NORTHWEST STRAITS
marine conservation initiative

A Cost-Benefit Analysis of Derelict Fishing Gear Removal In Puget Sound, Washington

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ABSTRACT

Information collected over the past four years (2004-2007) during the Northwest Straits Initiative's derelict fishing gear survey and removal program in Puget Sound, Washington, was used to estimate costs and directly measurable benefits of derelict fishing gear removal. Costs of derelict net survey and removal totaled $4,960 per acre of net removed. Costs of survey and removal of derelict pots/traps totaled $193 per pot/trap. Directly measurable monetized benefits of derelict fishing gear removal were based on the commercial exvessel value of species saved from mortality over a one-year period for derelict pots/traps, totaling $248 per pot/trap and a ten-year period for derelict nets, totaling $6,285 per acre. The cost-benefit ratio was positive and similar for the removal of both gear types measuring 1:1.28 for pots/traps and 1:1.27 for derelict nets. Although indirect benefit values of human safety, impediments to vessel navigation, habitat restoration, reduction in mortality of non-commercial and protected or endangered species and pollution removal were not monetized, derelict fishing gear removal compared favorably in cost effectiveness with habitat restoration and oiled wildlife rehabilitation projects. Given the expected long-term lifespan of these mainly synthetic-based derelict gears, negative impacts may continue for many years or decades beyond the 10-year period used in the cost-benefit analysis. The cumulative costs of not removing this derelict gear now will likely be much higher in the future.

INTRODUCTION

Cost-benefit analysis can play an important role in legislative and regulatory policy decisions on protecting and improving the natural environment. Policy makers and natural resource managers are faced with the difficult task of comparing a myriad of environmental resource conservation programs each with varying costs and benefits to society and deciding which to implement with limited public funds. Cost-benefit analysis can provide an exceptionally useful framework for consistently organizing disparate information and both improving the process and the outcome of policy analysis. While the costs of environmental conservation/restoration programs are typically directly measurable, there is no general agreement about the correct method for valuing all of the environmental benefits of such programs. Nevertheless, measures of observable market values and inferred social values of environmental conservation/restoration actions compared with the costs of implementing those actions can provide policy makers with the necessary information to make informed public policy and expenditure decisions.

The Northwest Straits Initiative (NWSI) working in cooperation with the Washington Department of Fish and Wildlife (WDFW) and the Washington Department of Natural Resources (WDNR) has developed a comprehensive derelict fishing gear removal program for Washington State. The program includes a "no-fault" derelict fishing gear reporting system for fishers and the general public, survey techniques to find existing derelict gear, a database of known derelict fishing gear, a process for prioritizing derelict fishing gear removal, safe and environmentally effective removal protocols, a science-based data collection system on the impacts of derelict fishing gear and a reporting system that summarizes the costs and benefits of derelict fishing gear removal. Four years of work has been completed and there are still thousands of items of derelict gear yet to be removed. This report represents an attempt to analyze the costs and benefits of derelict gear removal for the purpose of informing decisions about continued expenditure of funds for this program.

The costs of derelict fishing gear removal are both economic and environmental. Economic costs are directly measurable as expenditures for finding, removing and reporting on derelict gear removal operations. Environmental costs include impacts on the environment from the physical removal of derelict fishing gear and the loss of habitat the gear itself may have been providing. While more difficult to monetize, the environmental impacts of derelict fishing gear removal are collected during the removal process.

