

Fleet communication to abate fisheries bycatch

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Abstract

Fleet communication systems report near real-time observations of bycatch hotspots to enable a fishery to operate as a coordinated “One Fleet” to substantially reduce fleet-wide capture of protected bycatch species. This benefits the bycatch species per se, reduces waste, and can provide economic benefits to industry by reducing risk of exceeding bycatch thresholds and causing future declines in target species catch levels. We describe case studies of fleet communication programs of the US North Atlantic longline swordfish fishery, US North Pacific and Alaska trawl fisheries, and US Alaska demersal longline fisheries, and identify alternative fleet communication program designs to reduce fisheries bycatch. Evidence supports the inference that these three fleet communication programs substantially reduced fisheries bycatch and provided economic benefits that greatly outweighed operational costs. Fleet communication may be appropriate in fisheries where there are strong economic incentives to reduce bycatch, interactions with bycatch species are rare events, adequate onboard observer coverage exists, and for large fleets, vessels are represented by a fishery association.

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1. Introduction

Bycatch in marine fisheries is an increasingly prominent international environmental, social, and economic issue [1–16]. The issue is addressed as a component in a growing number of broad international resolutions, including Agenda 21 (1992); the Cancun Declaration (1992); UN General Assembly Resolutions 49/118 (1994) and 50/25 (1995); the Rome Consensus on World Fisheries (1995); the UN Food and Agriculture Organization International Code of Conduct for Responsible Fisheries (1995); and the Kyoto Declaration and Plan of Action (1995) [6,15,17].

Bycatch, incidental catch that is discarded dead or released injured to a degree that delayed mortality will

soon occur [6], can harm ecosystems and economic viability. Some bycatch species of seabirds, sea turtles, marine mammals, sharks, other finfish species are particularly sensitive to increased mortality above natural levels because of their life history traits, including their being long-lived, having delayed maturity, and having low reproductive rates [6,18]. Other possible ecosystem effects of bycatch include altering biodiversity by removing top predators and prey species at unsustainable levels, and altered foraging strategies by species that learn to take advantage of discards [6]. Economic effects on industry from bycatch include the imposition of a range of restrictions, closed areas, embargos, and possible closures; interference between fisheries, where bycatch in one fishery reduces target catch in another; and if bycatch in a fishery results in mortality of juvenile and undersized individuals of a commercial species before the finfish or shellfish reach their optimal size, this can adversely affect future target

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species catch levels [6]. And bycatch is a social issue where discarding millions of tons of fish is a wasted food source as well as a waste of animal lives. While global commercial marine fisheries bycatch estimates are based on large assumptions due to incomplete data for many fisheries, including unobserved bycatch such as in abandoned and lost gear, Alverson et al. [1] estimated that in 1994 about 27 million metric tons (27% of the world catch), ranging between 17.9 and 39.5 million tons, of fish per year was discarded at sea. FAO [12] estimated that 1998 global marine fisheries fish discards totaled 20 million metric tons.

Prominent bycatch issues include dolphins and porpoises in purse seines and driftnets; fish discards in shrimp trawls; seabird, sea turtle, marine mammals, and shark bycatch in longlines, purse seines, gillnets, and trawls [6,19]. For instance, hundreds of thousands of seabirds, including tens of thousands of albatrosses, are caught annually in longline fisheries worldwide, posing a critical global threat to some albatross and large petrel populations [15,16,20]. Cumulative turtle mortality in pelagic longline gear worldwide poses a priority threat to sea turtles, in particular, to leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) sea turtles [13,14,21].

There are many strategies to manage commercial marine fisheries bycatch. These include formal constraints through laws, regulations, and policies; multi-lateral accords; marine protected areas, including area and seasonal closures; best practices for handling and release of bycatch species; changes in fishing gear and methods; eco-labeling; industry self-policing; industry awareness-raising and capacity-building; and fleet communication programs [6,16]. Multiple methods can be implemented in combination to pursue sustainably managing fisheries bycatch.

Fleet-wide communication programs can report real-time observations of bycatch hotspots, where fisheries bycatch rates of finfish, shellfish, seabirds, sea turtles, and marine mammals are high, so that vessels in the fleet can avoid fishing in the area [22,23]. Fleet communication is a voluntary form of temporary area and time closures to reduce marine fisheries bycatch. Fleet communication programs have the potential to allow commercial fisheries to operate as a coordinated “One Fleet” to significantly reduce the fleet’s bycatch levels and rates. In the short term this could allow an industry to reduce the risk of exceeding government-established seasonal bycatch thresholds. And in the long term this could help prevent a decline in the capture of target species in fisheries where bycatch of juvenile and undersized individuals of commercial species is problematic.

