A COST COMPARISON OF VARIOUS METHODS OF RETRIEVING DERELICT FISHING GEAR

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ABSTRACT

This paper poses the question: "Which marine debris cleanup program most efficiently minimizes marine animal deaths and reef destruction?" It is a pioneering work offering the hypothesis that the most cost-effective use of marine debris cleanup funds is to provide incentives for fishermen to retrieve and bring ghost nets to port. The literature is reviewed to reflect the vastness of the marine debris problem and demonstrate that there are very few hard numbers published to, a) measure the "killing efficacy" of various debris types or, b) measure the cost of removing the various types of debris. The conclusion is that while certain clean up programs (beach cleanups) are far less expensive than ghost net retrieval, and certain types of debris (crab pots and snagged net) are more deadly, the ghost net program will most cost-efficiently reduce marine animal deaths caused by marine debris.

The pioneering nature of the paper is reflected in nearly half of the references being personal communications. The paper suggests an incentive price for retrieved ghost net and proposes that the cost of ghost net disposal can be reduced by providing facilities on ports for recycling companies to pick up other fishing boat detritus such as used oil and metal. The paper is intended to serve as a base for scientists and fishing organizations to build on the hypothesis and offer refinements to the proposed solution.

SUMMARY

Huge inefficiencies offer huge opportunities. Marine debris is a problem so massive that scientists can only fill in additional pieces of a gargantuan puzzle. The Ocean Conservancy estimates that over one million birds and over 100,000 marine mammals and turtles die each year from marine debris and that literally millions of cigarette butts have been picked up from beautiful beaches, (Sheavely, 2002) and that nets snag on pristine reefs, severely impacting reef and marine life (Donohue, 2000). It is known that plastic debris degrades far more slowly in marine environments than they do on land becoming "killing machines" for up to 20 years (Andrade, 2004). Abandoned crab pots and nets kill up to 50% of the available catch in some regions (Matsuoka, 2000). Debris entangles boat propellers so frequently that some fishing boats routinely carry scuba gear in anticipation of entanglement (Cook, 2004).

Treaties, laws and guidelines have limited success in reducing marine debris. While papers call for more effective enforcement of MARPOL Annex V and for related creation of other guidelines or laws, there is little indication that these measures are working in international waters. (Moore, et al., 2000). While the US Navy has taken the lead in being responsible marine stewards, (Baucom, 2002), not one paper reported a decrease in the amount of marine debris since MARPOL Annex V or the release of other guidelines. (Laist, et al., 1995). Many ports do not supply adequate disposal facilities to accommodate MARPOL-mandated detritus, thus impeding compliance (Minton 2002; Burch 2004).

Funding for marine debris removal is severely limited. A search of some 500 articles and numerous conversations with researchers and fishermen reveal that the issue of the most efficient use of capital has not been directly addressed. In an attempt to find a huge opportunity in this huge inefficency, this paper points to maximizing removal of the most harmful debris with the minimal dollars available.

This paper examines retrieval programs ranging in cost from $65 to $25,000 per ton, rank types of debris from mildly harmful to extremely harmful, and hypothesizes that the most efficient use of limited funding is through buyback programs wherein fishermen are paid to bring debris to port. A higher reward is suggested for monofilament line.
This paper concludes with a call to test this hypothesis by, a) working with organizations with buyback programs to measure their costs per ton, and b) shifting existing funding to carry out pilot buyback programs, c) create in Honolulu a larger marine debris recycling program to reduce current disposal costs of oil and metal, thereby freeing up funds to help pay for net buyback programs.

MARINE DEBRIS MAGNITUDE AND LACK OF DATA

While research pioneers such as Dr. Mary Donohue and Dr. Russell Brainard supply broad outlines of the magnitude of the marine debris problem, there has been no comprehensive estimate of tonnage or impact.

Sheavely (2000) provides a good overview, documenting that somewhere between 50% and 80% of all marine debris come from land sources such as storm water outfalls. She quotes studies showing 136 marine species becoming entangled in marine debris and 137 ingesting marine debris. She estimates that more than 103 millions pounds (65,000 tons) of beach debris have been collected worldwide from over 114,000 miles of coastline. Minton (2000) refines the data by estimating that "Commercial fishing gear accounts for approximately 5 percent of the total debris found in the ocean."