Quantifying the benefits of derelict fishing gear removal is a more complicated process. There are the directly measurable costs of the impact of derelict fishing gear with respect to the loss of commercially valuable species. Other costs include those associated with the impacts on non-commercial species, such as endangered or protected species that are the focus of expenditures in other conservation programs. Lastly, there are costs associated with the impact of derelict fishing gear on the environment. Quantifying the value of directly measurable benefits of derelict fishing gear removal on commercially valuable species requires an estimate of the loss rate of the species, the effective impact lifespan of the derelict fishing gear, and the market value of the species impacted. Quantifying the value of derelict fishing gear impacts on non-commercial species and the environment is more difficult. Typically cost-benefit analyses have attempted to value these indirect benefits using contingent valuation (reference). The social value of non-monetized benefits are assessed by polling the public on whether they would be willing to pay to conserve or restore a particular natural resource. Contingent valuation of the benefits of derelict fishing gear removal on non-commercial species and the environment is beyond the scope of this analysis. However, the costs and benefits of derelict fishing gear removal for environmental conservation or restoration can be compared with costs and benefits derived from projects that require marine habitat mitigation measures. For example, a marine construction project such as a marina development may include negative impacts to existing marine habitat that the proponents are required to mitigate through like-kind habitat development or restoration. In these scenarios the monetized cost of mitigation is a known sum based on the actual cost of the development or restoration project. These mitigation costs represent the benefit value that the permitting agencies, acting on behalf of the public, place on the service functions the habitat provides.

This paper provides an overview of the information available from the Northwest Straits Initiative's (NWSI) derelict fishing gear program that is relevant to cost-benefit analysis, presents preliminary cost-benefit estimates and compares these estimates with other derelict fishing gear removal projects worldwide. A comparison between the costs of species protection and habitat restoration through derelict gear removal and other programs is also presented.

METHODOLOGY

This cost-benefit analysis relies on data collected over the past four years of derelict fishing gear removal work conducted by the NWSI. Data is collected both during derelict fishing gear surveys and removal operations. During derelict fishing gear surveys, data is collected on the number of days of survey operations, the location and area surveyed, the number of derelict fishing gear targets found and the cost of the survey operation. Data typically collected during a derelict fishing gear removal project includes number of total operation days, number of actual dive removal days, number of derelict fishing gear items recovered, length, width and surface area of derelict nets recovered, surface area and type of habitat impacted, relative age and condition of the derelict fishing gear, number of animals dead and alive by species, impacts of the derelict fishing gear on the habitat and the cost of removal and disposal.

Survey and Removal Costs

Costs for derelict fishing gear surveys and removal operations are based on actual costs incurred for these operations. Costs are calculated per operational day, per unit of derelict gear and, in the case of derelict nets, on a per unit of habitat area restored. Operational days include vessel transit to and from the removal site, actual dive removal operations and unloading and disposal of the derelict fishing gear recovered. Estimated costs for removal operations include costs required under the Washington State derelict fishing gear removal program for preparation and approval of a removal plan, notification of local, state and federal agencies, onboard data collection, storage and return of gear to owner, disposal costs and final report preparation costs.

Benefits

Directly measurable benefits from derelict fishing gear removal include the value of commercial or recreational species that would otherwise be lost due to mortality from entanglement or entrapment in the derelict fishing gear. Dungeness crab, *Cancer magister*, is the primary commercial and recreational species entrapped and killed by derelict crab pots. Derelict nets capture Dungeness crab and several species of salmon, *Oncorhynchus spp.*, that are valuable to commercial fisheries in Puget Sound and a variety of species of value to recreational fisheries including rockfish, *Scorpaenidae spp.* and lingcod, *Ophiodon elongates*. Studies are underway to better estimate the annual mortality of these species in derelict fishing nets in different habitats. However, some preliminary projections of average annual mortality from derelict fishing gear are possible with current information on the number and condition of species collected during derelict gear removal operations.

