue 2003). According to one review, 136 marine species have been reported in entanglement incidents in the wider U.S. area, including six species of sea turtles, 51 species of seabirds, and 32 species of marine mammals (MMC 1996). In the Northwestern Hawaiian Islands, derelict fishing gear from throughout the North Pacific finds its way to the areas coral reefs. Not only does the gear abrade, enshroud, and break the fragile coral reefs, it injures and kills federally endangered Hawaiian monk seals, protected sea turtles, and cetaceans. Between 1982 and 2000, over 200 Hawaiian monk seals were found entangled in derelict nets (Boland and Donohue, 2003), and rates of entanglement appear to be greater in El Niño years (Donohue and Foley 2007). Since 1998, NOAA Fisheries and other state and federal organizations have removed 495 tons of derelict nets since from the Northwestern Hawaiian Islands’ coral reefs in an effort to restore the fragile habitats and reduce the impact on the local marine fauna.

Derelict Gear in Puget Sound

In Puget Sound and the Northwest Straits, several observations have raised the profile of the problems associated with derelict fishing gear. Bottomfish surveys by the Washington Department of Fish and Wildlife (WDFW) estimated 117,000 derelict nets and pots weighing approximately 2.6 million pounds may lie beneath the waters of Puget Sound (WDFW, unpubl. data). The Puget Sound gillnet fleet, which targets primarily salmon but also herring and dogfish fisheries, may have lost an estimated 9000 full-size nets (1800'x 100') over the past 30 years (WDFW, unpubl. data). Thousands of derelict crab pots have been reported from the waters of Puget Sound, and a substantial portion of the Dungeness crab fishery may be lost to derelict pots in some areas (NRC 2003). Finally, single instances of derelict gillnets have highlighted the risk to marine populations in Puget Sound; during recovery operations off the southwest corner of Lopez Island in the San Juan Islands, divers reported piles of bones 1 to 3 feet deep under a derelict gillnet suspended between rocks (NRC 2004b). The accumulation of these reports and potential risks posed has raised the removal of derelict gear to an immediate priority action for a healthy Puget Sound by 2020 (PSP 2006).

Since 2002, the Northwest Straits Commission, working with Natural Resources Consultants, Inc., the Washington Department of Fish and Wildlife, and NOAA Fisheries/ National Marine Fisheries Service, has documented and removed over 60 tons of derelict nets, pots and traps from the inland marine waters in Washington (NWSC 2007). The overall objective of the derelict gear removal project is to locate and remove existing derelict gear in the Puget Sound and the Northwest Straits. The goal of the analyses presented here is to describe patterns of the derelict gillnets recovered as well as of marine taxa documented in the recovered nets.

Methods

Derelict gear recovery was conducted in sites in 26 areas throughout Puget Sound and the Northwest Straits (Fig. 1). Some sites visited were in the derelict gear database maintained by the Washington Department of Fish and Wildlife; reports in the database occur from a variety of sources, including recreational, commercial and research vessels, and commercial, recreational, and research divers. Other sites were visited following side scan sonar surveys conducted by a separate vessel or as the result of random dive surveys or previous gear recovery efforts. To locate derelict gear, a chartered 40-foot dive-support and gear recovery vessel was equipped with a laptop linking a GPS-referenced database to onboard Nobeltec™ navigation software. To recover derelict gear, a lead weight attached by line to a surface float was deployed at the recorded site of the derelict fishing gear and the dive support vessel was anchored nearby. Divers followed the buoy line to the seabed, while real-time two-way radio communications was maintained at all times between the support vessel and the divers. After locating the derelict nets, a recovery line was attached, and the gear was hauled aboard the recovery vessel by hand or with the aid of a hydraulic winch after freeing the gear from the seabed by hand. In some cases the diver attached an air lift bag to the derelict net and floated the gear to the surface where it was recovered by the vessel.

Once on board, a variety of data was recorded for each net recovered. Net-specific information included the net's precise location (GPS coordinates), the type of net, the vintage of the net (older or more recent construction), its condition, its maximum and minimum water depth *in situ*, its approximate length, height, and area, the maximum net suspension, the benthic habitat type,

and any observations on impacts of the derelict net on the habitat. Marine wildlife-specific information included the number and identity (where possible) of whole or partial organisms observed entangled in the net, their status (alive or dead); notes of any evidence of cumulative mortality in the vicinity of the net was also relayed by the divers. Organisms living on or associated with the derelict gear but not entangled or trapped were noted but not counted. Living organisms were immediately returned to the sea after identification; dead organisms not identified at sea were retained for identification in the lab via examination of tissue and skeletal elements.