While the tonnage estimates remain vague, there is agreement that marine debris' impact is grisly. In Japan, as many as 500,000 octopuses may be accidentally killed yearly. (Matsuoka, 2004) In Alaska, up to 30,000 northern fur seals die from entanglement each year (Fowler, 2000). The gillnet problem is so serious that gillnet fishing has been banned in the Gulf Coast area and a ban is being considered in the Pacific (Wilson, 2003).

The research vessel *ORV Alguita*, exploring the North Pacific Central Gyre in 2000 found the surface layer, "contained alarming amounts of plastic products, tons of drifting nets, packing straps…a group of plastic fragments was seen in the water column every time we dove to visually confirm our findings…This was a sad confirmation of last year's survey results which found six pounds of plastic for every pound of plankton…" (Moore et al., 2000).

Even plankton is affected by debris. "Humans are smearing the oceans with plastic…microscopic fragments of plastic had been ingested by barnacles—which filter water for food—and in lugworms that burrow in the mud…plankton samples (contain) evidence of polymer debris as small as 30 millionths of a metre." Scientists raise the specter of the fragments working up the food chain to humans' bloodstreams (Radford, 2004).

Johnson (2000) describes marine debris as a propeller-snagging problem for fishermen. The Japanese have done the best job of measuring the problem. They state that "derelict fishing nets were…the most dangerous drifting objects for Japan," and that the Japanese fishing industry spent $4.1 billion repairing boats damaged by debris in 1992 (Watanabe, 2004). Matson Industries, a leader in marine transportation, indicates that while debris do get caught in propellers, they are "chewed up" and removed from the shafts while in port. (Hazlehurst, 2004), Sause Brothers, however, report revenue losses from being directed to rescue fishing boats with entangled propellers. (Burch, 2004) Even the famed voyage of the Hokulie'a to the Northwest Islands was delayed when the companion ship became entangled in net (TenBruggencate, 2004). Rather than attempting to quantify the magnitude of the problem, this paper focuses on removing as much of the most undesirable debris as possible.

THE COST EFFICIENCY OF MARINE DEBRIS REMOVAL

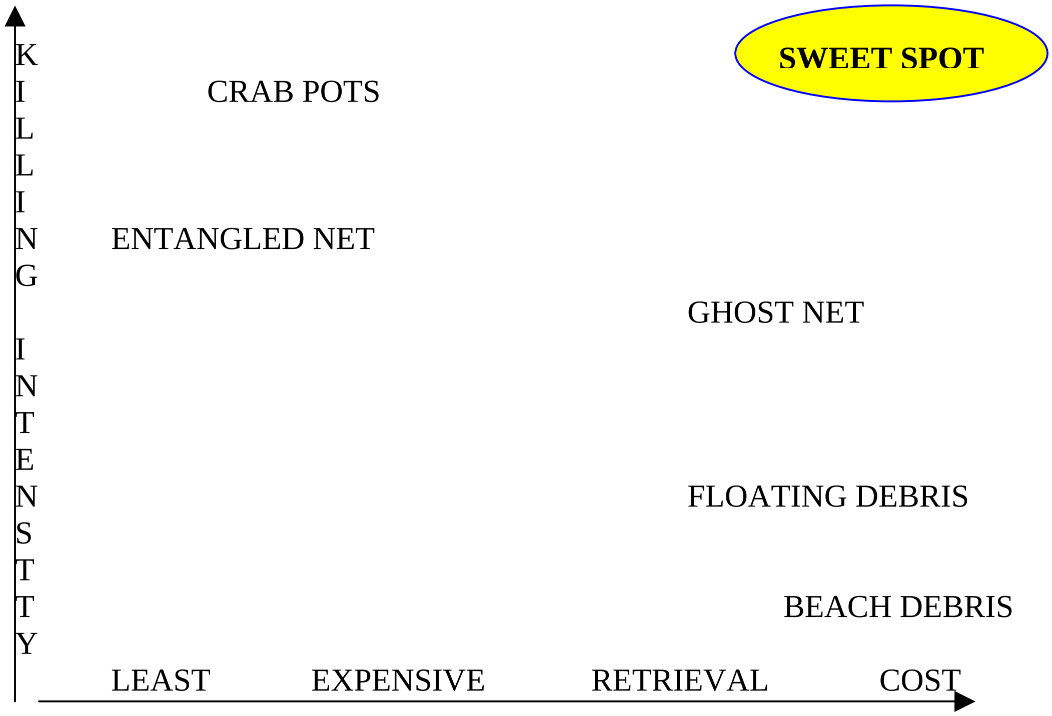
In addition to ignorance regarding the magnitude of the problem, hard data is also lacking regarding the efficiency of retrieving the various types of marine debris.
One study (Morozova, 2000) examines the issue of measuring the "efficiency" of marine debris removal but provides no hard data.

