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POTENTIAL IMPACTS OF FISHING GEARS (EXCLUDING MOBILE BOTTOM-CONTACTING GEARS) ON MARINE HABITATS AND COMMUNITIES

Figure 1: The administrative regions of Fisheries and Oceans Canada (DFO).

Context

Canada is moving towards an ecosystem approach to the management of human activities in the sea. In support of this, Canada has committed domestically and internationally to conserve, manage, and exploit fish stocks in a sustainable manner, as well as to manage the impacts of fishing on sensitive benthic areas. In December 2006, Canada endorsed Resolution 61/105 of the United Nations General Assembly (UNGA) which calls on States to directly, or through regional fisheries management organizations and arrangements, apply the precautionary and ecosystem approaches in order to sustainably manage fish stocks and protect vulnerable marine ecosystems. In addition, at the 9th meeting of the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) in March 2008, Decision IX/20 was adopted and endorsed by Canada, to address issues relating to the conservation and sustainable use of biodiversity in marine areas beyond national jurisdiction. Canada is domestically implementing the Sustainable Fisheries Framework (SFF) which, using the precautionary and ecosystem approaches, aims to ensure that fisheries are environmentally sustainable while supporting economic prosperity.

A Canadian Science Advisory Secretariat (CSAS) science advisory process to examine the impacts of trawl gears and scallop dredges on benthic habitats, populations and communities was held in March 2006 (DFO, 2006). An additional science advisory process was held in January 2010 to examine the impacts of other fishing gears (excluding bottom trawls and dredges), to assemble available information on their uses and to provide scientifically-based conclusions and advice regarding their potential impacts on marine habitats and biodiversity. This science advisory report contains the conclusions and advice from that meeting.

SUMMARY

- The fishing gears reviewed in this science advisory report have impacts on marine habitats and biodiversity. However, these impacts are not uniform and are not expected to occur universally every time a particular gear is used.

- Generally, the impacts of any fishing gear are relative to the effort of the fishery. The severity of any impact will depend on at least:
  - The nature of the impact (i.e. what is impacted and in what way);
  - The location and scale of the fishery (overall and relative to the location and scale of the ecosystem feature being impacted);
  - How the gear is rigged, deployed, and retrieved; and
  - Any additional threats facing the ecosystem feature being impacted by the gear in question.

- Mitigation measures exist to reduce, and sometimes eliminate, every documented impact related to fishing gears. Many Canadian fisheries make use of appropriate mitigation measures as part of their regular operations and some have been shown to provide benefits to the fishery (e.g. reduced handling time and/or improved product quality).

- The effectiveness of every mitigation measure is fishery-specific and depends on the particular impact being addressed, the appropriateness of the measure, and the how it is implemented. An evaluation of the nature and scale of impacts is an important step in identifying appropriate mitigation measures.

INTRODUCTION

A Canadian Science Advisory Secretariat (CSAS) science advisory process was held to examine the impacts of trawl gears and scallop dredges on benthic habitats, populations, and communities was held in March 2006 and resulted in a science advisory report (DFO, 2006). Advice and conclusions from the 2006 meeting stated that mobile bottom-contact fishing gears have impacts on benthic populations, communities, and habitats; however, these impacts are not uniform and at least depend on: i) the specific features of the seafloor habitats, including the natural disturbance regime; ii) the species present; iii) the gear type and the method, timing, and frequency of its deployment; iv) the frequency with which a site is impacted by specific gears; and v) the history of human activities, especially past fishing, in the area of concern.

In January 2010, an additional science advisory process to examine the impacts of fishing gears not reviewed at the previous meeting in 2006 (i.e. mobile bottom-contacting trawls and dredges), to assemble available information on their uses, and to provide scientifically-based conclusions and advice regarding their potential impact on marine habitats and biodiversity. This advisory process was informed by: 1) two reports that reviewed the global experience of the potential impacts of the selected fishing gears on marine biodiversity, and 2) a number of science-based contributions from all DFO Regions related to different studies on the impacts of the selected gears. This science advisory report contains the conclusions and advice from that meeting.

This science advisory report is based on the global and Canadian experience with various fishing gears (excluding bottom trawls and dredges). This report presents a generic framework for the evaluation of individual fisheries. It does not address the documented or expected impacts of any single fishery in Canada; these evaluations are expected to be conducted at regional or zonal scales, as appropriate for the individual fishery. This report also does not weigh the diverse possible impacts of fisheries by their "seriousness" or "importance". The severity of an impact will be at least partly context specific, and depend on, *inter alia*:

- The nature of the impact (i.e. what is impacted and in what way);
- The location and scale of the fishery (overall and relative to the location and scale of the ecosystem feature being impacted);
- How the gear is rigged, deployed, and retrieved; and
- Additional threats facing the ecosystem feature being impacted by the gear in question.

An impact that may occur at a low level but on a large scale (i.e. spatially or temporally) can have serious ecological consequences, especially if the impact is large compared to the scale of the ecosystem feature being impacted, or if that feature has a crucial ecological role. Even an infrequent impact can have serious ecological consequences if the feature being impacted is rare and highly vulnerable. Conversely, some impacts may be chronic and widespread but hard to distinguish from the background variation in the feature being impacted and therefore their severity may be challenging to evaluate.

A science advisory framework for evaluating the severity of different types of fishery impacts is in the early stages of development. Components of such a framework include advice on: i) factors to consider in recovery potential assessments (DFO, 2007a; DFO, 2008), ii) the identification of conservation objectives (DFO, 2007b), , and iii) the expected outcomes from the planned CSAS science advisory process on selected benthic attributes (i.e. coldwater corals, sponge dominated communities, and hydrothermal vents) that will convene in March 2010.

Terminology

The term *impact(s)* refers to any way that a fishing gear, used in standard fishing operations for that fishery, may interact with an ecosystem feature other than the targeted species and sizes in the fishery and any way that the feature may be changed by the interaction from its state prior to the interaction. It does not imply that all impacts are necessarily detrimental, or that the impacts will necessarily persist long after the interaction with the fishing gear is over. Nonetheless, as a generalisation it is expected that responsible Canadian fisheries will strive to keep the number and intensities of impacts low, unless there is sound evidence that the interactions are not ecologically adverse.

Most Canadian fisheries have a clearly-identified suite of species that the fishery is targeting or intending to catch. Sometimes other species are caught and retained, and these may comprise an important part of the value of the fishery. On the other hand, sometimes part or all of the catch of a targeted or intended species may not be retained, because of inappropriate size or quality, regulatory constraints, or other reasons. The following terminology defines how these different circumstances will be referred to in this report:

- *Discards* refers to catch that is not retained, regardless of whether it is a species that is intended to be caught or not.
- *Live release* is defined as part of the catch that is not retained, but released under conditions where there is evidence to support the expectation that survivorship will be high.
- The term b*ycatch* or *incidental catch* is used variably throughout Canadian jurisdictions, and presently there is no single, accepted definition corresponding to its usage in all Canadian fisheries. "*Bycatch"* may refer to all non-targeted species in a fishery, all the catch that is not landed and intended for markets, or some other subset of the catch. It should be acknowledged that some bycatch mitigation measures may be very effective at reducing the

bycatch mortality of a fishing gear; either by making live release and survival of caught individuals likely (perhaps even if the number of individuals caught by the gear may not be reduced markedly).

