

Marine Bycatch and Damage from Fishing Gear: Key Academic References

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Overview:

Issues of Marine bycatch and ecological damage from commercial fishing gear have generated hundred of published papers. Fortunately, a few key summary papers have been recently published in the academic literature and on-line. This report outlines the major findings of these summary reports. It is also recommended that those preparing the TRCP platform look at the online references cited here for particular details. One seminal paper (Harrington et al., 2005) details the finfish bycatch issue for U.S. fisheries and is attached to this report for the reader's reference. The Harrington et al. (2005) paper does not address the bycatch of marine mammals, turtles and sea birds, so a few representative papers on each subject have been included here.

All summary papers point to the shrimp fishery, especially in the Gulf of Mexico and along the Southeast United States, as one of the most debilitating to non-target species. Many papers have been published on particular aspects of the shrimp bycatch problem, including the study and use of various excluder devices. One recent paper indicative of these is summarized here.

In addition to bycatch-specific papers, there is also a growing body of academic literature on the ecosystem effects of various types of commercial fishing gear. Some recent papers in this area are summarized as well.

The economic aspects of bycatch and commercial fishing gear are not well covered in the literature aside from small specific examples for single fisheries, or large scale numbers of tons of bycatch recorded in overview papers. No economic papers were located that in and of themselves would be useful to this project.

On-line Resources:

- The "NOAA National Bycatch Strategy": (<http://www.nmfs.noaa.gov/bycatch.htm>) contains information and links to regional fisheries bycatch statistics, initiatives to reduce bycatch, and to various meetings and reports addressing this issue nationwide.
- "Discards in the world's fisheries" (Kelleher, K. 2005) (<ftp://ftp.fao.org/docrep/fao/008/y5936e/y5936e00.pdf>) is an on-line report that updates the cornerstone bycatch study by Alverson, et al (1994). This updated report details the global amount of bycatch fishery by fishery using statistical techniques a bit different than those applied by Alverson, et al. so the numbers are not directly comparable. A weighted discard rate of 8% was used to calculate that in the 1992-2001 period, an average of 7.3 million tons were discarded each year. Trawl fisheries

for shrimp and demersal fish accounted for over 50% of the total tonnage discarded. There has been a notable reduction in discards in recent years for a number of reasons including the use of more selective fishing gear, new regulations and improved enforcement. More species formerly considered to be bycatch and discarded, are now being processed for human or animal food, including fish meal for the aquaculture industry.

- “A global assessment of fisheries bycatch and discards. (Alverson, et al. 1994) is available on line at:“<http://www.fao.org/DOCREP/003/T4890E/T4890E00.htm>. The fisheries bycatch calculations in this exhaustive report are cited in most academic papers on the issue. In summary, in an analysis of more than 800 papers, this study determined that between 17.9 and 39.5 million tons of fish are discarded each year. Shrimp trawls are the most destructive, with a higher proportion of bycatch than any other fishery type, followed by bottom trawls, long-lines and pot fisheries. Although the authors say that there is inadequate data for a full assessment of the ecological, economic and cultural impacts of this problem, they state that the economic losses run into billions of dollars.

Overview of Bycatch Problems:

- Harrington, J.M., R.A. Myers and A.A. Rosenberg, 2005, "Wasted fishery resources: discarded by-catch in the USA," Fish and Fisheries 6(4): 350-362.

This paper is the most recent, relevant and comprehensive of all those that came to light in this literature review. Data from published reports were analyzed for all U.S. fisheries and for all finfish and invertebrate bycatches, but no effort was made to include mammals, sea turtles and pelagic birds that also fall to fishing gear. All in all, it is estimated that in U.S. fisheries each year, 3.7 million tons of fish were landed and another 1.06 million tons of fish were discarded in 2002, leading to an overall discards to landing ratio of .28 which is among the highest in the world. Although many U.S. fisheries have much lower discards to landing ratios, this number is increased largely due to the very high discard to landing ratio of shrimp fisheries, at 2.95 for the east coast of the U.S. and as high as 4.56 for the Gulf of Mexico shrimp fleet. Those U.S. fisheries with the lowest bycatch ratios include the Alaskan (0.12) and west coast fisheries (0.15). As far as gear type goes, shrimp trawls accounted for 46.9% of discards in 2002/2003, followed by bottom trawls (25.1%). The remaining percentages were attributed to hook and line (7.2%), dredge (5.3%), midwater trawl (5.1%), pot/trap (4.5%), longline (3.9%), gillnet (1.2%) and purse seine (0.7%). Crustacean (50.0%) and demersal (36.3%) fisheries resulted in the most bycatch by far.

Due to the importance of the data in this study to our efforts, the entire paper is attached to this summary. Those interested should especially notice table 2, which details discards and landings by U.S. fishery type, and figures 1, 2 and 3.