Pooley, an Industrial Economist notes, "A cost benefit perspective has much to offer in attacking the issue of marine debris." However, he does not provide any data or suggest a specific program. Most of the cost data presented herein is derived from conversations with those on the front line of debris removal, rather then from published papers (2000).

To find a measure of efficiency in removing debris, a hazard-hierarchy of debris, ranging from unaesthetic nuisances to long-term "killing machines." is needed. This paper assigns such a hierarchy in order of killing intensity: 1) crab pots, 2) entangled net, 3) ghost net, 4) floating debris and 5) beach debris.

This paper also assigns per-ton estimates to the cost of removing each debris type. From the least expensive to the most, the order is: 1) beach debris, 2) floating debris, 3) ghost net, 4) crab pots and 5) entangled net. The resulting matrix reveals that the least expensive clean-ups are also the least effective in removing "killing machines," to wit:

TABLE 1: THE “SWEET SPOT”



Note that Ghost Net retrieval comes closest to the “Sweet Spot” of retrieving killing machines at low cost. The “Sweet Spot” is an engineering term for denoting the intersection between optimum efficiency with work output. The table was derived from the following reports:

The Northwest Hawaii Islands retrieval of *entangled net* cost about $25,000 per ton. For example, the 2003 expedition retrieved 120 tons of net at a cost of $3,000,000 (Brainard, 2004), the major expense being two chartered boats at a cost of $10,000 per day (Collins, 2004). This estimate does not include the donated time involved in hauling the nest to a recycling facility for cutting, or the fee waiver at the garbage-to-energy plant.

There are no cost estimates for *crab pot* retrieval. While labor-intensive, the pots being located in near-shore locales ameliorate the cost of retrieving pots, and by the useable pots having a resale value of about $50 (Schmitt, 2004). A clue to retrieval cost is provide by an International Fund for Animal Welfare $12,000 grant to Massachusetts’s lobstermen to clear fishing and lobster gear that was discarded or illegally floating in Cape Cod Bay. Seven boats were deployed, at a cost of $1,700 per boat. The tonnage retrieved was not reported, but even if each boat retrieved only one ton, the retrieval cost would be $1,700 per ton (Blumenfield, 2000).
A mini-cost breakout of *ghost net* retrieval is Woolaway’s “Points for Pounds” program, which encouraged fishermen to bring debris into the Kaneohe Bay pier. The effort yielded 3 tons at a cost of $7,400, for an average of $2,467 per ton. (Woolaway, 2004)

Joe Schmitt of the Northwest Straits Commission, acting on information provided by fishermen, cleared 3 to 4 tons of floating net from a 12-acre sanctuary at a cost of $35,000, for an average of $10,000 per ton (2004).

Perhaps the most cost effective *floating debris* retrieval programs are in Korea. The Korean central government's program pays fishermen $3.50 per 40-liter bag of marine debris, and the Inchon Municipal Government pays fishermen $5.23 per bag. Assuming, based on Sheavly's data, that a 40-liter bag of debris weighs about 60 pounds, the Korean Government pays about $117 per ton, while the Inchon Government pays about $174 per ton. This does not, however, include the costs of administration, storage and disposal, which often exceeds reward costs. An indication that these costs can be high is provided by the fact that the Inchon City Government previously did the marine cleanup itself. The cost was between $1685 and $3,075 per ton (Dong Oh Cho, 2004). Sheavly (2002) forms a basis for the above estimate by reporting weight per bag of collected debris by reporting that a Texas cleans up involved 7,900 trash bags holding 124 tons of debris, indicating 60 pounds per bag of debris.

Ron Clarke of Alaska reports a *beach-clearance* of heavy nets on St. Paul Island in the Privilofs, at a cost was about $1,000 per ton, held down mainly to the presence of "free" heavy machinery and some volunteer labor (2004). Taiwan has undertaken many beach clean-up projects, averaging about $65 a ton because of the extensive use of volunteers. As with the Korean report, the estimate did not include the cost of landfilling the debris (Liu, 2004).
As a basis for comparison to similar operations, a Nature Conservancy marine algae removal project cost about $3,175 per ton (Sato, 2004).