Commercial value is based on the exvessel value of Dungeness crab, salmon (sockeye salmon, *O. nerka*), lingcod, and rockfish. Although other commercially or recreationally valuable fish and invertebrates are entangled or entrapped in derelict fishing gear in Puget Sound, either exvessel values were not available or the numbers of each species found in the gear was low. Therefore, they were not considered in the overall benefit value of removing the derelict gear. Although a number of species killed by the derelict fishing gear are popular recreational target species, assigning a recreational value to species caught and killed in derelict fishing gear is difficult. Numerous studies have attempted to quantify the value of recreational caught species based on either direct expenditures or contingent (social) value. In this analysis, commercial exvessel value for Washington State caught fish and shellfish is used as a conservative surrogate for recreational value. Most of the commercially or recreationally important animals entrapped and killed by derelict fishing gear are adults and no adjustments in benefit values were made for natural mortality to recruitment to the fisheries. Although only male Dungeness crab with a carapace width of 6.25 inches or larger can be legally retained by commercial and recreational fisheries in Puget Sound, both male and female crab were included in the benefit value calculations for derelict crab pots and nets. The benefit value of the reproductive potential of female Dungeness crabs was believed to be at least equal to the commercial value of the male crab (Rich Childers, WDFW, pers. com.). No future reproductive benefit value was assigned to other species.

Other benefits of derelict fishing gear removal to non-commercial/non-recreational species and to habitat restoration are more difficult to monetize. Non-commercial/non-recreational species entangled and killed by derelict fishing gear (primarily derelict nets) include mainly marine mammals and seabirds. For this analysis, we use a surrogate value for impacts to these species based on the estimated costs of rehabilitating these animals during oil spill events. Rehabilitation cost represents a reasonable contingent value the public is willing to pay to recover these species, whether impacted by an oil spill or entangled and killed in derelict fishing net. The value of the reproductive potential of animals killed by derelict fishing gear is not considered in this analysis.

Derelict fishing gear has both negative and positive impacts on marine habitat. Derelict crab pots impede marine vegetation growth such as eelgrass within its footprint on the seabed, approximately 7 sq. ft. per pot. When left untended in areas with high tidal currents, derelict crab pots can cause erosion of the seabed around the pot amounting to four to five times the foot print area of the pot or up to 35 sq. ft. Derelict crab pots can host a number of sessile organisms and facilitate growth of marine algae. Derelict fishing nets limit access to natural habitat reducing service functions. Tidal or current-caused movement of the nets can sweep areas clean of sessile animals and impede the growth of marine plants. Net meshes have been observed to filter and trap fine sediments from the water column suffocating plants and animals. Derelict nets can host juvenile scallops, provide protective habitat for small fish and host plants and animals such as marine algae and barnacles. However, based on diver observations during the past four years of removal operations, derelict fishing gear is believed to have a significantly greater negative impact on natural marine habitats than positive impact. Access to habitat is limited and habitat service functions are diminished by the presence of derelict fishing gear. Studies of the rate of recovery of habitat after derelict fishing gear removal are ongoing, but initial observations indicate that habitat recovery is rapid and that many natural service functions are restored within several months. This analysis uses the reported cost to create or restore similar habitats to those impacted by derelict fishing gear as a monetized valuation of the benefits of derelict fishing gear removal.

RESULTS

Costs

Over the past four years (2004-August 2007), the NWSI has conducted 81.5 days of derelict fishing gear survey operations, including 31 days of diver derelict net surveys and 50.5 days of diver and/or side scan sonar surveys for derelict pots/traps. The 31 days of diver surveys for derelict nets found 178 derelict nets, or 5.7 nets per day. The average cost for the 31 days of diver net surveys was $2,200 per day, or approximately $386 per derelict net found. Derelict nets removed varied widely in size from small scraps to entire gillnets 1,800 ft in length and 100 ft wide. On average, each net covered approximately 0.28 acres of habitat, or 12,180 sq. ft. Therefore, survey costs for derelict fishing nets averaged approximately $1,380 per acre of habitat impacted. A total of 4,411 derelict pots or traps were found during the 50.5 days of diver and/or side scan sonar surveys conducted for the four year period for an average of 87.3 derelict pots found per day. Diver and/or side scan sonar survey costs for derelict pots were similar to diver survey costs for nets at $2,200 per day for an average survey cost of $25.02 per derelict pot/trap found.