Data Analyses

We explored summarized data to determine overall patterns in habitat types, net age, net condition, net area, net maximum suspension, and mortality of marine taxa graphically and via univariate parametric and non-parametric tests (SYSTAT 2000). The Puget Sound and Northwest were subdivided into five geographic regions roughly corresponding to subregions used in local recovery planning for endangered and threatened natural resources. Habitats from which gillnets were recovered were lumped into five categories: 1) high relief rocky substrate, 2) low relief rocky substrate, 3) boulders on sand/mud/gravel, 4) mud/sand/gravel/vegetation, and 5) underwater obstructions. Gillnets were categorized as being of newer or older construction, based on net vintage or style, and as being in good or poor condition. The maximum suspension of gillnets was categorized *in situ* to the nearest 1 foot increment, as was the minimum and maximum depths.

Results

Spatial patterns and properties of derelict fishing gear

Of the 494 derelict fishing nets recovered from Puget Sound and the Northwest Straits since 2002, 486 were gillnets; the remaining nets were purse seines ($n = 5$), trawl nets ($n = 2$), and aquaculture nets ($n = 1$). Of those gillnets, 481 had datasets complete enough to examine spatial patterns and properties of derelict fishing gear and mortality patterns of marine fauna documented therein. Gillnets were recovered from throughout the Puget Sound and Northwest Straits, however, most of them were recovered from the San Juan Islands ($n = 214$) and Northern Puget Sound ($n = 202$), followed by Central Puget Sound ($n = 58$), Southern Puget Sound ($n = 4$), and the Strait of Juan de Fuca ($n = 3$) (Fig. 1). Most gillnets were recovered from habitats with boulders on sand/mud/gravel ($n = 206$), and high relief rocky substrate ($n = 150$), with lower numbers recovered from habitats with underwater obstructions ($n = 54$), mud/sand/gravel/vegetation ($n = 38$), and low relief rocky substrate ($n = 32$). Most gillnets recovered were relatively small in size; 35% of the derelict gillnets recovered were $\leq 2,500$ ft² in area, a majority (69%) were $\leq 12,500$ ft² in area, and only a few ($n = 7$) were $> 50,000$ ft² in area (Fig. 2). Most gillnets recovered (63%) were of relatively recent construction, while a minority (37%) were recorded as being of older construction. Most gillnets recovered (76%) were in relatively good condition, while a minority (24%) were reported as being in poor condition. Most gillnets (80%) recovered were open to some extent (*i.e.*, maximum suspension > 0 ft); the maximum suspension of gillnets ranged from 0 to 120 ft. (Fig. 3), with a mean value of 3.37 ft. and a median value of 3 ft. Gillnets were generally recovered from medium depths, relative to potential depths for divers; the minimum depth of recovered gillnets (mean = 57 ft, range 0 – 90 ft) did not differ appreciably from the maximum depth (mean = 63 ft, range 4 – 120).

Mortality patterns in derelict fishing gear

We documented 7539 marine organisms in derelict gillnets recovered from the waters of Puget Sound and the Northwest Straits; of these, 74% (n = 5591) were recovered dead, while 26% (n = 1948) were recovered alive. For the 6619 marine invertebrates documented, 71% (n = 4699) were recovered dead, while 29% (n = 1920) were recovered alive. For the 920 vertebrates documented, 97% (n = 892) were recovered dead, while only 3% (n = 28) were recovered alive. Marine birds (n = 123) and mammals (n = 16) were always recovered dead, while 96% of marine fishes were recovered dead (Fig. 4). Derelict gillnets captured and/or killed at least 27 species of marine invertebrates, 18 species of marine fishes, 7 species of marine birds and 3 species of marine mammals (Tables 1-4).

We documented invertebrate mortality (whole or partial dead marine invertebrates) in 34% (164/481) of the derelict gillnets recovered. Dead invertebrates were associated with region; gillnets recovered in northern Puget Sound (95/202) were most likely to have them, followed by the San Juan Islands/Strait of Juan de Fuca (56/217) and the Central Puget Sound/Southern Puget Sound (13/62) ($\chi^2_2 = 26.4$; $p < 0.0001$). Dead invertebrates were associated with habitat; gillnets recovered from areas with boulders on sand/mud/gravel (84/206) were more likely to have them than those from high relief rocky substrate (51/150), low relief rocky substrate (9/33), mud/sand/gravel/vegetation (9/38) and underwater obstructions (11/54; $\chi^2_4 = 11.1$; $p = 0.025$). Dead invertebrates were not associated with total area of gillnets recovered; the largest gillnets (12,500 - 150,000 ft²) were as likely to have them (51/151) as the medium-sized gillnets (2,900 - 12,000 ft²; 59/162) and the smallest gillnets (< 2900 ft²; 54/168; $\chi^2_2 = 0.7$; $p = 0.7$). Gillnets of

relatively recent construction were no more likely to have them (99/304) than those of older construction (65/177) ($\chi^2_2 = 0.9$; $p = 0.4$), and those in relatively good condition were no more likely to have them (122/366) than those in poor condition (42/115; $\chi^2_2 = 0.4$; $p = 0.5$). Dead invertebrates were not associated with net suspension; the likelihood of having them was similar among gillnets with a maximum suspension of 0 ft (31/94), 1 - 2 ft (51/114), 3 ft (41/137) and \geq 4 ft (41/136; $\chi^2_3 = 7.8$; $p = 0.05$). Dead invertebrates were not associated with gillnet depth; the likelihood of having them was similar among shallow minimum depths (57/153), intermediate minimum depths (48/171), and deeper minimum depths (59/157; $\chi^2_2 = 4.3$; $p = 0.1$), as was the likelihood of having them among shallow maximum depths (47/147), intermediate minimum depths (63/192), and deeper minimum depths (54/142; $\chi^2_2 = 1.4$; $p = 0.5$).