- Hall, S. J. and B. M. Mainprize, 2005, “Managing by-catch and discards: how much progress are we making and how can we do better?” Fish and Fisheries, 6 (2): 134-155.

This report summarizes the problem of fisheries bycatches worldwide then devotes most of the paper to evaluating different approaches to minimizing bycatch and various parameters measuring effectiveness. Scores of studies of different fisheries, different gears, different species of bycatch and different bycatch devices were subjected to a meta-analysis. Data from the Alverson, et al (1994) FAO report on bycatch were used in this analysis. Prawn (shrimp) fisheries using trawls, with the highest bycatch to target species ratios were the subject of nearly half of the published studies that were examined. Eight different target species groups were investigated: crabs, demersal fish, eels, flatfish, pelagic fish, prawns, salmonids, and tuna.

Bycatch reduction approaches include technical systems, such as selectivity, deterrence and avoidance devices; regulatory systems such as discard bans and by-catch utilization; and social systems involving understanding trade-offs, engaging the fishing sector in finding solutions, etc. were all summarized and examined. The authors concluded that between 25% and 64% of bycatch could be reduced if global fishing fleets could match somewhere between the minimum and median performance of experimental gear reported on in various studies. The addition of further legislative and social approaches would also have a strong benefit.

Bycatch of Marine Mammals, Birds and Turtles:

- Julian, F. and M. Beeson, 1998, “Estimates of marine **mammal, turtle, and seabird** mortality for two California gillnet fisheries: 1990-1995”, Fishery Bulletin, 96 (2), pp. 271-284.

The authors estimate incidental kills of marine mammals, seabirds and turtles in drift and set gillnet fisheries in California based on estimates of on-board observers from July, 1990 to December, 1995. An average of 450 marine mammals, mostly common dolphins, and elephant seals, were killed each year in the drift gillnet fishery but only 20 turtles and 3 seabirds over the entire period. In the set gillnet fishery, pinniped (seals and sea lions) mortalities reached a high of 4,777 in 1992 but decreased to 1,016 in 1995. Cetaceans (whales and dolphins) in the set gillnets ranged from 38 in 1991 to 14 in 1993. The declines in these mortalities were probably due to area closures during this period. The set gillnet fishery also resulted in the mortality of 1,018 seabirds and 6 sea turtles over the study period.

- Read, A. J., P. Drinker and S. Northridge, 2006, “Bycatch of **marine mammals** in U.S. and global fisheries,” Conservation Biology, 20 (1): 163-169.

The bycatch of marine mammals in U.S. fisheries from 1990 to 1999 was calculated with data from stock assessments required under the U.S. Marine Mammal

Protection Act. During this period, the mean yearly bycatch of cetaceans (dolphins and whales) and pinnipeds (seals and sea lions) was 6215 animals, spread nearly evenly between the two taxa. The vast majority of these animals were taken in gillnet fisheries. Due to the use of acoustic alarms and time-area closures in later years, the bycatch of cetaceans diminished over time, with a high of about 5000 taken in 1990, reduced to less than 2000 in 1999. The bycatch of pinnipeds was also reduced in the later years, but to a much lesser extent. The Atlantic gill net fisheries were the most detrimental to cetacean populations, while the Pacific fisheries took more pinnipeds. Gillnet fisheries in Alaska accounted for only a small proportion of all marine mammals taken.

- Lewison, R. L., S.A. Freeman and L. R. Crowder, 2004, "Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback **sea turtles**," Ecology Letters, 7: 221-231.

More than 200,000 loggerhead and 50,000 leatherback sea turtles were estimated to have been taken by the global pelagic longline fishery in the year 2000, based on bycatch data from more than 40 nations and from 13 international observer programs. In the past 20 years, the Pacific loggerhead and leatherback populations have declined from 80-95% . The authors calculate that the current bycatch levels for these turtles is unsustainable, and more effort needs to be made to better quantify the bycatch, and to find ways to reduce it.

- Lewison, R. L. , L. B. Crowder and D. J. Shaver, 2003, "The impact of **turtle** excluder devices and fisheries closures on loggerhead and Kemp's ridley strandings in the Western Gulf of Mexico," Conservation Biology, 17 (4): 1089-1097.