We describe case studies of fleet communication programs of the US North Atlantic longline swordfish fishery, US North Pacific and Alaska trawl fisheries, and

US Alaska demersal longline fisheries, and identify alternative fleet communication program designs to reduce fisheries bycatch. We also put the concept of fleet communication programs into context by describing the broad range of strategies for reducing marine fisheries bycatch.

2. Case studies

2.1. US North Atlantic Longline Swordfish Fishery “Captain’s Daily Communication”

Information sources for this case study are John Watson, US National Marine Fisheries Service Southeast Fisheries Science Center, personal communication, 11 August 2004; Nelson Beideman, Blue Water Fishermen’s Association, Inc., personal communication, 11 August 2004; Shah et al. [24]; and Watson et al. [25].

In 2001 the Blue Water Fishermen’s Association voluntarily established a fleet communication program for the US North Atlantic longline swordfish (*Xiphias gladius*) fishery, primarily to reduce loggerhead and leatherback sea turtle bycatch. The formal industry-managed daily captain communications ended in 2003 when an experimental fishery research project ended. However, alerting members of the fleet about grounds to avoid where turtle bycatch is a high risk is now a standard part of the information shared between vessels, so the communication program informally remains in operation.

Vessels use short and long range radio and e-mail to communicate. Information communicated amongst the fleet includes sea turtle encounters, sightings of clusters of sea turtles, and specific oceanographic features. The fleet-wide communication protocol enabled vessels to avoid fishing on the warmer side of oceanographic fronts and tight bends in the edge of an oceanographic front, where fishers found relatively high interaction rates with turtles.

There was enormous peer pressure among fishers to avoid turtle interactions to ensure a government threshold was not exceeded. An area of over 7.7 million km² in the western North Atlantic, which includes the productive Grand Banks, had been partially closed to the US pelagic longline fleet since 2000, and completely closed since 2001 due to concerns over turtle bycatch [26–28]. All of the vessels participating in the fishery during the time period when the formal fleet communication program was in operation from 2001–2003 were part of a government research experimental fishery to test the effectiveness of new gear (circle hooks) at reducing turtle injury and capture, and there was a limit on the total number of turtle takes for the fleet during this experiment. All of the vessels participating in the experiment were members of the Blue Water

Fishermen's Association, facilitating having all of the vessels participate in the voluntary communication program.

Turtle bycatch-per-unit-of-effort on traditional J hooks during operation of an experimental fishery that used both traditional J and new circle hooks, conducted between 2001 and 2003, when industry was implementing the fleet communication program, was reduced by 50% compared to observer program records of turtle bycatch-per-unit-of-effort on J hooks prior to 2001 before the fleet communication protocol was instituted [24,25].

There has been no formal assessment of the economic benefits and costs from instituting the fleet communication program. However, the fleet communication program is hypothesized to allow the fleet to reduce turtle captures by half. If turtle captures exceed limits established under the US Endangered Species Act, fishing effort could be restricted or the entire fishery could be closed. The fishery is worth US \$40 million per year. Captains are in regular frequent communication via radio and e-mail, so there is minimal additional cost for the transfer of information about sea turtle bycatch.

2.2. US Alaska Demersal Longline Fisheries, Fisheries Information Services-Managed Fleet Communication Program

Primary information sources for this case study are Janet Smoker, Fisheries Information Services, personal communication, 17 January 2005; Fitzgerald et al. [29]; Williams and Chen [30]; and US North Pacific Fishery Management Council [31].

In 1992 the North Pacific Longline Association voluntarily instituted a fleet communication program by hiring a private company, Fisheries Information Services, to manage fleet communication to reduce halibut (*Hippoglossus stenolepis*) bycatch, and in 1999 added fleet communication to reduce seabird bycatch in Alaska demersal longline fisheries for freezer-longline vessels. These 64 to 74 active vessels target Pacific cod (*Gadus macrocephalus*), Greenland turbot (*Reinhardtius hippoglossoides*), and sablefish (*Anoplopoma fimbria*). The fleet communication program is still in operation.

Observer program raw data is delivered to the US National Marine Fisheries Service via radio. US National Marine Fisheries Service observer data include catch data for each observed vessel: observations of number and weight of target and bycatch species hooked, locations of set deployment and retrieval, and fishing effort. Fisheries Information Services accesses the government observer database over the internet and sends reports to managers and, if requested, to skippers, via e-mail.