The term *fishery operations* is used inclusively in this report to refer to the particular gear used in a fishery, how the gear is rigged, deployed, and retrieved, where and how the fishery occurs, and how the catch is handled. In this report, the term *fishery* is intended to include commercial, recreational, and subsistence fisheries. However, it is important to note that the majority of information reviewed at this science advisory process was related to commercial fisheries.

In this report, the term *habitat* usually refers to the seafloor and its associated biota. In the few cases when habitat is intended to include the pelagic habitat, it is made explicit in the text.

The *effectiveness* of a mitigation measure must be judged relative to the overarching goals of the fishery and the specific objectives set for the mitigation measure. Therefore, the process of selecting and implementing mitigation measures for a fishery should include the setting of operational objectives for the mitigation measures.

When the term *protected species* is used in this report, it includes species legally listed under Canada's federal *Species at Risk Act (SARA)*. In addition, it includes cases where all catch of a particular species is allocated to another fishery, or retention is prohibited for other management reasons.

ANALYSIS

1. All documented effects associated with each gear are fishery-specific. The likelihood of impacts occurring depends on where and how the gear is used (i.e. rigged, deployed, and retrieved), and is not expected to occur universally every time a particular gear is used.

2. Generally, the impacts of any fishing gear are relative to the effort in the fishery but there are case-specific exceptions to this generalisation. Impacts may be clustered in space and time and may not be evenly distributed throughout a fishery, thus a low level of monitoring may not properly characterise the scale and pattern of the impacts. However, if effort is reduced in a fishery, the scale of the impacts will likely be reduced as well. For many case-specific reasons, the reduction in impacts may be proportionally greater or less than the reduction in effort.

3. Fishery participants have shown substantial innovation in reducing the undesirable impacts of their operations. This suggests that there are benefits to engaging members of the fishing industry as partners and a source of potential solutions when addressing unsustainable fishing impacts. Many examples were provided at this science advisory process that demonstrated effective cooperative approaches of all stakeholders to addressing the impacts of fisheries. It was also demonstrated that many of the initiatives already undertaken in Canada, including training on the uses of mitigation measures and building awareness regarding the potential impacts of fishing gear, have already paid benefits in reducing the impacts of certain fisheries. Knowledgeable fish harvesters can, and sometimes do, tailor the deployment of fishing gear based on information regarding the depth and bottom type of areas they intend to fish. This is often done in a way that aims to minimise contact with defined biologically sensitive areas, or areas with a complex surface structure that could support, for example, coral or sponge communities.

4. The provision of credible and reliable information on the impacts of specific fisheries requires some form of independent monitoring of the fishery operations. As many impacts have been observed to be clustered in space and time and may not be evenly distributed throughout a fishery, a low level of monitoring may not properly characterize the scale and pattern of the impacts. Also, if the results of the monitoring program are to be extrapolated to the full fishery, the level of coverage and the design of the monitoring program must be appropriate for the characteristics of the fishery. The potential for an "observer effect" should be taken into account when planning monitoring programs and using the information from them, as it has been shown that in some cases fish harvesters may operate differently in the presence of onboard monitoring.

5. For every documented impact of the fishing gears reviewed, we were able to identify mitigation measures to reduce, and sometimes eliminate, the associated impacts. Many Canadian fisheries make effective use of appropriate mitigation measures as part of their fishing operations. It is acknowledged that some fishing methods are essentially always destructive, such as explosives and poison. However those methods are prohibited in Canada and thus were not considered in this report.

6. An evaluation of the nature and scale of potential impacts is an important step in identifying appropriate mitigation measures for a specific fishery. The evaluation should make best use of all available information regarding the fishery and the ecosystem in which the fishery occurs.

7. To evaluate the impacts of a fishery and the effectiveness of mitigation measures, information from monitoring fishery operations (including mitigation measures when they are being used) must be combined with information about the ecosystem features potentially being impacted by the fishery. Where the information about the ecosystem features potentially being impacted is uncertain, but the potential impacts could be serious or difficult to reverse, the application of precaution is appropriate.

8. Evaluations of the impacts of particular fisheries should consider the cumulative effects of other pressures (including other fisheries and industries) on the ecosystem components being impacted by the fishery. Mitigation of fishery impacts is most effective when compatible measures are chosen to address the various important pressures on the ecosystem feature(s) of concern.

9. The selection and application of mitigation measures to reduce fisheries impacts should consider their effectiveness relative to large, uncommon impacts, and also relative to an "average" rate of impacts that may not actually occur.

10. The effectiveness of every mitigation measure is also fishery-specific, and depends on the particular impact being addressed, how appropriate the measure is to mitigate the impact, and how the measure is implemented.

11. Credible and reliable information on the effectiveness of mitigation measures applied in a specific fishery also requires some form of independent monitoring of fishery operations. Please note that the same considerations defined above (see paragraph 4) apply here as well.

12. Most mitigation measures have some cost (e.g. financial, time, etc.) to the fishery. For example, various combinations of increased costs associate with the purchase or construction of the gear, greater complexities and expenses in fishing, lost opportunities to

fish, and potentially lower catch per unit effort. However, mitigation measures may provide benefits to fishery operations, such as reduced handling time and/or improved product quality. Many cases reviewed reflect that appropriate incentives increased the likelihood that fisheries will be willing to assume the potential aforementioned costs.

13. Fisheries are conducted to produce social, cultural, and economic benefits. Programs to mitigate the impacts of specific fisheries should be developed while giving appropriate consideration to the objectives for the fishery, within the framework of Canada's commitments of responsible fishing and the conservation of marine biodiversity.

Organisation of the Advice on Selected Gears

For each gear, four questions were addressed that helped to determine the potential impacts of the gear, see a) and b) below, and also the effectiveness of the mitigation measures for impacts of concern, see c) and d) below:

a. Has each type of impact been documented to occur when the gear is used without special mitigation being applied?
b. What factors have been reported to affect the extent and seriousness of the impact?
c. What types of mitigation measures have been applied to deal with the identified impacts?
d. What factors influence the effectiveness of the mitigation measure?

It is likely that for any particular gear at least some of the impacts on habitats and species will be considered to be very unlikely or to occur on a scale low enough that mitigation is rarely necessary. Nonetheless, for each gear the types of impacts that may affect habitats and also species groups were considered. Impacts on habitat were considered in general and also more specifically for special features such as corals, sponges, kelp, seagrass, and other specified features. In addition, the impacts of fishing gear were also considered for certain species groups (i.e. seabirds, marine mammals, sea turtles, sharks, fish, and invertebrates). In some cases, these species groups were disaggregated into more specific groups such as: non-commercial species, commercially-exploited species not usually targeted by the particular fishery, targeted species that may be partially or wholly discarded, other marine organisms, and protected species.