We documented evidence of vertebrate mortality (whole or partial dead marine fish, birds, mammals) in 30% (143/481) of the derelict gillnets recovered. Dead vertebrates were not associated with region; gillnets recovered in the San Juan Islands/Strait of Juan de Fuca (72/217) and Northern Puget Sound (55/202) were as likely to have dead vertebrates as in the Central Puget Sound/Southern Puget Sound (16/62) ($\chi^2_2 = 2.3$; $p = 0.32$). Dead vertebrates were not associated with habitat; gillnets recovered from areas with boulders on sand/mud/gravel (56/206), high relief rocky substrate (45/150), low relief rocky substrate (14/33), mud/sand/gravel/vegetation (14/38) and underwater obstructions (14/54) were similarly likely to have dead vertebrates ($\chi^2_4 = 4.5$; $p = 0.34$). Dead vertebrates were not associated with total area of gillnets recovered; the largest gillnets (12,500-150,000 ft²) were as likely to have dead vertebrates (49/151) as the medium-sized gillnets (2,900-12,000 ft²; 46/162) and the smallest gillnets (48/168; $\chi^2_2 = 0.8$; $p = 0.68$). Gillnets of relatively recent construction were no more likely to have dead vertebrates (94/304) than those of older construction (49/177) ($\chi^2_2 = 0.6$; $p =$

0.4), and those in relatively good condition were no more likely to have dead vertebrates (112/366) than those in poor condition (31/115; $\chi^2_2 = 0.6$; $p = 0.5$). Dead vertebrates were not associated with maximum gillnet suspension; the likelihood of having dead vertebrates was similar among gillnets with a maximum suspension of 0 ft (30/94), 1 - 2 ft (32/114), 3 ft (34/137) and ≥ 4 ft (47/136; $\chi^2_3 = 3.5$; $p = 0.3$). Dead vertebrates were not associated with depth of gillnets recovered; the likelihood of having dead vertebrates was similar among shallow minimum depths (55/153), intermediate minimum depths (45/171), and deeper minimum depths (43/157; $\chi^2_2 = 4.2$; $p = 0.1$), as was the likelihood of having dead vertebrates among shallow maximum depths (52/147), intermediate minimum depths (56/192), and deeper minimum depths (35/142; $\chi^2_2 = 4.0$; $p = 0.1$).

Discussion

Derelict gillnets have been recovered from throughout Puget Sound, and their presence in a wide variety of habitats poses a substantial risk for a variety of marine invertebrates, fish, birds, and mammals. The majority of gillnets were recovered in the San Juan Islands and northern Puget Sound, which are also habitats dominated by large relief rocky ledges and boulders. However, these regions have also been the focus of many individual projects (NRC 2003, NRC 2004a, NRC 2004b), based upon the extent of fishing effort in the northern parts of Puget Sound and reports of lost fishing gear over the years. Past/present fishing effort superimposed on the fjord-like bottom topography and strong tidal currents likely creates “hotspots” of derelict fishing gear throughout the Sound, and concentrated effort in other parts of Puget Sound and the Strait of Juan de Fuca will no doubt reveal more derelict gear in those regions. Similarly, hotspots in

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Hawaii result from nets, getting hung up on topographically complex benthic habitat formed by coral reefs (Donohue et al. 2001). In Hawaii, however, most of the nets are trawl nets that have ridden oceanographic currents down from the north Pacific (Boland and Donohue 2003), especially in El Niño years (Donohue and Foley 2007), derelict nets in Puget Sound have resulted from decades of local commercial fishing activities.

Derelict gillnets were also recovered relatively intact, despite reporting times that ranged from 1 week to more than 20 years. Divers familiar with Puget Sound gillnets believed that some of the derelict gillnets recovered were up to 20 to 30 years old based on mesh size and construction material. Other derelict nets appeared to be almost new with little or no algal growth and retained nearly all of their original breaking strength. Nets were fairly large (1000s of square feet in area), in relatively good condition, in around 60 feet of water, and of recent construction. Nets were often stretched open several feet on underwater obstacles, which can pose a danger to many species of marine animals over time (Nakashima and Matsuoka 2005). Bottom topography plays a role in the disposition of the net, as rocky ledges and boulders, as well as manmade obstructions, stick upward from the seabed throughout Puget Sound. This differs from derelict fishing nets in more open sandy or muddy habitats, where nets tend to ball up and pose less risk to target stocks (reviewed in Matsuoka et al. 2005). In deeper water, ghost-fishing gillnets break down slowly, and there are fewer crabs and fouling organisms; thus, the capture of target species may continue for long periods (Breen 1990).