Fisheries Information Services e-mails weekly "report cards" to the fleet and provides detailed information on individual boats' bycatch to each vessel owner. Weekly

information includes raw numbers of birds caught and weight of halibut bycatch for each vessel and totals for the entire fleet. Vessel codes rather than vessel names are used in the report in order to protect confidentiality. However, all vessels have provided their codes to a fishery organization, the North Pacific Longline Association, which is then able to contact individual vessels whose bycatch levels and rates are high. This separation of the analytical and "enforcement" parts of the program is deemed critical. Fisheries Information Services also produces semi-annual seabird bycatch reports that compile bycatch-per-unit-of-effort by individual boats, fishing areas, targets, and fleet summations. These are usually completed 1–2 months after closure of winter and fall cod seasons. Fisheries Information Services also develops maps showing halibut and bird bycatch hotspots (vessel names are not attached to these data to protect confidentiality). This information is not typically distributed during the fishing season as some members of the fleet want to avoid disclosing their fishing locations. Maps showing seabird bycatch locations (by species) for the same month of the previous year are provided to fishery participant prior to each month.

Since 1990 government-established annual caps on halibut mortality for hook-and-line cod fisheries and "other" (turbot) fisheries in the Bering Sea and Aleutian Islands and cod fisheries in the Gulf of Alaska have been in place. Reaching any of these thresholds results in closure of all hook-and-line fishing for those species and areas for the remainder of the year. There is also an annual cap on the number of Short-tailed Albatrosses (*Phoebastria albatrus*) than can be captured by the Alaska demersal longline fleet. If this threshold is exceeded, the fleet could be subject to additional restrictions and possibly closure.

All of the vessels in the freezer-longline vessels in the Alaska demersal fleet participate in the fleet communication program. During the first four years of operating the halibut bycatch avoidance program, the number of participants increased from 14 to 28 boats. When the seabird bycatch avoidance program was added in 1999, gradually over several years, all of the remaining vessels in the freezer-longliner fleet joined the fleet communication program. There are dozens of smaller hook and line boats that fish for Individual Fishery Quota sablefish a few weeks to months each year, which also incidentally catch seabirds, but have infrequent observer coverage, and have declined to participate in the fleet communication program.

Because the fleet communication program was implemented concurrent with the introductions of additional measures to reduce halibut and seabird bycatch, including new practices for the "careful release" of halibut, and bird-scaring tori lines for seabirds, this prevents a determination of the single factor effect of

instituting the fleet communication program on trends in bycatch rates through comparison with historical bycatch rates before the fleet communication program was initiated. However, during a period of seven years when about ten boats did not participate in the fleet communication program, the average halibut bycatch rates of non-participating boats were 10–30% higher than participating vessels, supporting the inference that the fleet communication program contributed to reducing halibut bycatch for participating vessels. Analysis also shows that fishing effort moved away from bycatch hotspots after warnings were issued to the fleet.

The bycatch mortality rate of halibut for Bering Sea and Aleutian Islands cod fishery decreased 33% from 1992 (the year the fleet communication program to address halibut bycatch was initiated) to 1995, and continues to decline, but more slowly [30]. The Bering Sea and Aleutian Islands cod fishery has not been closed due to exceeding its halibut bycatch cap since 2001.

Seabird bycatch rates and total annual catch has been decreasing in recent years: over 24,000 seabirds were caught in 1998 (the fleet communication program for seabirds was initiated in 1999) at a rate of 0.14 seabird captures per 1000 hooks, and fewer than 5000 were caught in 2003 at a rate of 0.02 seabird captures per 1000 hooks [31]. The fleet communication program likely contributed to this decrease. Many captains and vessel owners expressed surprise when they first were informed about their boat's seabird bycatch levels, and most of these vessels subsequently reduced their seabird bycatch rates. Owners of some of the boats that receive warnings from the North Pacific Longline Association about their having high bycatch contact Fisheries Information Services for advice to help them reduce their bycatch.

In 2003 the Bering Sea and Aleutian Islands hook and line catcher-processor cod fishery was worth US \$67.9 million ex-vessel. The open-access fishery lasted 193 days in 2003, making the average daily value of the fishery more than US \$350,000. Fisheries Information Services charges the fleet US \$60 per observed vessel per week. Vessel communication costs are an additional operational expense for participating vessels. However, because Fisheries Information Services reports are typically attached to existing e-mail message traffic between companies and their boats, this cost is likely nominal. The cost for onboard observers, without which the program could not successfully operate, is an additional expense, but the observer program is mandatory and a cost that would still exist without the communication program.

2.3. US North Pacific and Alaska trawl fisheries Sea State, Inc.—Managed Fleet Communication Program

Primary information sources for this case study are Karl Halfinger, Sea State, Inc., personal communica-

tion, 25 January 2005; Gauvin et al. [22]; and Halfinger [23].