It is acknowledged that direct impacts of fisheries can have indirect consequences. For example, impacts on food-web dynamics, including local depletion of prey, and species' life-history traits. This report focuses on the direct effects of fisheries and measures to mitigate those impacts. Reduction of direct fishery impacts is expected to contribute substantially to the reduction of possible indirect impacts as well. However, once all direct impacts are considered to be sustainable, it would be appropriate to evaluate the possible residual indirect effects of the fishery, and if any such effects were found, to ensure they were sustainable as well.

It is also acknowledged that fishing gears might have direct impacts that were not reviewed at the advisory process which produced this report. Some such impacts are characteristic of any of the fishing gears reviewed and although the types of impacts outlined below are not considered further in this report, they may warrant consideration when evaluating the potential impacts of a specific fishery. For example, any lost fishing gear could be considered marine debris, whether or not it continues to catch and kill marine organisms (a factor that is considered in this report as ghost fishing), and of course, a general goal exists to reducing the production of marine debris. Fishing vessels and gears can be vectors for disease-causing pathogens, bacteria, alien invasive species, etc. that may be attached to a vessel or gear, just like any other type of vessel or structure put in the water. For fisheries using bait, there is the possibility that live bait may be a vector for transfer of alien invasive species, and that large and concentrated disposals of waste bait may decompose on the seafloor, causing a reduction in dissolved oxygen levels and local excessive nutrient enrichment.

The classes of mitigation measures to be considered for each gear include:

- Catch or effort limits/quotas
- Spatial measures (e.g. closures, zoning, etc.)
- Temporal closures (e.g. seasonal closures, real-time "hotspot" closures, etc.)
- Managing the time and duration that a gear is deployed (e.g. "soak times", diurnal time of deployment, etc.
- Managing the size or shape or mode of deployment of the gear (e.g. hook size and shape, mesh size of nets, etc.)
- Making the gear less attractive or more detectable by the use of deterrents (e.g. pingers, streamers, bait choice, etc.)
- Managing how the catch is handled (i.e. usually with the objective of achieving live release of any non-retained catch)
- Reducing the loss of gear that may continue to cause impacts while it remains in the ocean.

It is likely that for any particular gear, at least some of the identified mitigation measures may be considered to be ineffective, while others may have varying degrees of effectiveness and associated costs for a variety of reasons.

CONCLUSIONS AND SCIENCE ADVICE

Documenting the Ecosystem Effects of, and Possible Mitigation Measures for, Longline Fisheries

Overview of Longline Gear Fisheries in Canada

This summary is limited to Canadian longline fisheries and will not address other hook and line fisheries (i.e. troll, hand-line, and jig). Longline fisheries in Canada and elsewhere use a long line, called the main-line, with baited hooks attached at intervals by means of branch lines called "gangions" or "lead-lines". A gangion is a short length of line, attached to the main line using a clip or swivel, with the baited hook at the other end.

Longlines can be set near the surface (i.e. pelagic) or on the sea bottom (i.e. demersal). Both types of longlines are moored to the bottom at each end, with those ends marked with buoys and floats. However, pelagic longlines in the Maritimes are not moored to the seafloor. Hundreds or thousands of baited hooks can be deployed from a single line, which may be kilometres long. Longline fishing equipment is popular worldwide and can be deployed in areas often deemed "difficult" to fish with other gears (e.g. deep water, rough bottom, near-shore areas, etc.).

Longline fisheries occur on all three coasts of Canada and target a broad range of species (e.g. halibut, swordfish, tuna, Atlantic cod, rockfish, etc.). However, the current Canadian longline fisheries land only a small portion of the total landed weight of catches for all Canadian fisheries. In Canada, demersal longline fishing occurs in a wide range of depths up to 1500 metres (e.g. Pacific Sablefish and Atlantic Greenland Halibut fisheries). The size and weight of the gear used varies depending on the fishery. Halibut is generally fished with strong, large-diameter gangions and large hooks attached to the main-line at intervals of one to six metres.

However, cod are usually fished with shorter, weaker gangions and smaller hooks, with spacing between the hooks of approximately 1 metre.

Longline fisheries may have direct impacts on marine habitats and species, and also indirect impacts on these ecosystem features through second-order effects. Although many of the available longline fishery impact studies are not from Canadian waters, experiences internationally are typically representative. The scale and severity of longline impacts is affected by factors such as the type of benthic communities over which they are fished and also the strength and length of the longlines (as it relates to gear loss).

Potential Impacts of Longline Fisheries on Marine Habitats in Canada

Pelagic Longlines

The impact of pelagic longline fisheries on marine habitats are expected to be minimal, except in cases where the gear is lost. If lost pelagic longline gear drifts to the seafloor, it can degrade habitat through direct impacts such as smothering of organisms on the benthos and also via entanglement of bottom-dwelling species (e.g. coral and/or sponge communities). However, there are no studies to quantify whether the frequency or scale of these types of impacts are rare or common, nor local or extensive. The effects are not uniform and depend on at least the specific features of the seafloor habitats (i.e. flat, sandy bottom versus sloped and/or rough bottom). The anchor systems or weights usually cover a small area on the seafloor, and the impact of these gears on seafloor habitats is usually restricted to this area of contact.

Loss of pelagic longline gear is likely impossible to eliminate, but could be reduced by avoiding fishing during periods of predictably bad weather, sea ice, or other conditions when soak times are likely to be prolonged. The use of transmitting devices on the gear may be effective in facilitating retrieval should the gear move from the location in which it was deployed.

Demersal Longlines

Demersal longline fisheries may impact marine habitats. Setting and retrieving demersal longline gear can degrade habitat directly through the displacement or removal of features such as single or colonial bottom-dwelling organisms on the seafloor (e.g. coral and/or sponge communities). The spatial scale of these impacts is generally local and can depend on factors such as the length and strength characteristics of the gear (as it relates to gear retrieval and gear loss), how the gear is deployed and connected to the seafloor, weather conditions, local currents, tides, and the specific features of the benthic environment. Habitat impacts have been shown to sometimes be of special concern when longline gears are set in less-perturbed areas in which mobile, bottom-contacting gears are prohibited (because of the presence of sensitive habitats) or vessel captains avoid (owing to the risk of gear damage).

Impacts of demersal gear are likely impossible to eliminate, but could be reduced by not conducting the fishery during periods of predictably bad weather, sea ice, or on structurally sensitive substrates. Loss of demersal longline gear could have similar impacts to those outlined above for lost pelagic longline gear. The mooring of demersal longlines is likely to have little impact on marine habitat as the anchor systems or weights usually cover a small area on the seafloor.