A total of 225.5 days of derelict fishing gear removal operations were conducted over the four-year period, including 167 days of derelict net and 58.5 days of derelict pot/trap removal operations. The total removal costs averaged $3,580 per operational day for both derelict nets and pots/traps. During the 167 days of derelict net removal operations 115 days was actually spent in diver removal operations and the remaining 52 days were transit and offloading days. A total of 604 derelict nets covering an area of 168.4 acres were removed during the 167 days of operations for an average of 3.6 nets per day or 1.0 acre of habitat restored. The average cost per net for the removal operations was $994, or $3,580 per acre of habitat restored.

During the 58.5 days of derelict pot/trap removal operations, 51 days were actually spent in diver removal operations and the remaining 7.5 days in transit and offloading. A total of 1,248 derelict pots/traps were removed for an average of 21.3 pots/traps removed per operational day for an average cost of $168 per pot/trap removed.

Total costs of both survey and removal operations for derelict fishing nets averaged $1,380 per derelict net ($386/net survey costs + $994/net removal costs) or $4,960 per acre ($1,380/acre survey costs + $3,580/acre removal costs) of habitat restored. Total costs for survey and removal of derelict pots/traps averaged $193 per pot/trap ($25/pot or trap survey cost + $168/pot or trap removal cost).

Directly Measurable Benefit Values

Directly measurable benefits include the value of commercial or recreational species that would otherwise be lost due to mortality from entanglement or entrapment in the derelict fishing gear. Actively fishing derelict crab pots contained on average 6.2 Dungeness crab per pot. Based on reports of local commercial crab companies that hold live crab, most crab die within three weeks to one month of holding. Therefore, we assumed the crab observed in the derelict pots represent the catch for a 30 day period. Expanding the monthly catch to an annual catch yields an estimate of 74.4 crab caught per year. Although crab may be caught and escape from pots (High, 1976), we assumed escaped crab would be replaced by new entrants and the crab observed in the pots represented crab likely to die in the pot. A study in British Columbia showed little, if any, escape of legal sized Dungeness crab from derelict pots (Breen, 1987). WDFW regulations require the use of a degradable cotton cord material on commercial and recreational crab pots designed to allow crabs to escape after 30 to 90 days. However, 24% of the crab pots recovered during the NWSI program have not been equipped with the proper degradable cord. Additionally, pots with the proper cord have been observed to be still actively fishing due a failure of the pot lid to open after degradation of the cord either because the lid was jammed shut against the frame or because animal or plant growth on the pot rim held the door closed. Some pots recovered more than two years after loss based on the date of the registration tag in the pot, were still actively fishing. During NWSI removal operations, 37% of the derelict pots recovered were still actively fishing and, on average, probably continued to actively fish for at least one year.

The average weight of Dungeness crab found in the derelict pots was approximately 2 lbs. An actively fishing derelict crab pot can be expected to result in the mortality and commercial loss of approximately 148.8 lbs of crab per pot per year. The average exvessel value of Dungeness crab on the U.S. West Coast is reportedly $1.67/lb yielding a lost commercial value of $248.50 per actively fishing derelict crab pot. The WDFW derelict fishing gear database currently has 2,811 derelict crab pots that have been detected by side scan sonar, but have not been investigated by divers. The area surveyed represents less than 20% of the Puget Sound crab fishing grounds monitored by WDFW. Assuming crab pot loss rates are similar in all areas, the actual number of derelict crab pots in Puget Sound may total approximately 14,000 pots. Based on the 37% of the derelict pots recovered that were still actively fishing, up to 5,000 actively fishing derelict crab pots probably exist in Puget Sound. The total annual loss of Dungeness crab from the derelict pots could be 372,000 crab weighing 744,000 lbs with an exvessel value of $1.2 million. This loss represents approximately 30% to 40% of the average annual commercial catch of Dungeness crab in Puget Sound that has ranged from 1.8 to 2.3 million lbs per year in recent years (Don Velasquez, WDFW, pers.com.). Based on $193/pot for survey and removal costs and directly measurable monetized benefits from Dungeness crab saved of $248/pot/year, derelict crab pot removal has a cost benefit ratio of 1:1.28.