We cannot conduct such experiments to determine the catching efficiency profile over time of derelict gillnets in Puget Sound, due to the risk such deployments would pose to a variety of threatened and endangered marine taxa. Still, the tendency of nets in Puget Sound to remain stretched open over long time periods and the piles of bones beneath a number of nets suggests

that rates of entanglement and mortality may not decline to negligible rates. Newer nets, suspended above the seabed on high relief habitat, appeared to have a greater diversity and number of species entangled and killed than did older nets, lying prone on the seabed over low relief habitat. Moreover, derelict nets appeared to enhance the accumulation of fine sediments that likely suffocate sessile organisms and marine plant growth and to prevent access by fish and invertebrates to important habitat features. Finally, derelict gear facilitates the accumulation of additional fishing gear; many items associated with sport fishing get entangled in derelict nets, including downrigger balls and wire, lures, hooks, flashers and jigs.

Our results suggest that derelict gillnets pose a substantial hazard to marine fauna in Puget Sound and the Northwest Straits. As with derelict gear elsewhere (Laist et al. 1996), derelict gillnets capture a diverse assemblage of marine taxa, a number of which are of commercial and conservation concern. Invertebrates are the most numerous victims, no doubt due to their overall abundance in benthic habitats, where most gillnets end up. Many invertebrate scavengers are drawn to the net as they accumulate dead animals, and some scavengers, in turn, become entangled. Sunflower stars (*Pycnopodia helianthoides*) are the scavengers most commonly observed on and under the gillnets, but they are rarely entangled, and can be returned to the ocean if they are. Dungeness crabs often become entangled in derelict nets, where they can survive long periods without being fully mobile; still, fully 50% of Dungeness crabs recovered were dead. Derelict crab pots, the other major derelict fishing gear type in Puget Sound, are even more effective at “ghost fishing” and may be responsible for killing up to 24,000 crabs annually in one shallow river mouth area in northern Puget Sound (NRC 2003).

Gillnets are especially lethal for marine fish, as nets are designed specifically for catching and killing them. Almost all fish were recovered from derelict nets dead (96%), and, as bones fall out of nets during recovery, the number and species diversity of fishes affected may be even greater than we have estimated. Gillnets are also deadly for marine birds and mammals, which must periodically surface to breathe air. Diving birds and marine mammals appear to fall prey to nets while pursuing fish underwater; some of the forage fish and smaller fish species aggregate in and under the relative safety of the netting, which results in entanglement of their predators. For marine birds, marine debris-related mortality increased substantially at the end of the 20th century (Tasker et al. 2000). For marine mammals, marine debris-related mortality is likely important but requires looking closely in particular situations. Where that has been done, *e.g.* with Hawaiian monk seals, we are beginning to understand how local, regional and ocean basin-wide factors contribute to their entanglement, mortality, and population dynamics (Donohue and Foley 2007). As we increase the numbers of studies into this issue globally, we will no doubt suggest that the problem may have worsened in many nearshore areas.

To our knowledge, no other derelict gear recovery program has documented the diversity of marine taxa (55 species of marine taxa; 11 species of conservation/commercial concern) entangled and killed by derelict fishing nets in Puget Sound. Invertebrates included commercially important Dungeness crab, and fish included species of concern for Washington, the United States, and/or Canada (Chinook salmon, sockeye salmon, black and quillback rockfish). Marine birds included species of concern in Washington (western grebe, Brandt's cormorant, common loon) and British Columbia (Brandt's, double-crested, and pelagic cormorants), and marine mammals included species of concern in Washington and British Columbia (harbor porpoise). In the Hawaiian Islands, a number of marine invertebrate taxa (13

species) and fish (10 species) as well as endangered Hawaiian monk seals have been documented in recovered trawl nets (Donohue et al. 2001). In Australia, animals recorded in derelict nets include juvenile hawksbill turtles (*Eretmochelys imbricata*), catfish (*Arius* sp.), triggerfish (Balistidae) and a shark (*Carcharhinus* sp.) (White 2006).

The overall goals of any derelict fishing gear program include assessing the extent of the derelict fishing gear damage to marine organisms and ecosystems and to identify possible remedies. The Northwest Straits Initiative's Derelict Fishing Gear Assessment, Recovery, Training and Outreach Program will continue to 1) quantify and understand the loss and abandonment of fishing gear, 2) recover and dispose of existing derelict fishing gear, 3) prevent derelict fishing gear through education, regulation and compensation, and 4) review fishing gear materials and develop new technologies.