Potential Impacts of Longline Fisheries on Marine Species in Canada

Pelagic and demersal longline fisheries may affect biodiversity and Vulnerable Marine Ecosystems (VME) as they have been documented on all three Canadian coasts to impact a range of marine taxa through catch and entanglement. Notably, this gear type (both pelagic and demersal) is known to impact seabirds, marine mammals, elasmobranchs and other fishes, invertebrates, and also sea turtles in the Atlantic.

Seabirds

Seabirds are caught on longlines, but available information is deficient to assess the state of seabird bycatch. However, reports from the Maritime Region on seabird bycatch conclude this mortality is not common in Canadian fisheries as they currently operate. Whether this mortality is significant is unknown. The Black-footed Albatross is the only seabird listed under SARA that is documented as captured or entangled in longline fisheries in Canada. Although this is considered a rare event in Canadian Pacific longline fisheries using current operating procedures, low rates of bycatch mortality have sometimes had significant population-scale impacts on some species of albatrosses in the southern hemisphere.

Marine Mammals

Whales, porpoises, dolphins, seals, and sea lions are caught on or entangled in longlines, but such captures are not common in Canadian waters. Some of these species are listed under SARA (e.g. North Atlantic Right Whale and the Scotian Shelf Northern Bottlenose Whale).

Sea Turtles

Sea turtles, such as Loggerhead and the SARA-listed Leatherback, are caught on pelagic longlines and these catches occur commonly in some areas in Atlantic Canadian waters.

Elasmobranchs (Sharks, Rays, and Skates)

Sharks (i.e. Spiny Dogfish, Blue, Porbeagle, Sleeper, Six-gill, and Greenland) are commonly caught in longline fisheries in most areas in Canadian waters. Depending on the fishery, various combinations of these species may be retained or discarded. Rays and skates are also caught in longline gear in Canada and are usually discarded.

Fish and Invertebrates

Fish are commonly taken in longline fisheries in all Canadian waters. Depending on the fishery, various combinations of fish species may be targeted or caught incidentally, and when caught, may be retained or discarded. Some of the species that are caught but not retained are listed under SARA (e.g. Spotted, Northern, and Striped Wolffish) or prohibited for other reasons (e.g. Atlantic Salmon).

Invertebrates such as squid may be caught on pelagic longlines, but available information indicates these events are not common in Canadian waters. The capture of sea stars, seawhips, stone crabs, corals, and sponges in demersal longlines is a relatively common event in Canadian waters. Some of these species groups have been identified as characteristic of VME.

Classes of Mitigation Measures for Longline Fisheries in Canada

In Canada and elsewhere, studies of longline impacts and mitigation efforts have tended to focus on more charismatic species (e.g. marine mammals and seabirds). As in other countries, the impacts of longline fisheries in Canada could be reduced using one or more of the following mitigation strategies:

Catch or effort limits

Catch limits as a mitigation tool have been applied to longline fisheries in Canada. For example, the Groundfish Integration Program on Canada's Pacific coast, and the provision of a bycatch quota for some tuna and shark species in the directed swordfish fishery in the Atlantic.

Spatial and/or Temporal Closures

Spatial closures have been applied to longline fisheries in Canada to address both habitat and bycatch impacts. The Northeast Channel Coral Conservation Area in the Atlantic has been used to manage the impacts of demersal longline fishing in this area as well as other types of bottom contact fishing (e.g. gillnets, traps, and otter trawls); however, pelagic longline fisheries are permitted here. The Rockfish Conservation Areas in the Pacific are additional examples of spatial closures used as a measure to mitigate fishery catch and impacts.

Temporal closures have been applied to longline fisheries in Canada to reduce the capture of undersized or spawning target groundfish species in the Atlantic. Time and area closures have also been used in the swordfish longline fleet to avoid Atlantic Bluefin Tuna bycatch.

Managing the duration or time that gear is deployed (i.e. "soak time")

Managing soak times may reduce bycatch mortality. Also, it has been shown that deploying longline gear at night can reduce the incidence of seabird bycatch; this is required for longline fisheries in some jurisdictions.

Managing the size or shape of the gear or the mode of deployment

Large circle hooks (18/0) have been used in place of "J" hooks as a means to reduce the amount of sea turtle bycatch on pelagic longline gear, decrease the probability of the hook being swallowed, and facilitate an easier release of live, hooked turtles. Although turtles are the primary species targeted by this mitigation measure, other species may benefit as well. In addition, the gangions on pelagic longline gear are usually of sufficient length to allow hooked turtles to reach the surface to breathe. However, there is evidence in Atlantic Canada that the use of circle hooks may result in the increased mortality of smaller cod caught in demersal longline gear, and this impact is not resolved by practical increases in hook size. This case illustrates a situation where a measure implemented to address one impact has amplified another problem, highlighting the need for a coordinated approach to mitigating impacts. There are some studies that demonstrate that the type of hook can affect the success of live release of several species groups; many international jurisdictions, as well as fisheries in the Canadian Pacific, have adopted related regulations.

Some international studies have shown that seabird bycatch can be reduced by adding weights to the longline gear to speed the gear's deployment to fishing depths, reducing the time during which the baited hooks are exposed to bird encounters. Changes in the bait used have also been shown in some, but not all, cases to reduce the bycatch of at least seabirds and other species groups.

Use of Deterrents

Multiple streamers are deployed prior to setting longline gear as a means to mitigate seabird bycatch. This technique aims to deter seabirds from closely approaching the gear deployment zone near the vessel. Most studies indicate that streamers have some benefit in reducing seabird catch, but the scale of the benefit depends on many details (e.g. streamer configuration, fishery operations, and species of bycatch concern). Although current studies using manufactured baits have been conducted only in association with trap gear, these may provide a promising means to reduce bycatch by making the longline gear more attractive only to the target species.

Catch-handling Techniques

In Canada fish harvesters are encouraged, and offered training in some fisheries, to release bycatch alive and in the best possible condition; this is particularly the case for sharks and sea turtles. All active vessels in some longline fisheries are required to carry de-hooking and line-cutting equipment, as well as dip nets to aid in the live release of sea turtle and shark bycatch; fish harvesters are trained in the use of these tools. Sub-legal halibut in the Atlantic and Pacific are released alive as part of the standard gear handling protocol. Studies are planned to assess the relationship between halibut survival following release and the depth at which fish are caught.

Gear loss

Lost pelagic or demersal longline fishing gear is unlikely to continue fishing ("ghost fishing") once the baits are lost or consumed. Studies are planned to assess the efficacy of biodegradable lines to ensure that lost gear will not remain intact for an extended period in the environment. In some fisheries, the GPS location of longline set locations is now recorded in fish harvesters' logbooks to facilitate relocating lost gear. Radio transmitters are deployed with some pelagic longline sets to aid in recovering them should they be lost from their deployment location. In the Pacific halibut fishery, an estimate of the impact of lost longline gear is included in the stock assessment of the species – an approach that may be useful to consider in other Canadian fisheries as well.