In 1994, the US Washington, Oregon, and Alaska trawl fisheries, which target Alaska Pollock (*Theragra chalcogramma*), Pacific cod, Bering Sea Rock Sole (*Lepidopsetta bilineata*), Bering Sea Yellowfin Sole (*Limanda aspera*), Atka mackerel (*Pleurogrammus monopterygius*), Pacific whiting (hake) (*Merluccius productus*), and scallops (*Placopecten magellanicus*), voluntarily hired a private company, Sea State, Inc., to establish and manage a fleet communication program. The fleet communication protocol aims to reduce the bycatch of chum (*Oncorhynchus keta*) and chinook salmon (*Oncorhynchus tshawytscha*) in pollock fisheries; halibut in flatfish and cod fisheries; several species of crab in flatfish, cod and scallop fisheries; and several species of rockfish in pollock, mackerel and whiting fisheries. The fleet communication program is still in operation. Participation in the fleet communication program has always been high, and has now reached 100% of vessels for participating fleets.

Methods used for fleet communication are e-mail via several satellite systems and the Northwest Groundfish Observer Program, short catch logs via satellite-based vessel monitoring systems (VMS), and occasional phone calls. Most of the trawl fisheries have high onboard observer coverage and send their observer data directly to Sea State. The observer data includes bycatch data for each vessel on the number of bycatch species hauled aboard, location where bycatch species were hauled aboard, and fishing effort. Some smaller trawl fisheries that have relatively low observer coverage submit their own observations of bycatch to Sea State. Sea State analyzes the bycatch data to produce maps, tables, commentary, and other products providing information on the location of bycatch hotspots, and sends these products daily, usually via e-mail, to the fleet. Most coastal catcher vessels, which cannot receive email attachments, receive copies of the Sea State materials when they are in port. These coastal vessels' trip lengths are relatively short, lasting 1–3 days, so the bycatch information is still pertinent when they receive it. When necessary, urgent bycatch information can be sent to these vessels through their processors. Vessels also communicate bycatch hotspot information to each other using their radios.

The pollock fishery faces seasonal and area closures if government-established salmon bycatch caps are reached. The flatfish and scallop fisheries face seasonal area closures if halibut or crab bycatch caps are reached. Mackerel fisheries face seasonal closure if rockfish bycatch limits are exceeded.

Some of the fleets, such as the trawl pollock fishery, have formal elaborate agreements in place between the individual vessels related to the operation of the fleet communication program. Other fleets, with fewer boats,

tend to adapt to the information provided by Sea State through informal agreements between the vessels developed ad hoc on the fishing grounds. The informal agreements are often discussed in skippers meetings before the season begins. Most boats belong to a trade organization that organizes pre-season meetings. Sea State has come to anticipate the occurrence of bycatch problems at certain times of the year, enabling some industry decisions to be made before the season begins. If, for example, crab bycatch rates are above three crabs per metric ton of fish, then the fleet has agreed to move south of 56 degrees N. latitude in the winter rock sole fishery. Other responses to bycatch levels are not made in advance, but the fleets are typically small enough that the skippers communicate when they receive information on bycatch levels and decide ad hoc how to respond.

No formal evaluation of the effectiveness of the Sea State-managed fleet communication programs has been conducted. Because abundance of bycatch species is not well understood, trends in bycatch rates do not necessarily provide an accurate indicator of the effectiveness of the fleet communication program, but instead could be caused by changes in abundance of bycatch species.

The fleet communication program is worth on the order of millions of dollars to the participating fleets. Gross revenue to a boat in the rock sole fishery is about US \$50,000 per day. The fleet communication program has likely enabled the fleets to operate days and perhaps weeks longer in some years. Fuel costs alone mount into the millions of dollars in the pollock fishery, so avoiding time and area closures, which would increase distances from port to fishing grounds, is economically important.

Sea State charges an average of \$2,000 per year per boat for participation in the fleet communication program. Participating vessels are required to use VMS and e-mail regularly, so additional communication costs from participating in the Sea State program are nominal. The cost per vessel to transmit observer data is roughly estimated to be US \$200 per year.

3. Alternative designs for “One Fleet” communication programs

Four central parameters need to be considered when designing a new fleet communication program:

- *Technology for communication:* The fleet communication program can use e-mail through satellite-based vessel monitoring systems, e-mail through other satellite-based systems, radio, phone, fax, or a combination of these technologies to facilitate communication between vessels and to transmit data to a designated hub.