Future studies will prioritize areas for gear survey and removal; for example, areas near U. S. Fish and Wildlife Service National Refuges may have derelict gear that entangles and kills diving seabirds and mammals, affecting their protection and recovery in Puget Sound and perhaps throughout the Pacific Northwest. We also want to target recovery and assessment efforts on areas known to be important migration routes for threatened and endangered Pacific salmon stocks; derelict gillnets, particularly those suspended in these areas, may kill salmon on their way back to natal streams to spawn. We will also continue modeling the impact of derelict gear on marine taxa; parameterizing survival times of captured animals, deterioration and self-baiting rates, and seasonal animal densities are necessary to estimate impacts of derelict fishing gear on marine fauna in the Puget Sound and surrounding marine waters. We hope to refine prioritization of derelict gear removal as well as to reduce and prevent new derelict gear by

identifying potential hotspots of recruitment. These efforts will benefit the Puget Sound marine ecosystem by reducing the level to which marine debris is a threat, and they will benefit society by reducing risks to human health, safety and navigation by facilitating the removal and reduction of derelict gear in nearshore marine environments.

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Table 1. Marine invertebrate species identified in derelict fishing nets recovered from the inland marine waters of Washington.

	Alive	Dead
Giant barnacle	982	2447
Butter clam	0	766
Dungeness crab	1748	558
Red rock crab	594	417
Smooth pink scallop	15	263
Oregon triton	96	136
Kelp crab	55	45
Longhorn decorator crab	44	31
Pacific littleneck clam	0	27
Puget Sound king crab	4	14
Leafy hornmouth	43	12
Lyre crab	35	12
Nuttall's cockle	0	8
Seastar (unidentified)	28	7
Heart crab	2	4
Northern kelp crab	5	2
Sunflower star	10	1
Golfball crab	7	1
Brown box crab	0	1
Granular claw crab	0	1
Tanner crab	0	1
Spiny pink star	4	0
Green sea urchin	2	0
Helmet crab	2	0
Giant Pacific chiton	1	0
Red fur crab	1	0
Pacific octopus	1	0

Table 2. Marine fish species identified in derelict fishing nets recovered from the inland marine waters of Washington.

	Alive	Dead
Salmon (unidentified)	0	154
Spotted ratfish	0	111
Flatfish (unidentified)	0	92
Fish (unidentified)	0	78
Lingcod	2	73
Kelp greenling	5	57
Spiny dogfish shark	1	52
Black rockfish	0	51
Rockfish (unidentified)	7	46
Sockeye salmon	0	25
Peamouth chub	0	15
Cabezon	8	14
Sculpin (unidentified)	3	6
Red irish lord	5	5
Chinook salmon	0	5
Quillback rockfish	3	2
Great sculpin	1	2
Starry flounder	0	2
English sole	0	1
Greenling (unidentified)	0	1
Puget Sound rockfish	2	1
Six-gill shark	0	1
Prickleback (unidentified)	31	0
Striped surf perch	1	0

Table 3. Marine bird species identified in derelict fishing nets recovered from the inland marine waters of Washington.

	Alive	Dead
Seabird (unidentified)	0	58
Cormorant (unidentified)	0	26
Brandt's cormorant	0	14
Pelagic cormorant	0	7
Double-crested cormorant	0	6
Grebe (unidentified)	0	4
Gull (unidentified)	0	2
Common loon	0	1
Merganser	0	1
Shorebird (unidentified)	0	1

Table 4. Marine mammal species identified in derelict fishing nets recovered from the inland marine waters of Washington.

	Alive	Dead
Harbor Seal	0	8
California Sea Lion	0	2
Harbor Porpoise	0	1
Marine mammal (unid.)	0	1