Documenting the Ecosystem Effects of, and Possible Mitigation Measures for, Gillnet Fisheries

Overview of Gillnet Gear Fisheries in Canada

Gillnets, in the contemporary context, are panels of mono- or multi-filament webbing supported by a line with floats (i.e. "corkline" or "floatline") at the top of the panel and weighted with a leaded rope (i.e. "footrope" or "leadline") at the bottom of the panel. Gillnet panels range in depth from several metres to tens of metres. In some fisheries (e.g. deepwater turbot in the Atlantic and Arctic Regions) these panels are strung together in net "fleets" or "gangs" that can be tens of kilometres in length.

Commercial, recreational, and subsistence fisheries sectors are permitted to use gillnet gear in Canadian jurisdictions. Gillnets are deployed in several different configurations in Canadian waters and target a variety of different species:

- Demersal gillnets have a low buoyancy floatline and adequate weight in the leadline for the net to sink to the bottom; nets are anchored in place using weights at either end. In Atlantic and Arctic Canada, demersal gillnets are used to target groundfish (e.g. turbot, cod, plaice).
- Mid-water or pelagic gillnets are similar to demersal but have sufficient buoyancy for the net to float in the middle of the water column at a specified depth. This configuration is generally deployed perpendicular to shore, often with one end anchored to the beach and the other with a weight. In Atlantic Canada, mid-water gillnets are used to target small pelagic species (e.g. herring, mackerel).
- Surface gillnets have more buoyant cork lines, float at or near the surface, and may be anchored in place with weights or moored to the vessel from which it was deployed. Surface gillnets are used in all regions to target salmonids (e.g. Pacific Salmon, Arctic Char) as well as small pelagic species (e.g. herring, mackerel).

A special class of surface gillnets are “driftnets”. This term historically was used to refer to very large 10 – 50 kilometre long surface gillnets which may or may not be moored to the deploying vessel and are never anchored in place. Drift nets of this type have been used to target high seas salmon and squid but are not currently used in Canadian fisheries.

<u>Potential Impacts of Gillnet Fisheries on Marine Habitats in Canada</u>

Three components of gillnet gear interact with benthic habitats: i) the weights or anchors, ii) the leaded rope or footgear, and iii) the net itself. The weights can crush benthos or re-suspend sediment when retrieved. The leaded rope has some impact on bottom substrates while fishing, but impacts are greatest during retrieval or when gear is lost (i.e. due to dragging across the bottom, entanglement with biogenic habitat, or re-suspension of sediment). The mesh could become entangled on bottom features and cause damage upon retrieval. Fouling of substrate or benthic organisms could occur when gear or portions thereof are lost.

The length of a fleet of demersal gillnets and the depth in which it is deployed influences the likely degree of impact. Fleets of length equal to or less than the fishing depth tend to have lower impact as they are retrieved nearly vertically in the water column, thereby limiting dragging or entanglement. The area in which the gear is deployed affects the degree of impact such that the relative impacts of the gear are exacerbated in areas with high current, poor weather, high vertical heterogeneity or high species diversity. The mass of the weights or anchors employed and the lead line used will likewise exacerbate either crushing or dragging impacts of demersal gillnets.

The breaking strength of the lines, ropes and net used also affect the relative impact of the gear. Ropes of greater strength increase the likelihood of damaging entangled biogenic habitat, while weak lines or web increase the possibility of loss leading to entanglement and fouling. The impacts noted above apply principally to demersal gillnets; mid-water and surface gillnets interact little with benthic habitats except when the gear is lost. For all gear configurations, there may be an issue of diminished availability of water column habitat to pelagic species or species groups (e.g. marine mammals) if an area becomes unusable or undesirable due to the presence of gillnets.

Potential Impacts of Gillnet Fisheries on Marine Species in Canada

Seabirds

Demersal, mid-water, and surface gillnets drown seabirds. A diversity of seabirds can become entangled as the gear is deployed and recovered. In general, the diversity of seabirds impacted decreases as depth increases. Only the deepest diving seabird can interact with deep-set demersal gillnets, but as depth of deployment decreases, shallow-diving and surface-foraging seabirds do become entangled in the gear. Marbled Murrelets, which are protected under SARA, are known to interact with Canadian salmon surface gillnet fisheries.

Marine Mammals

All three deployment configurations of gillnets have documented interactions with pinnipeds (e.g. Harbour Seal and sea lions) and cetaceans (e.g. Sperm Whale and Narwhal); some of the impacted species are listed under SARA (e.g. Bowhead Whale, Harbour Porpoise, Right Whale). Interactions are not limited to direct interaction with gillnets themselves, but also include entanglements with the buoy lines of demersal or mid-water deployed gear. Pinnipeds tend to become entangled in the web of the nets, while cetaceans can entangle in either the web or buoy lines.

Sea Turtles

Surface gillnets and buoy lines of demersal and mid-water gillnets interact with sea turtles through entanglement, including the SARA-listed Leatherback Sea Turtle.

Elasmobranchs (Sharks, Skates, and Rays)

All three deployment configurations of gillnets are known to capture several species of sharks, as target species and/or non-directed catch.

Fish and Invertebrates

All three deployment configurations of gillnets do have non-commercial and non-targeted catch of finfish which may be retained or discarded. As well, there are discards of targeted species due to poor quality and increasing soak times are generally associated with decreasing quality of harvested fishes. Demersal deployment may also result in invertebrate catch such as crab, which may be discarded or released alive. Interactions between protected species have been documented for this gear type. For example, White and Green Sturgeon are encountered in the Pacific salmon surface gillnet fisheries; Atlantic Salmon and Striped and Northern Wolffish have been encountered in the Atlantic.

Classes of Mitigation Measures for Gillnet Fisheries in Canada

Responsible fishing practices have been shown to reduce the impact of gillnets on marine habitats and non-targeted species, as well as to produce higher quality product from the fishery. Continuation of education and awareness programs as well as a collaborative approach to addressing detrimental impacts has the potential to further the adoption of responsible fishing practices.

Catch or effort limits

Catch or effort limits for bycatch have been used in Canadian gillnet fisheries. For example, bycatch limits for undersize haddock led to the closure of the demersal gillnet fishery in NAFO Area 4X in the late 1990s.

Spatial and/or Temporal Closures

Spatial and temporal measures are employed extensively throughout Canadian waters to mitigate the impacts of gillnet fisheries. For example, combinations of spatial and temporal measures are employed to reduce the harvest of threatened or endangered conservation units salmon populations in the Pacific. Likewise, spatial and temporal closures have been employed in Atlantic Canada during spawning periods to reduce the catch of undersize target species.