Endangered Kemp's ridley sea turtles and threatened loggerhead sea turtles are often taken in shrimp trawls in the Gulf of Mexico. Data in this report comes from the Sea Turtle Standing and Salvage Network and covers the years from 1986 to 2000. Despite the fact that turtle excluder devices (TEDs) have been used by shrimp fleets since the late 1980's, between 100 and 200 turtles of each species are still taken most years. In 1994, a peak number of both species of sea turtles were taken and numbers have been relatively high ever since. The authors evaluated these numbers based on specific fishing zones in the Gulf, and compliance rates for TEDs in the shrimp fleets. The relatively high numbers of sea turtles caught in latter years may correspond to recovery of some sea turtle populations due to increased conservation efforts on nesting beaches. In addition, fishing closures during nesting season off Padre Island, Texas, has helped the population of Kemp's ridley sea turtles that nest here, with an estimated 39% reduction in strandings during the closure months. Higher compliance rates for the use of TEDs would also help lower the sea turtles caught by shrimp trawls.

- Melvin, E.F., K.S. Dietrich, O. Hamel and J.K. Parrish, 2000, "Solutions to the bycatch of **seabirds** in the Alaska freezer-longline cod fishery," Marine Ornithology, South Africa, Vol.28(2), p. 136; 2000 [Second International Conference on the Biology and Conservation of Albatrosses and Other Petrels. E.Flint & K.Swift (eds).

Longline fisheries in Alaska often hook short-tailed albatrosses, fulmars, shearwaters and other seabirds. This paper examined the effect of different types of deterrent strategies to the fishery catches and the bycatch of seabirds. Two strategies, using added weight and using a lining tube resulted in a reduction in seabird catch by 76% and 81% respectively. Another experimental deterrent, the line shooter, actually increased the seabird catch by 35%. All deterrents tried had no effect on the target fish species.

- Uhlmann, S; D. Fletcher, and H. Moller, 2005, "Estimating incidental takes of shearwaters in driftnet fisheries: lessons for the conservation of seabirds," *Biological Conservation*, 123(2): pp. 151-163.

The bycatch of two petrel species, sooty shearwaters and short-tailed shearwaters, were estimated for seven driftnet fisheries of the North Pacific. Between 1952 and 2001 an estimated 1.0 to 12.8 million sooty shearwaters and between 4.6 and 21.2 million short-tailed shearwaters were killed in these fisheries.

Shrimp Bycatch Example:

Steele, P., T. M. Bert, K. H. Johnston and S. Levett, 2002, "Efficiency of bycatch reduction devices in small otter trawls used in the Florida shrimp fishery" *Fishery Bulletin* 100(2): 338-351.

This paper begins by laying out the conservation problems with the southern United States shrimp fishery then reports on research to determine the reduction in bycatch accomplished with different devices. According to this report, otter trawls used to catch shrimp in the Gulf of Mexico and Atlantic coast of the southeastern United States are particularly destructive to the seabed and also result in one of the largest proportions of bycatch of any U.S. fishery. In this shrimp fishery the conservative estimates of the Gulf and South Atlantic Fisheries Development Foundation (GSAFDF) report that the ratio of bycatch finfish to shrimp harvest is 4.1 to 1 for the Gulf shrimp fishery and 2.8 to 1 for the Atlantic coast shrimp fishery. Overall this means that, in 1996, for these two shrimp fisheries combined, 398 million kg. of finfish were discarded. In addition, horseshoe crabs, blue crabs and many other invertebrate species also were taken as bycatch in shrimp otter trawls.

Two different types of bycatch reduction devices (BRDs) were tested by the authors during a series of night time trawls in Tampa Bay, Florida in comparison to control trawls without BRDs. The bycatch for all trawling methods consisted primarily of finfish, but also horseshoe crabs, blue crabs and other invertebrates were abundant in some samples. Ten fish species made up 92% of the bycatch, and 7% of the bycatch were commercially important species. Southern kingfish (whiting) alone made up 4.6% of the bycatch in Tampa Bay. This paper showed a significant reduction in both the weight and number of finfish in the catches when either of the BRDs was employed. The biomass of shrimp caught, however, was not affected. Based on this study, the State of Florida enacted regulations requiring BRDs to be employed by the shrimp fishery.

Ecosystem Effects of Fishing Gear:

- Moore, G. and F. Jennings (eds), 2000, Commercial fishing: the wider ecological impacts. Ecological Issues Series, British Ecological Society/Blackwell Science Ltd, Oxford.

This book was not available for direct review, but has been reviewed by:
Gordon, J. D.M., 2001, "Ecosystem effects of fishing," Global Ecology and Biogeography 10: 333.

The book apparently gives an overview of different fishing gears, the vulnerability of various marine habitats to different fishing activities and the impacts of fishing on various non-target species. Various examples are given of success stories that show how various fishing legislation and enforcement efforts may help mitigate these problems.

- Kaiser, J.J., F. E. Spence and P.J. B. Hart, 2000, "Fishing-Gear restrictions and conservation of Benthic habitat complexity," Conservation Biology 14 (5): 1512-1525.