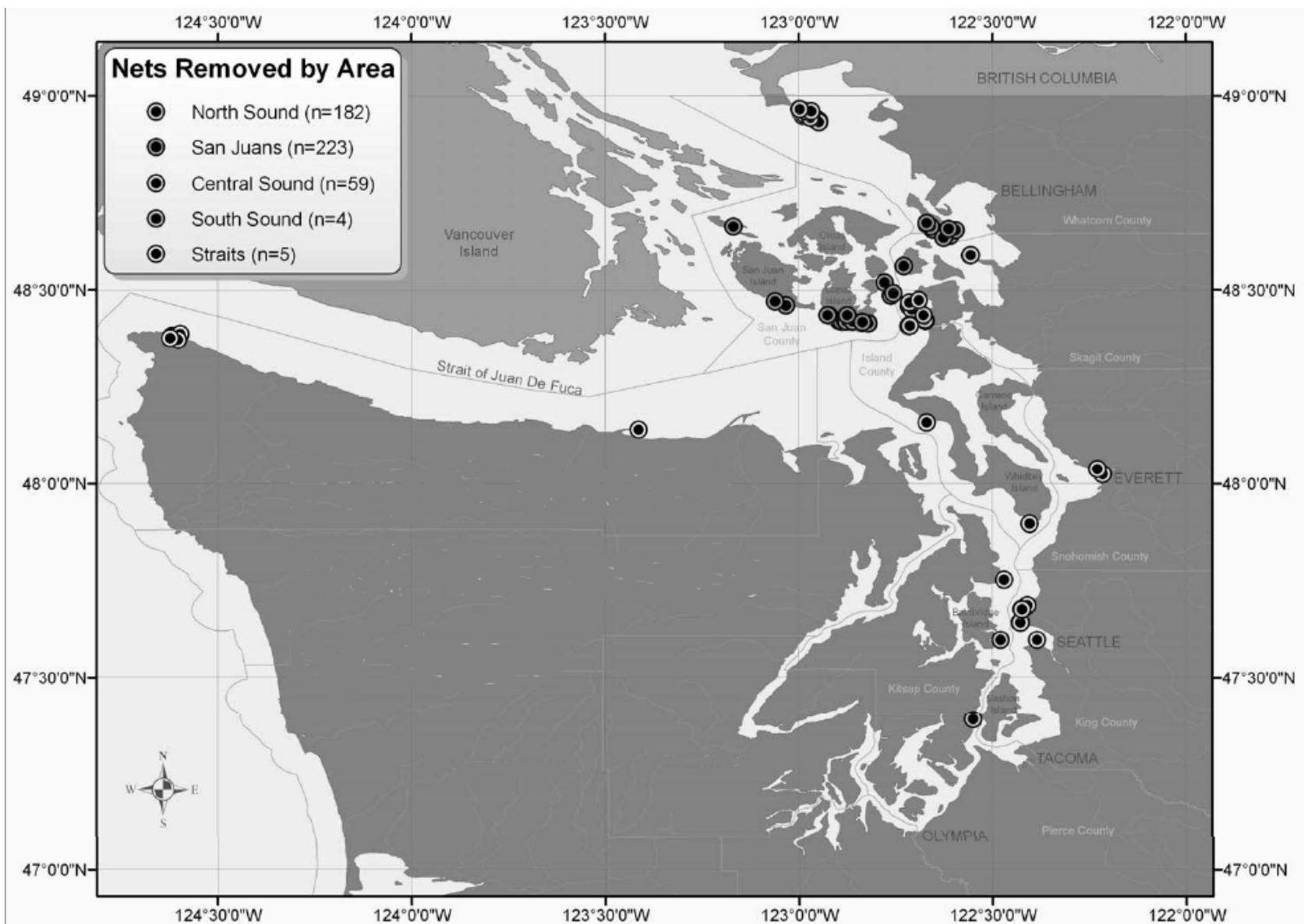


Figure 1