Managing the duration or time that gear is deployed (i.e. "soak time")

Timing of gear deployment has been recommended to reduce the catch of seabirds in USA Pacific salmon fisheries and avoidance of crepuscular (dawn/dusk) deployment times has been demonstrated to reduce seabird interactions. Reduced soak times have been employed to reduce the bycatch of all species in Atlantic demersal gillnet fisheries. Furthermore, reduced soak times are associated with less drop-out of decomposing dead fish (and unaccounted fishing mortality) and less discarding of unmarketable product.

Managing the size or shape of the gear or the mode of deployment

Various combinations of mesh size, shape, and mode of deployment of gillnets have been used as mitigation measures. In the Pacific, surface gillnet fisheries targeting Pacific salmon have mesh size regulations as well as the use of weedlines (deployment of the web half a metre below the cork line) as a condition of license.

Use of Deterrents

Gillnet gear is made less attractive and/or detectable to non-target species by the use of deterrents such as pingers in Europe. In Canada, experiments with some deterrents including pingers, biodegradable mesh, and increased-visibility mesh types, have been evaluated experimentally. Results of these experiments have not always shown these methods to be effective. These measures have not been implemented as regulatory measures in any Canadian jurisdiction.

Catch-handling Techniques

Improved catch handling practices have been documented to increase survival of released cetaceans, pinnipeds, sturgeon, Snow Crab, Pacific salmon and other finfish species. Revival tanks are a condition of license for the salmon gillnet fishery in the Pacific. They are specifically required for salmon and steelhead bycatch (but not other species) and have been demonstrated to be effective at reducing mortality.

Gear loss

Mandatory tagging of demersal gillnets in Atlantic fisheries with government issued tags (each fish harvester has a fixed and limited number of tags) and GPS technology have reduced the quantity of fishing gear lost each year as fish harvesters are accountable for the fate of their gear and are able to locate it more accurately. Sonic tagging of gear has been recommended as a possible additional mitigation measure allowing rapid, easy location and recovery of lost gear.

Documenting the Ecosystem Effects of, and Possible Mitigation Measures for, Purse Seine Fisheries

Overview of Purse Seine Fisheries in Canada

A purse seine consists of large sections of multi-filament net with floats along the top edge and weights along the net bottom. Purse seines are set in the water at the surface and extend down into the water column; a small boat called a "skiff" is used to encircle an aggregation of fish. Once the fish are encircled, the bottom of the net is pulled together to enclose the fish. Fish are brought aboard the vessel either by hauling the net on deck using a pump, or dip-netting the fish from the water. In Atlantic Canada, purse seines are used to fish small pelagic species such as herring, mackerel and capelin. In Pacific waters, they are used to fish various salmon species and small pelagic species.

Potential Impacts of Purse Seine Fisheries on Marine Habitats in Canada

Purse seines are generally operated to avoid contact with the sea floor although contact is occasionally made, particularly when fishing near-shore. When contact is made, biogenic structures (e.g. plants, corals, sponges) may be damaged and/or sediment may be re-suspended. The resistance of the seine material is such that damage to the gear is likely to occur before substantial damage to the seafloor and associated fauna/flora occurs, except possibly on very soft bottoms. However, some habitat features such as kelp may be quite sensitive to encounters with the rings and netting in the seines.

Potential Impacts of Purse Seine Fisheries on Marine Species in Canada

In some purse seine fisheries directed at small pelagic fishes, the catch is sampled once the seine is closed (but not necessarily pursed) to assess the size composition of entrapped fish. The catch may be released if it is felt to be composed of a large proportion of fish of undesired size and/or species. The mortality rate of the released fish is highly variable, from 0 to 100%, depending on factors such as the species and the circumstances surrounding the handling of the catch.

There is limited information on the catches of non-target species in most purse seine fisheries. The purse seine fisheries target schooling fish, and while the gear is not necessarily selective, the fishing operations generally are. The types of incidentally captured species differ greatly depending on the target species.

In Canadian fisheries, non-target species captured include sharks, some groundfish, squid, and rarely some benthic invertebrates (e.g. lobster). In addition, small pelagic fishes in the Atlantic and salmon in the Pacific may also be encountered. Based on limited observer coverage or reporting, these incidental catches or discards represent a small proportion of total catch (e.g. 0.4% of the total catch of NAFO 4VWX Atlantic herring and 2% of the Pacific salmon fishery). There are documented reports of marine mammals being enclosed in purse seines (i.e. the SARA-listed Humpback Whale) but these animals were apparently released alive.

<u>Classes of Mitigation Measures for Purse Seine Fisheries in Canada</u>

Catch or effort limits

Bycatch limits are used in certain fisheries (e.g. mackerel in herring fisheries) but these measures are uncommon as the fishing operations are generally selective.

Spatial and/or Temporal Closures

Spatial and temporal closures are sometimes used to avoid unintended species or stock components (e.g. Pacific salmon and herring fisheries), though these types of restrictions are not specific to purse seines.

Managing the duration or time that gear is deployed (i.e. "soak time")

This class of mitigation measure has not been applied to this gear.

Managing the size or shape of the gear or the mode of deployment

When bycatch of larger fauna is of concern, purse seines can be designed with special panels to facilitate the live release of these species. Mesh size and configuration, in portions or the entire seine, can be used to select the retained species; sorting panels can likewise be incorporated. Seine-mounted sensors can be used to avoid touching the sea floor.

Use of deterrents

This class of mitigation measure has not been applied to this gear.

Catch-handling Techniques

The survival of fish that are released from purse seines will depend in part on the extent to which they are handled. Survival rates decrease with the extent to which fish are compressed in the seine and/or removed from the water. Survival rates also vary considerably among species; indicators of post-release survival for released herring in Atlantic and Pacific Canada suggest that if the seine is only lightly pursed (and the fish not removed from the water), survival is often high. Revival tanks are a condition of license for the salmon seine fishery in the Pacific. They are specifically required for Steelhead Salmon bycatch (but not other species) and have been demonstrated to be effective at reducing mortality.

Gear Loss

Due to the nature of purse seine fishing operations, the likelihood of gear loss is probably very low; however, no information on gear loss rates was available for review at the advisory process. When it does occur, the effects are likely limited to smothering of bottom fauna and the footprint of this impact would be relatively small. Ghost fishing by lost gear is likely to be very limited because the gear is not expected to attract or retain fish effectively.

Documenting the Ecosystem Effects of, and Possible Mitigation Measures for, Mid-water Trawl Fisheries in Canada

Overview of Mid-water Trawl Fisheries in Canada

Mid-water trawls are constructed similarly to bottom-trawls but lack rollers on the footropes. They are operated using trawl doors and are used to fish a variety of small pelagic species (e.g. herring and Atlantic Mackerel) and bentho-pelagic fish species (e.g. redfish, Pacific Hake and pollock), as well as euphausiids (i.e. krill) in the Pacific. Canadian fish harvesters also participate in the North Atlantic mid-water trawl fisheries for Short-finned Squid. Mid-water trawls can be used throughout the water column, including near the bottom when fishing bentho-pelagic species. Presently in Canada, mid-water trawls are widely used only in the Pacific, and have limited use in the Atlantic (e.g. Georges Bank, some exploratory fisheries).