Although this study was made of seafloor habitats and fishing gear use off the coast of Devon, England, it is applicable to U.S. fisheries as well. The authors compared the effects on the ocean bottom from bottom fishing gear (scallop dredges, beam trawls and otter trawls) and fixed fishing gear (crab pots). These two fisheries come into conflict, when one type of gear use impacts the use of another. In this example, the voluntary agreements reached by these two fishing industries resulted in closures of certain areas either permanently or seasonally to the use of trawls. Analysis of the sea bottom under various fishing gear types, showed that the bottom communities in trawled areas, either seasonally, or year-round, were significantly different than those in which trawls were prohibited completely or partially. Areas closed to trawlers had a higher overall biomass including soft coral and hydroids, long-lived bivalves and fragile sea urchins and increased habitat complexity. Trawled areas had more smaller-bodied species, like some bivalves, and more scavenging species. Of the different types of trawls, scallop dredges and beam trawls had a greater impact than the lighter-weight otter trawls usually employed in shallower water with less stable bottom sediments.

- Watling, L. and E. A. Norse, 1998, "Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting," Conservation Biology, 12 (6): 1180-1197.

The effects of mobile fishing gear (i.e. bottom trawls) on marine ecosystems is similar to that of clear-cutting a terrestrial forest. Although bottom-dwelling marine organisms are smaller than trees their structural complexity is equally important to biodiversity of those areas. Bottom trawls crushes, buries and exposes marine organisms,

thus reducing the structural diversity of the sea bottom and these systems often require long periods of time to reestablish. The most damaging effects of trawls are seen in areas that are trawled repeatedly, up to 7 times/year in some places, and along the edge of the continental shelf where disturbance is naturally low and species take a longer time to recover. The area of sea floor damaged yearly by mobile fishing gear is 150 times the land area that is lost to clearcutting. In addition to the overall damage to sea floor structures and biodiversity, many commercial or recreational fishery species are also damaged. A few economically important species, however, are not as negatively impacted by this process. More work needs to be done to study and implement the Essential Fish Habitat provisions of the U.S. Magnuson-Stevens Fishery Conservation and Management Act to help understand and mitigate the losses to biodiversity and economically valuable fishery species.

Conclusions:

The various problems associated with commercial fishing gear and fishing techniques are well-covered in the academic literature although economic numbers for the damage done are scarce or nonexistent. A few publications detail the overall bycatch involved in all fishing techniques in all fishing areas worldwide (Kelleher, K. 2005; Hall and Mainprize, 2005; Alverson et al, 1994). The potential environmental damage, particularly of bottom-trawls, such as otter trawls used in the U.S. shrimp fisheries is also documented (Watling et al, 1998, Kaiser et al, 2000). These trawling techniques generate both the greatest percentage of bycatch worldwide—more than four times as much bycatch as target species taken (Steele, et al, 2002, Harrington et al, 2005). Although economic figures were not cited, important commercial fish in Tampa Bay, Florida make up 7% of the bycatch in the shrimp fishery, along with some other commercially valuable species (Steele, et al, 2002). Bottom trawlers used in many fisheries are also the most destructive to sea floor ecosystems. In shallow water with less stable substrates, however, the damage done to the sea floor by our shrimp fishery otter trawls is not nearly as great as the global problems of deep sea trawls over complex, stable substrates (Watling, et al 1998, Kaiser et al, 2000). Various techniques are being employed to reduce the finfish and sea turtle bycatch in the U.S. shrimp fishery (Steele, et al, 2002; Lewison et al, 2003).

The bycatch of macrovertebrates, such as pelagic seabirds, marine mammals and sea turtles, has generated another body of scientific literature. California gillnet fisheries result in bycatches of sea birds, turtles and marine mammals (Julian and Beeson, 1998). Gillnet fisheries in U.S. waters were also seen to be especially detrimental to marine mammals--seals and sea lions; dolphins and whales (Reid, et al, 2006). Drift net and longline fisheries in the North Pacific and Alaska are particularly hazardous to sea birds (Uhlman et al, 2005; Melvin et al, 2000) and global pelagic long line fisheries killed 250,000 or more sea turtles in the year 2000 alone. (Lewison et al, 2004). The bycatch of sea turtles in U.S. shrimp fleets in the Gulf of Mexico has increased in recent years, even despite the implementation of turtle excluder devices, but this is most likely due to the recovery of some sea turtle populations in this area due to a number of conservation

measures (Lewison, et al, 2003). The bycatch of in U.S. waters is analyzed by fishing area, and fishery technique and extrapolated to global numbers by).

The “NOAA National Bycatch Strategy”:<http://www.nmfs.noaa.gov/bycatch.htm> provides links to various U.S. efforts to quantify bycatch and to develop and implement new ways to reduce it in all the national fisheries.

References:

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