A study of crab loss in deliberately set derelict crab pots in the Fraser River estuary in British Columbia, estimated that each pot killed 7.88 to 9.95 Dungeness crab per pot per year and total loss from industry reported crab pot losses totaled approximately 7% of the annual value from the commercial fishery (Breen, 1987). However, the observed crab mortality in British Columbia may have been underestimated because the pots were set within 10 meters of each other along a groundline and pots set on the ends caught significantly higher numbers of crab (40+) during the experiment. Derelict pots were found to have a constant catch rate of Dungeness crab at the end of the one year study. Annual mortality of blue crabs, *Callinectes sapidus*, in derelict pots, ranged from 25.8 crabs/pot/yr in Louisiana (Guillory, 1993), to 20 to 60 crabs/pot/yr in South Carolina (Whitaker, 1979).

Other studies have found crab losses from derelict pots or traps to represent a significant percentage of the commercial catch. The reported catch of lobster in pots lost off the New England coast was 5% of the total lobster landings in 1976 (Smolowitz, 1978). A study in Louisiana estimated that approximately 250,000 derelict traps are added each year in the Gulf of Mexico (Guillory *et al*, 2001), with ghost fishing leading to a loss of 4 to 10 million blue crabs each year in Louisiana (GSMFC, 2001). In the trap fishery of Kuwait financial losses due to ghost fishing were estimated to reach 3 to13.5% of the total catch value in the fishery (Mathews *et al*. 1987 in Al-Masroori *et al*. 2004). Matsuoka et al. (2005) estimated that derelict octopus traps in a municipality in southern Japan were catching between 212,000 to 505,000 octopuses per year weighing 100 to 250 metric tons (mt) and representing two times the commercial landings in the fishery.

The NWSI returns derelict crab pots to fishers if the ownership can be established and if the pots are of reasonably good condition. Over the four year period, 75 of the 1,248 pots recovered or about 6% have been returned to owners. Fishers estimate the value of returned derelict pot at about $50 per pot (Joe Schmitt, pers. com.) for a total value of $3,750 for all pots returned. This equates to a direct benefit to fishers of approximately $3 per pot for the 1,248 pots recovered in the program to date.

Derelict nets also catch and kill species with commercial value. With funding from the National Fish and Wildlife Foundation, the NWSI is currently conducting a study to estimate the catch and decomposition rate of animals in derelict nets. Preliminary results of tagging experiments of live and dead animals in derelict nets indicate that captured animals are processed rapidly either through natural decomposition or due to consumption by other animals, primarily sunflower stars (*Pycnopodia helianthoides*) that are abundant on most derelict nets encountered. Soft-bodied animals such as fish, seabirds and smaller marine mammals are processed fairly rapidly and may only be obvious in the derelict net for seven to ten days after first encountered. Hard-bodied animals like crab and bivalves may remain alive for up to a month if not eaten by another animal. Estimating the actual annual mortality of animals in derelict nets from data collected during recovery is difficult without knowing the rate of capture, decomposition and seasonal effects. However, based on preliminary net tagging experiments, animals observed in derelict nets conservatively represent catches that have occurred within that past 14 days. Therefore, annual total mortality is likely to be 25 times the number of animals observed in the net at recovery. Total mortality caused by the derelict net is the annual mortality multiplied by the number of years the derelict net has been in place. In most cases it is very difficult to estimate the number of years derelict nets have been in place in Puget Sound. Many of the nets are believed to have been lost during the peak of the gillnet fishery in the 1970s and 1980s. Changes in mesh size and construction materials in the 1970s indicate that some of the nets recovered are over 30 years old. For the purposes of this analysis we have used a conservative estimate of an average effective age of ten years for derelict fishing nets encountered.