Potential Impacts of Mid-water Trawl Fisheries on Marine Habitats in Canada

Mid-water trawls may be operated near the bottom, but the goal is to avoid touching the sea floor. Contact by the doors or the footrope is only occasionally made in most fisheries, though contact can be frequent (e.g. Bering Sea pollock fishery). When contact is made, biogenic structures (e.g. plants, sponges, and corals), epifauna, and infauna may be damaged and sediment may be re-suspended. Unlike bottom trawls, the gear is not designed to withstand substantial bottom contact; thus damage to the gear is likely to occur before substantial damage to seafloor structures occurs, although fragile flora and fauna contacted by the gear may be damaged.

Potential Impacts of Mid-water Trawl Fisheries on Marine Species in Canada

Mid-water trawl fisheries often target schooling fish and are generally selective, even though the gear is usually not. The types of incidentally captured species differ greatly depending on the target species. In high-speed pelagic trawl fisheries, marine mammals (e.g. dolphins and seals) may be caught. In bentho-pelagic fisheries, discarded fish consist largely of undersized individuals of the target species, but also may include other groundfish. In mid-water or surface fisheries, other small pelagic fish may be caught. Bycatch rates in mid-water trawl fisheries are generally considered low (~1-3%), based on available data. However, as overall catch rates are often large for this gear, even a low rate of capture of non-target species may result in bycatch mortality large enough to be of concern.

Classes of Mitigation Measures for Mid-water Trawl Fisheries in Canada

Catch or effort limits

This class of mitigation measure has not been applied to this gear.

Spatial and/or Temporal Closures

Spatial restrictions are sometimes used to avoid unintended species or stock components (e.g. Alaskan Pollock fishery uses rolling closures to reduce salmon bycatch), though these types of restrictions are not specific to this gear. The times of day in which mid-water trawling takes place can affect the incidental catch of marine mammals.

Managing the duration or time that gear is deployed (i.e. "soak time")

Incidental catches are likely commensurate with fishing effort, so longer tows are likely to have more bycatch.

Managing the size or shape of the gear or the mode of deployment

Mesh size and configuration can be used to select retained species and sizes. Sorting panels can likewise be incorporated. Survival of fish passing through meshes or panels can vary among species; the effectiveness of mesh size as a mitigation tool for incidental catch management therefore needs to be evaluated accordingly on a fishery-specific basis. Sensors can be used to help avoid the gear touching the sea floor.

Use of Deterrents

This class of mitigation measure has not been applied to this gear.

Catch-handling Techniques

Survival of some released species may be likely. Post-release survival in trawl fisheries generally varies inversely with the set duration and the handling time on deck, and also positively with fish body size.

Gear Loss

Owing to the nature of fishing operations using mid-water trawls, the likelihood of gear loss is probably low, though it does occur in some fisheries, especially when fishing near high-relief features. When it does occur, the effects are likely largely limited to smothering of bottom fauna and the footprint of this impact would be relatively small. Ghost fishing is likely to be very limited, but there is evidence in the Alaskan Pollock fishery of northern fur seal entanglement in lost gear.

Documenting the Ecosystem Effects of, and Possible Mitigation Measures for, Trap Net and Weir Fisheries in Canada

Overview of Trap Net and Weir Fisheries in Canada

In Canada, trap nets and weirs are used almost exclusively in estuaries and near the shore on the Atlantic coast. The nets and weirs can vary from a few metres wide to as much as 100 metres in circumference. Trap nets can be used to catch cod, pelagic fish (e.g. herring, mackerel, and capelin) as well as a number of diadromous and coastal fish species (e.g. smelt, gaspereau/alewives, eels, silversides, winter flounders). In addition, traps are used in some subsistence fisheries for salmon. Presently in Canada, trap net and weir fisheries are used only in the Atlantic Ocean.

Potential Impacts of Trap Net and Weir Fisheries on Marine Habitats in Canada

When set on the bottom, traps are usually set on substrate of low complexity. Thus impacts are localized to the footprint of the trap and generally restricted to a reduction in available habitat. Little physical habitat modification occurs except for the anchoring mechanisms and driving of stakes in the sediment.

<u>Potential Impacts of Trap Net and Weir Fisheries on Marine Species in Canada</u>

A variety of non-target fish species, as well as undersized specimens of the targeted fish species can be impacted by these gears. In estuaries, species of concern (e.g. salmon, Striped Bass) can be caught. Tuna and sharks can be caught in herring weirs. In addition, marine mammals ranging from seals and harbour porpoise to whales can be caught or become entangled in trap nets and weirs. Other mammals (e.g. river otters) and sea birds can be caught in trap nets. In some circumstances, successful live release of captured non-target species is possible.

<u>Classes of Mitigation Measures for Trap Net and Weir Fisheries in Canada</u>

Catch or effort limits for bycatch

In the Atlantic (i.e. St. Margaret's Bay, Nova Scotia), a portion of the Atlantic Bluefin Tuna quota is reserved for tuna bycatch in mackerel traps.

Spatial and/or Temporal Closures

This class of mitigation measure has not been applied to this gear.

Managing the duration or time that gear is deployed (i.e. "soak time")

Important mitigation measures include restricting the duration of deployment and ensuring frequent monitoring of these gear types.

Managing the size or shape of the gear or the mode of deployment

When the trap nets are not submerged, marine and terrestrial mammals, as well as seabirds, are usually able to reach the surface and breathe which increases the possibility of live release. If not necessary for retaining the catch, excluding the top of the trap net can improve their chances of survival even further. Bycatch from trap nets can be reduced by additional gear designs including: i) appropriate mesh size to limit the catch of undersize fish, ii) appropriate material, size, shape, location and design of entrances and escape openings, and iii) incorporation of excluder devices. Large mesh seines can be used in herring weirs to assist in the guiding of cetaceans, pinnipeds, and tunas out of the weirs (e.g. Grand Manan Island herring weirs).

Use of Deterrents

For submerged traps, acoustic devices can be used to keep animals at a safe distance. Long-term effectiveness of acoustic deterrents has not been consistently demonstrated; there are concerns that these devices can be harmful to the hearing abilities of marine mammals after prolonged exposure and may disrupt behaviour of some animals.

Catch-handling Techniques

Trap nets offer the possibility of low mortality for non-targeted fish species because trapped fish are normally alive and uninjured and could be released alive with proper handling. The success of live release may vary in practice due to air exposure and delays during the catch sorting process.

Gear Loss

Lost gear is very unlikely except in exceptional circumstances (e.g. very severe weather). When it does occur, the effects are likely limited to the smothering of bottom fauna and the footprint of this impact would be relatively small. Ghost fishing by lost gear is likely to be very limited because the gear is not expected to attract or retain fish effectively.