Thus we see the range from $25,000 to $65 per ton and an indication of how inexact the numbers is. However inexact, the "sweet spot" table points to the retrieval of ghost net as the most cost-effective means reducing the problem. Adding to the potential cost effectiveness are the economies of scale. Ghost nets remain ubiquitous. Taiwan and Britain have created another, long-term category of retrieval: they are buying fishing licenses to reduce the size of fishing fleets. An extremely rough guess of the efficiency of this measure in Britain is $2,400 per ton.

GHOST NET: AN IMMENSE PROBLEM

A search of the literature provides a strong indication that ghost nets, although not "killing intensive" as entangled net and abandoned crab pots, may indeed be responsible for more marine deaths because of their sheer volume. The research group, Sea Life Surveys, estimates that more than one million birds and over 100,000 marine mammals and turtles did each year in marine debris (Ocean Conservancy, 2002).

For instance, drift nets, although banned in 1993, still pose a major problem. The World Wildlife first raised the alarm by reporting that "Moroccan, "Italian, French, Turkish and most probably other fishing fleets are using driftnets in breach of existing legislation"(Kaiser, 1996).
Apparently some nations are still employing drift nets. Just a few of the dozens of citations are listed below to present a sample of the findings worldwide. Minton reports that, "illegal vessels are still reportedly using driftnets to poach fish within the US Exclusive Economic Zone as well as on the high seas. Numerous documented cases exist of illegal driftnet vessels simply abandoning gear in the water once detected by surveillance aircraft.." (2003). Clemente-Colon suggests that "despite the ban, legal and illegal driftnet operations continue to take place.." (2003).

Burch cites an incident wherein a fishing boat aerially spotted with driftnet made a dash for its homeport, with a Coast Guard vessel unable to catch it in time. Senator Ted Stevens of Alaska phoned the errant nations' emissary in Washington and issued a threat of serious economic consequence if the boat were allowed to port. The vessel was stopped and duly issued a citation (2004).

Kiessling reports the recent discovery of a driftnet in the North Australian waters. It was traced to a homeport. Authorities reportedly destroyed the boat (2004).
Turtles are also victims of ghostnets. The Gainesville Florida-based Sea Turtle Survival League reports finding a turtle and hundreds of sharks and other fish were discovered dead and decomposing in an abandoned gill net—2.5 football fields long. Said Director David Godfrey, "Nets are one of the worst things floating around in the ocean. They're lethal to air-breathing animals like turtles and dolphins. They suffer a slow, horrible death by drowning (Moore, 2000).
In the San Juan Islands north of Seattle, "Ghost nets are killing fish and threatening the ecosystem. Ghost nets…are literally killing tons of (fish) in the waters around Washington. " Steve Jennison, Orca District Manager with the Washington State Department of Natural Resources said of ghost nets, "They entangle sea creatures and they become food for other fish who get entangled and they become a perpetual killing machine " (2002).

In Japan, a Kagoshima University team dove into heavy fishing areas and found that "40 % of the ghost nets were continuing to catch about 30 species including octopus, crab, flounder and sea bream." Professor Tatsuro Matsuoka, head of the study, "estimated 200.000 to 500,000 octopuses annually have been caught in the ghost nets. This amount is equivalent to the region's total annual harvest of octopus.." (2004).

A study of ghost net behavior in Britain indicated "ghost nets could continue to catch commercial species for at least 9 months after initial loss" (Anon, 2000).
Sheavly recognizes "derelict gear—nets, rope, fishing line, buoys and various traps" as a significant source of debris that "may be responsible for significant losses of some commercially valuable fish and crab species" (2002).

Finally, citing the most expensive examples of addressing driftnet entanglement problems, a report on the endangered Right Whales notes that many of "the known deaths of the endangered northern right whale each year are due to entanglement with lines that are dragged by fishing boats." In 1991, "researchers spent more than $250,000 trying to rescue a northern right whale entangled in rope, but couldn't' save it." In 2001, "multiple attempts to save an n entangled) 50-ton right whale named Churchill cost more than $250,000 and didn't work" (Onion, 2004). Regardless of cost, there is every indication that, ghost net, by its sheer volume, may be the largest "killing machine" of the marine debris categories.

THE SOLUTION: REWARDING THE FISHERMEN

Brainard and Donohue state that, "based on surveys of derelict fishing gear in the Northwestern Hawaiian Islands, trawl fisheries and gillnet fisheries, particularly driftnets, appear to be the most dominant forms of derelict fishing gear found." They continue, "The removal of derelict fishing gear at sea, before it encounters reefs or damages wildlife, may be the most advantageous mitigation action once debris enters the marine environment" (2002).