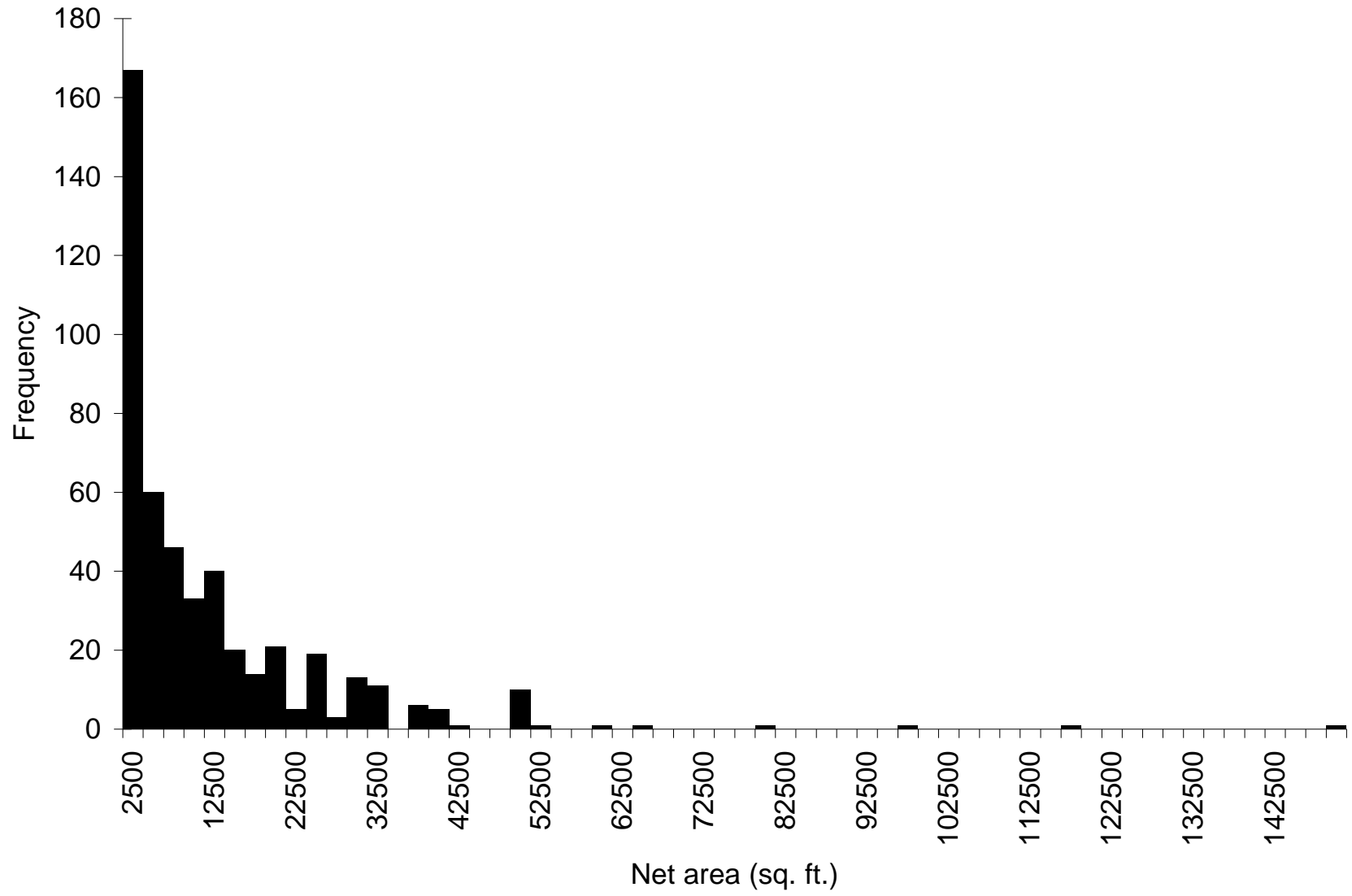


Figure 2

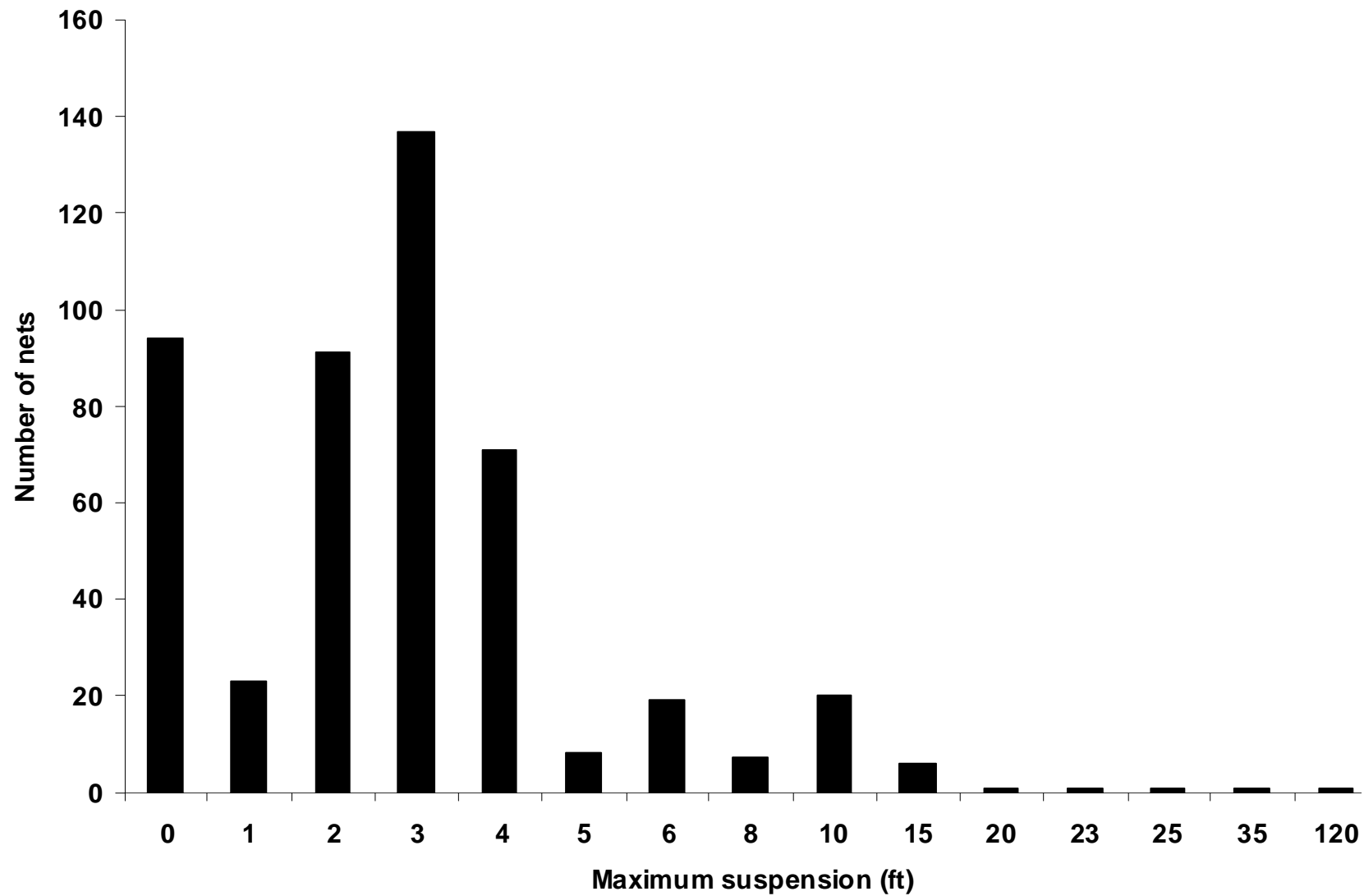