Documenting the Ecosystem Effects of, and Possible Mitigation Measures for, Trap and Pot Fisheries in Canada

Overview of Trap and Pot Fisheries in Canada

Traps and pots are passive gear types that rely on bait to attract the target species. The retained animals are neither hooked nor entangled. The terms “pots” and “traps” are used interchangeably in this document to refer to the gear type described above. Traps are used in fisheries on the Atlantic and Pacific coasts and currently include some of the most commercially valuable species in Canada (e.g. lobsters, crabs, sablefish, and spot prawns). This gear can be rigid, stackable, or collapsible and ranges in size and design depending on the target species. This gear can also be designed to be very selective depending on the target species.

Traps can be used in a wide range of habitats and depths and are deployed by a wide range of vessel sizes from small inshore boats to larger offshore vessels; the amount of gear on each vessel is also highly variable. They can be fished singly (i.e. one buoy and line to the trap) or in groups or “strings” (i.e. multiple traps connected with a groundline with one or two lines to surface buoys). Soak times (i.e. the time between hauls) varies by fishery, but is generally one or more days. Observer and/or electronic monitoring of trap fisheries range from 0 to 100% but in general are low for many fisheries. While most trap fisheries are commercial, recreational trap fisheries exist on the Pacific coast and subsistence fisheries occur on all Canadian coasts.

Potential Impacts of Trap and Pot Fisheries on Marine Habitats in Canada

Traps can impact biogenic structures (e.g. sponges, corals) through crushing or entanglement. Crushing and scouring effects can result if traps are dragged across the bottom during retrieval or during periods of strong currents (e.g. storms, tides).

The potential impact of traps on marine habitats is dependent on a variety of factors including:
- Characteristics of the bottom where they are set (sediment type, relief and depth);
- Weight, size and construction material of traps;
- Retrieval methods and sea state, weather, tides, currents;
- Type of rope (floatlines are less likely to entangle bottom structures);
- Soak time;
- Use of anchors or weights; and
- String configuration (e.g. length) can affect degree of entanglement on bottom.

Potential Impacts of Trap and Pot Fisheries on Marine Species in Canada

Seabirds

It was reported that there are records of seabirds (e.g. cormorants) caught in traps and in floating lines, however this a rare occurrence.

Marine Mammals

Whales (e.g. Sperm Whales and the SARA-listed Humpback and Right Whales) have been entangled in trap ground lines and the buoy lines of traps. Seals and river otters have been caught in traps but this is a rare occurrence.

Sea Turtles

Sea turtles, both the Loggerhead and the SARA-listed Leatherback, have been entangled in trap lines, but this is a rare occurrence.

Elasmobranchs (Sharks, Skates, and Rays)

Basking sharks have been entangled in trap lines. Dogfish have been reported in prawn traps in the Pacific. However, these are not common occurrences.

Fish and Invertebrates

A range of non-targeted fish and invertebrates, including sunfish, are caught as bycatch in traps and in their associated lines. The SARA-listed Northern, Spotted, and Atlantic Wolffish are also known to be captured in traps. Non-retained catch, particularly of target species (i.e. "live discards"), are often found to have high survival rates if given proper handling. Non-target invertebrate bycatch is also assumed to have a high survival rate at the time of release given proper handling practices. Survival of finfish is dependent on the species and on the depth of water from which traps are retrieved, as well as the handling procedures.

In some fisheries, (e.g. Atlantic Lobster), incidentally caught fishes are often converted to bait. Bait fisheries are challenging to monitor (e.g. fish exchanged at sea) and the fishing mortality, which can potentially be high, is therefore poorly assessed for a number of species.

Other effects

Trap fisheries use significant quantities of bait which is discarded after use. In some other jurisdictions, bait use in the lobster fishery may represent a substantial transfer of energy to the benthos. This impact has not been studied in Canada, but has been documented in Maine, USA.

<u>Classes of Mitigation Measures for Trap Net and Weir Fisheries in Canada</u>

Catch or effort limits

There are examples of limits on the catch of non-targeted species (e.g. Snow Crab in developing toad crab fishery in the Southern Gulf of St. Lawrence) but these are rare.

Spatial and/or Temporal Closures

Sensitive areas can be closed to all bottom fishing gears including traps. Examples include the Northeast Channel and Lophelia Coral Conservation Areas, the Stone Fence, cod spawning boxes, and some Marine Protected Areas. The timing of fishing seasons can be adjusted to reduce encounter rates with species likely to be entangled. Cod spawning boxes in the Gulf of St. Lawrence are both temporal and spatial; the intent of these boxes is to protect the area by excluding the operation of bottom fishing gears, including traps. Temporary closures can reduce interactions between fisheries and thus potential gear loss (e.g. shrimp boxes to prevent interaction with the snow crab fishery off Nova Scotia). Temporary closures can also reduce the capture of targeted non-retained individuals during critical parts of their life cycle (e.g. soft shell crab closures in Hecate Strait and in the Maritimes to reduce catch of moulting crabs).

Managing the duration or time that gear is deployed (i.e. “soak time”)

Managing soak times may reduce bycatch, but may also reduce the catch of targeted species. In addition, they may alter the composition of the target catch (e.g. in the Pacific spot prawn fishery a longer soak time generally leads to a higher proportion of legal-sized prawns being caught as larger prawns enter the trap over time and displace the smaller prawns).

Managing the size or shape of the gear or the mode of deployment

Traps can be designed and deployed to be very selective for target species and to minimize bycatch. Adjustments can be made to bait, entrance location, mesh size, shape, alignment of entrance, escape panels, ring size, degradable panels, and number of compartments. Bait systems can be designed to better attract and retain target species and avoid bycatch. Modifications can also be made to reduce impact on the bottom; sinking and neutrally buoyant lines can reduce entanglement. In addition, gear can be modified and/or deployed in a manner that will reduce snagging and the potential of entanglement.

Use of Deterrents

Bait systems have been modified in lobster fisheries to reduce the accessibility of bait to seals. The bait itself can also be altered to avoid unwanted bycatch (e.g. in the sablefish fishery).

Catch-handling Techniques

Handling practices can be very effective at reducing mortality (e.g. Snow Crab, Cusk, wolffish).

Gear Loss

Some traps can continue to capture marine fish and invertebrates for several years after they are lost (i.e. ghost fishing); annual trap loss can be significant in some fisheries. Ghost fishing and loss of gear can be mitigated in a number of ways such as:
- Improved fishing practices with more awareness of time, location, and configuration of gear when deployed;
- Location aids (transponders, strobes, and radar reflectors);
- Reduce risks of conflict by zoning different users (e.g. shrimp and snow crab off of Nova Scotia);
- Required reporting of lost gear (i.e. tagging of traps);
- Degradable panels, open tunnel design (i.e. no entrance triggers);
- Retrieval of derelict traps (e.g. west coast of USA, Gulf of St. Lawrence, Bay of Fundy).

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