There is widespread consensus of the idea. Marine Scientist Hannah Bernard, who participated in the first NW Hawaiian Islands clean up in 1998 says, "Yes, the fishers and recreational/commercial boats should be supported to recover floating debris" (2004
Schmitt of the Northwest Straits Commission perhaps makes the case most clearly, recommending, "using fishermen as your eyes and ears," and "treating abandoned crab pots as crops to be harvested." The cost of crab pot harvesting is augmented, he says, by the fact that many pots are still useable and can be sold at a discounted price of 50 per pot (2004).

Another "carrot" to reward fishermen is the removal of obstacles to bringing derelict gear to port. Gary Wood, also of the Northwest Straits Commission, reports that the most productive action taken by the Commission was the decriminalization of bringing derelict gear to port. This simple move eliminated the adversarial relationship between fishermen and enforcers, he says, and resulted in a major restoration of marine life in the greater Puget Sound region (2004.)
Other ports from Oregon to Alaska went a step further by providing convenient drop-off sites for derelict gear. Funding was provided to recycle as much of the net and other debris as possible (Minton, 2002).

Fishermen have been cooperative in bringing net to port and participating in recycling. Recycling, however, is dependent on the infusion of external (usually government) funds.
Brainard and Donohue outlined the disincentive problem in 2002: "Very few harbors around the Pacific basin provide cost-effective means for discarding damaged gear. For fishermen barely making ends meet, it is not surprising that some might succumb to the temptation to reduce high shoreside disposal costs by discarding worn out net and gear at sea. One obvious solution would be for coastal states to support port disposal facilities and work to encourage fishermen to dispose of their waste properly."

Raaymakers (2004) agrees: "the major obstacle (to addressing 'High concentrations of marine debris in high-seas sink areas') is the continuing poor performance of most (International Maritime Organization) member states, including many 'developed' counties in adequate waste reception facilities in port."

Specific Recommendations for Buyback Programs and a Pilot Recycling Program

An extensive review of the marine debris literature revealed an unfortunate pattern: recommendations were made for sweeping reforms—for treaties to be enforced, for large scale studies to be conducted, for new laws to be enacted. Years later, conference papers would note that these reforms still needed enactment.

The recommendations in this paper therefore, are very specific and can be undertaken with minimal funding and behavior change. The intent is that news of their success and specificity will lead to the establishment of similar programs adapted to local conditions.

i) *Collect and publish cost/benefit data from successful buyback programs.* Korea and the Puget Sound area have programs that, with documentation, could serve as examples.

Taiwan is moving ahead rapidly with similar programs, and should be able to report results shortly. Watanabe in Japan is refining his figures.

ii) *Establish a pilot Honolulu-based buyback program.* Cook and Burch (2004) agree that a an average buyback price of $500 for a ton of derelict fishing gear would strike a balance between "over-incentivizing" fishermen, causing them to "borrow" others' live gear, and being too low have them go out of their way to retrieve gear. Cook notes that $500 split between a crew of four is "good recreation money." Burch polled two skippers in his office. "Heck," they said, "we bring in gear for free now. Sure we'll do it for $500." Both men agreed on a sliding scale, with monofilament net receiving the highest price, then other types of nets, and finally, floating debris.

In addition, administering the program—sorting, weighing, paying, storing and disposing of the net would cost a minimum of $500 per ton. This cost could be ameliorated by the inclusion of recommendation iii:

iii) *Secure a federal grant for a general recycling program on Honolulu piers*. Curatilo demonstrated conclusively that fishermen home porting in Honolulu face a serious disposal problem. No coherent waste disposal program exists. Facilities to dispose of oil, oily rags, other fluids and metals are inadequate. One consequence is that useable oil placed in open containers is diluted by rain which renders it a hazardous waste, which must be transported to the mainland at considerable cost rather than used as industrial-grade fuel.

Hawaii Metals Recycling has been invited onto piers by the State Division of Harbors to haul away discarded metal products such as engine blocks. (Mansho, 2004). Honolulu houses many other recycling companies who may be engaged in the project.

A grant would, A) build open-air sheds to protect debris from rain, B) supply conveniently located bins labeled to receive various wastes, C) enter into contract with private and government entities to handle the waste, D) document the avoided cost by minimizing the creation of hazardous waste and maximizing the amount of material recycled, E) purchase and install a grinding machine specifically designed for continuous feed of plastic, nylon and rope, and, F) publishing a report detailing costs, benefits and recommendations—the first of its kind.

Readers are invited to contact the author with suggestions, comments and additional information.

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