Live or dead entangled animals having recreational or commercial value found in the 604 derelict nets recovered to date during the NWSI derelict fishing gear program include 183 salmon (*Oncorhynchus spp*.), 101 rockfish (*Scorpaenidae spp*.), 83 lingcod (*Ophiodon elongates*) and 600 Dungeness crab. Using WDFW average catch weights, reported commercial exvessel values and projecting the catches per derelict net annually and over the ten year estimated lifespan of the typical derelict gillnet, each derelict net removed results in the loss of approximately $1,760 of recreational or commercial species. Based on the 604 derelict nets removed having a total surface area of 168.4 acres, the average net covers 0.28 acres and the benefit in value of recreational or commercial species saved from derelict net removal is approximately $6,285/acre. The derelict nets removed to date by the NWSI project have killed commercial and recreational species valued at approximately $1.06 million. The estimate may overvalue some species such as salmon, which likely have seasonal variations in catch, but the overestimate may be offset by using the commercial value ($1.00 per lb or $8 per fish for salmon) as a surrogate for the recreational value, which is likely higher. The cost benefit ratio for derelict net removal is 1:1.27, based on survey and removal costs of $4,960 per acre and the directly measurable monetized benefit to commercial and recreational species of $6,285/acre/10 years.

Brown and Macfadyen (2007) constructed a hypothetical cost-benefit model for a UK gillnet fishery considering similar removal program costs to those in the NWSI program. They calculated benefit values in terms of the recovered value of the fishing gear to fishers and the decreased loss of value for commercial species to mortality in the derelict nets. They estimated a negative cost-benefit value of 1:0.49 based on total costs of ∈46,500 and benefits of ∈23,836 over a ten-day removal operation. However, their removal costs included ∈ 30,000 (≈$42,500) for retrieval gear development. If the retrieval development costs are eliminated (presumably a one-time expense), the overall cost of the removal declines to about ∈16,500 (≈$23,500) over nearly a 1:1.44 cost-benefit ratio, similar to our cost-benefit value of 1:1.28.

Although other estimates of the cost-benefit ratios for derelict fishing gear removal are not available, studies have shown that mortality caused by derelict nets can represent a measurable impact of the value of commercial fisheries. Brown et al. (2005) did a review of ghost fishing in European and other fisheries. They reported that losses from ghost fishing in the cod and turbot gillnet fishery in the Baltic Sea represented 0.01 to 3.2% of the commercial harvest and 1.46 to 4.46% of the Spanish monkfish gillnet fishery harvest, although ghost fishing losses in other EU fisheries were believed to be insignificant. Ghost fishing catches in derelict gillnets in the Norwegian continental slope Greenland halibut (*Reinhardtius hippoglossoides*) fishery were found to decrease to 20 to 30% of an actively fishing net after 45 days and may continue to fish effectively for 4 to 7 years or longer representing a potentially significant impact on this overfished resource (Humborstad et al. 2003).

DISCUSSION

The estimates of derelict fishing gear survey and removal costs are based on actual costs incurred and the quantity of fishing gear and seabed habitats restored and accurately reflect the costs of these operations. Estimates of directly measured benefits in the savings of commercial and recreational species from the removal of both derelict pots and nets are based on a variety of assumptions of catch rates, effective life-span of the derelict gear and exvessel values of the species caught. Ongoing research investigations being carried out as part of the NWSI derelict fishing gear removal program will provide better estimates of these parameters in the near future. The benefit value estimates presented are believed to be within a reasonable range based on information collected over the past four years of operations (2004-2007). The cost-benefit ratios provided only consider the directly measurable benefits in terms of the commercial exvessel value of species likely to be saved by the removal of the derelict gear. The benefits do not reflect the indirect value of the restoration of habitat and the resulting assumed increase in productivity of commercial and recreational species and other species important to a healthy ecosystem. Additionally, the benefit value estimates do not include the value of protected species such marine mammals, seabirds and ESA listed species that may be saved from entanglement and mortality in the derelict fishing gear removed. The benefit value of habitat restoration and of saving of protected species is difficult to monetize without an extensive contingent valuation study that is beyond the scope of this analysis.