- *Observer program:* It may be possible to make use of onboard observer data to facilitate implementation of the “One Fleet” program. Otherwise, vessel skippers or crew would need to collect and transmit the bycatch data.
- *Manager:* Options for the organization that manages the fleet communication program include a fishery association if one exists, relevant fishery management authority, or a private company. In most fisheries, government agencies do not have resources for requisite data processing and transmission of bycatch information in a time frame suitable to facilitate effective bycatch avoidance [22].
- *Program policies:* Information is needed to determine scientifically based minimum spatial and temporal closures for an identified bycatch hotspot to aid in developing policies for implementation of the fleet communication program.

4. Discussion and conclusions

During a period of seven years when some vessels were not participating in the Alaska demersal longline fleet communication program, the average halibut bycatch rates of non-participating vessels were 10–30% higher than participating vessels, supporting the inference that the fleet communication program reduced halibut bycatch rates. Turtle bycatch rates in the US North Atlantic longline swordfish fishery on traditional J hooks during a research experiment between 2001 and 2003, when industry was implementing a fleet communication program, was 50% lower than historical turtle bycatch rates on J hooks prior to 2001 before the fleet communication program was instituted [24,25], also supporting the inference that implementation of the fleet communication program reduced bycatch rates. These two cases assume that there were no significant differences between the vessels that would affect bycatch rates other than participating versus not participating in the fleet communication program. Inter-annual differences and other possible confounding factors prevent definitive conclusions about the efficacy of the US North Atlantic longline swordfish fishery fleet communication program. Comparison of bycatch rates from different time periods can be confounded by numerous variables, including weather, bycatch species behavior, fishing practices, location of fishing grounds, and consistency in observer methods [16]. For instance, there are annual and decadal oscillations in oceanographic conditions [32] that could alter foraging behavior of sea turtles or other bycatch species and their interactions with fishing gear.

Design of new pilot fleet communication programs could provide information for assessment of performance and cost effectiveness if some of the vessels opt

not to participate in the fleet communication program, and serve as a control treatment. A comparison of bycatch rates of participating and non-participating vessels could provide an understanding of the effect on bycatch rates from this single factor, assuming that there are no other substantial differences between the two categories of vessels that affect bycatch rates.

Available information from three case studies of fleet communication programs indicates that economic benefits likely substantially outweigh costs. In addition, non-monetary benefits from instituting a fleet communication program could be substantial, such as from positive media coverage and other values not described by established monetary indicators [33].

There is a need to augment efforts to engage fishers to abate fisheries bycatch. Fishers are some of the most qualified people to develop and improve bycatch mitigation techniques. Fishermen likely have a large repository of knowledge and information related to bycatch, which can be tapped to contribute to finding effective and practical solutions. This has been demonstrated by successful collaborative research in US Alaska demersal longline fisheries [34], US Hawaii pelagic longline fisheries [35] and the three presented case studies of industry-lead voluntary fleet communication protocols. Fishermen and fisheries associations are encouraged to become active participants to address bycatch problems by participating in research and commercial demonstrations, implementing best practices, and supporting adoption of regulations based on best available science before restrictions, embargos, and possible closures are imposed on them.

Most countries with longline fleets have a low degree of political will to address the problem of incidental seabird mortality, and have scarce resources for enforcement of seabird conservation measures. Few national fishery management authorities have frameworks to manage some types of bycatch, such as interactions between seabirds and longline vessels [20,36,37]. A bottom-up approach that fosters a sense of industry ownership for effective bycatch reduction methods, and concomitant voluntary compliance with legally required use of these methods, is needed in these countries. In this way, industry develops a sense of ownership for these tools and supports their required use.

Instituting incentive instruments can augment participation by fishers to abate fisheries bycatch [38]. Incentive instruments include formal constraints through legally binding accords, laws, regulations, policies, and policing; eco-labeling; industry-self policing; bycatch fee and exemption structure (similar to a “polluter pays” system); and education [38].

Solutions to marine fisheries bycatch, including the appropriateness and design of fleet communication programs, need to be tailored to specific fisheries.

Different bycatch reduction methods may be appropriate for different fisheries due to differences in the bycatch species that interact with each fishery, vessel designs, fishing gear, and fishing methods [16,20]. A fleet communication program is likely an ineffective strategy to address a fisheries’ bycatch problem when the incidence of interactions with the bycatch species is a common event and occurs across the fleet’s fishing grounds, and in fisheries where there is a lack of economic incentives to reduce bycatch. And instituting a fleet communication program would be difficult in fisheries lacking sufficient onboard observer coverage, and in large fisheries lacking a fishery association. Therefore, evaluation of the context of an individual fishery must precede advocacy for uptake of specific bycatch reduction strategies, including a fleet communication program.

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