Figure 3

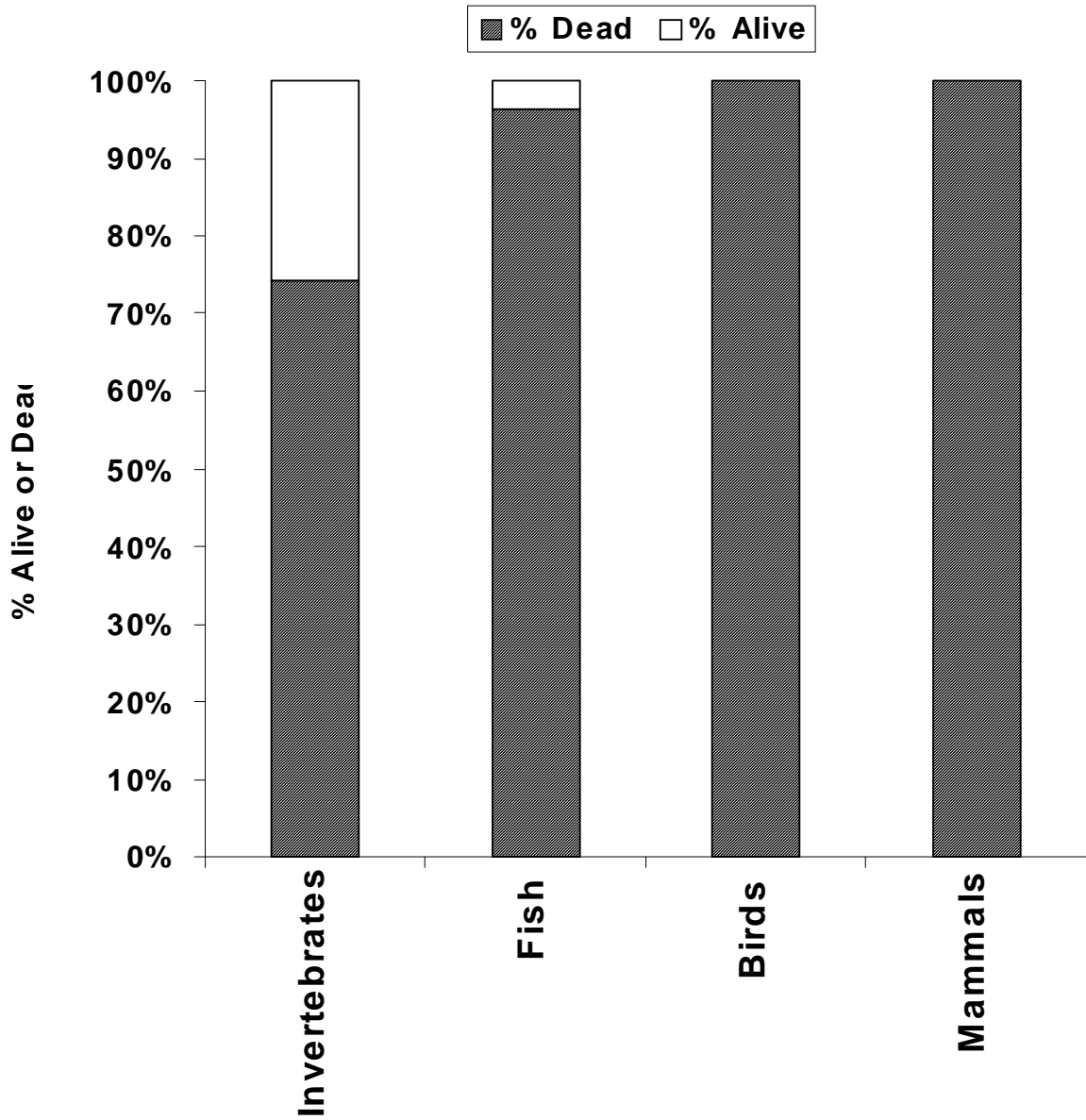


Figure 4