However, the cost effectiveness of derelict fishing gear removal can be compared with other habitat restoration and species conservation programs. For example, a project to restore bull kelp, *Nereocystis luetkeana*, in nearshore rocky habitats in the San Juan Islands in Washington State estimated restoration costs between $485,830 and $809,717 per acre (Carney, et al. 2005). In San Francisco Bay, a project to restore eelgrass habitat on 1.73 acres of seabed had an estimated cost of $1,130,000 or $653,179/acre (San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, 2002). On the East Coast restoration costs for salt marsh habitat averaged about $16,000/acre. However, these costs ranged from a low of $6,000/acre for the simple installation of a tidal gate to $90,000/acre for excavation and replanting, while seagrass restoration was estimated to cost about $245,000/acre (Restoring Coastal Habitat for Rhode Island's Future, 2007). In Puget Sound, tidal and shallow subtidal habitat improvements required as mitigation for marine construction projects can cost from $100,000 to $300,000/acre and more (Dr. Jon Houghton, Hart Crowser/Pentec, Inc., pers.com.). Results from the NWSI derelict fishing gear project in Puget Sound suggests that restoration of habitat by derelict fishing net removal is a cost effective alternative at $4,960/acre.

Although estimates of the monetized value of protected and endangered species are generally not available, costs incurred to rescue these animals from other anthropogenic perturbations can provide an estimate of the cost effectiveness of derelict fishing gear removal for the protection of these species. For example, seabirds and marine mammals oiled during oil spill events are often rescued, cleaned and released as part of oil spill response activities. In California, legislation mandates oiled wildlife care and has established California's Oiled Wildlife Care Network (Newman et al. 2003.). Estimates of the cost of oiled wildlife rehabilitation and survival rates range widely depending upon species and location. However, Jessup (1998) estimated that experience with oil spills in California shows that seabird rehabilitation costs on average $600 to $750 per bird and marine mammal costs average $4,000 per animal and that the long term survival of the rehabilitated animals is relatively low (50%) in most cases (Newman et al. 2003). A total of 17 dead marine mammals (mainly harbor seals, *Phoca vitulina*) and 208 dead seabirds (mainly cormorants *Phalacrocoracidae spp*. and grebes *Podicipedidae spp*.) were encountered in the 604 recovered derelict nets covering 168.4 acres, or 0.1 marine mammals and 1.2 seabirds per acre of net removed. However, numerous seabird and marine mammal bones are found under and around the derelict nets recovered, accounting for many more animals than actually recovered in the nets removed. If the seabird and marine mammal mortality observed in the derelict nets represents the catch rate for just the previous month, the number of animals killed annually is estimated approximately one marine mammal and 14 seabirds per year per acre of derelict net. The cost to rehabilitate this number of animals from oiling would be about $13,100 (one marine mammal at $4,000/animal and 14 seabirds at $650/seabird) whereas the cost of saving an equal number of animals in the NWSI derelict fishing gear program from the removal of one acre of derelict fishing nets is approximately $4,960.

Derelict fishing gear removal certainly provides benefits to the environment through reduction in entanglement and mortality of commercial and recreationally valuable fish and invertebrates, protected and endangered species, other species and restoration of important habitats. Monetizing these benefits for a quantitative cost-benefit analysis is more difficult. The comparative values of cost-benefit and cost effectiveness presented represent preliminary values that will be refined upon the completion of ongoing research projects into the impacts of derelict fishing gear. Additionally, the NWSI recently completed a derelict fishing gear prioritization process that will guide future removal operations assuring that available removal funds will be directed at the most damaging derelict fishing gear.

With cost-benefit ratios of about 1:1.28, derelict fishing gear removal can be justified based solely on the savings in exvessel value of commercial and recreational species impacted. The additional benefits of reduced threats to human safety and vessel navigation, habitat restoration, increased ecosystem diversity and removal of fishing gear pollution makes derelict fishing gear removal even more compelling. Given the expected long-term lifespan of these mainly synthetic-based gears, negative impacts may continue for many years or decades beyond the 10-year period used in the cost-benefit analysis. The cumulative costs of not removing this derelict gear now will likely be much higher in the future.

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