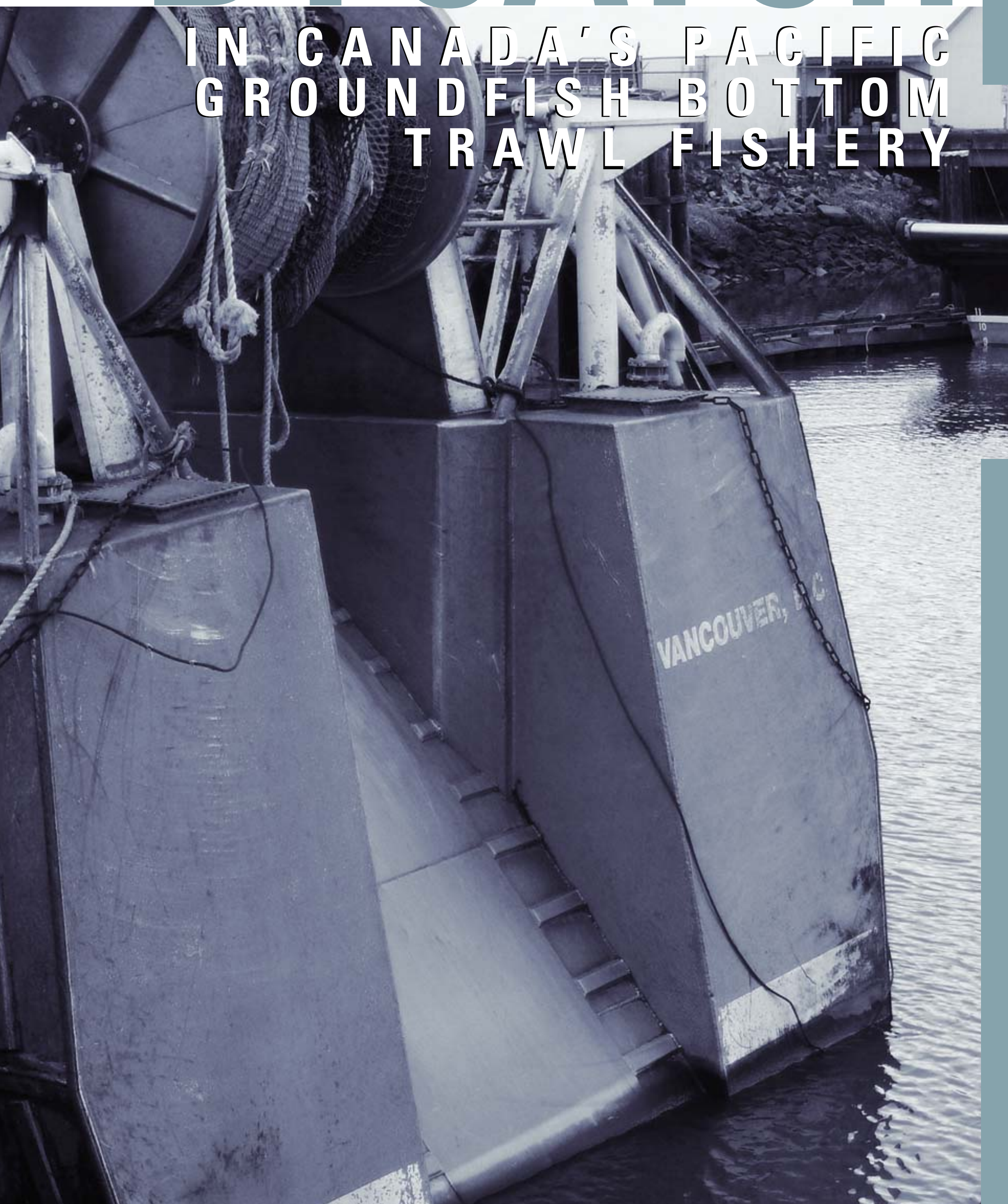
BYCATCH

IN CANADA'S PACIFIC GROUNDFISH BOTTOM TRAWL FISHERY



LIVING OCEANS SOCIETY

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A Living Oceans Society Report

Trends and Ecosystem Perspectives

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Executive Summary

Canadian fisheries management attention has historically focused on commercial species. The issue of bycatch — the catch of non-targeted species that are discarded at sea by fishermen — has been overlooked, especially when the bycatch species are of little or no economic or social importance. Since economic and social values do not indicate the ecological importance of a species, the "manage only what we eat" approach is clearly not consistent with an ecosystem approach to managing fisheries.

In this report, we bring attention to the bycatch issue in order to inform the development of Canada's ecosystem approach to fisheries. More specifically, we discuss spatial and temporal trends, and possible ecosystem impacts, of bycatch by the groundfish bottom trawl fleet that operates in Canada's Pacific region.

Bottom trawl fisheries often have high bycatch rates. The Pacific bottom trawl fleet is no exception. Based upon government data, we determined that the Pacific groundfish bottom trawl fleet discarded nearly 100,000 metric tonnes of bycatch from 1996 through 2006. This amounts to 20% of all of the biomass caught in this fishery during this time. While the majority of this bycatch was composed of commercial species, approximately 30% of the bycatch biomass was made of non-commercial species, for which there are currently no management measures in place.

Starting in 2006, an integrated groundfish management program has improved many aspects of the management of this fishery and other groundfish fisheries in Canada's Pacific waters. However, the bycatch of non-commercial species is still not managed. With no management measures in place and no clear economic disincentive to discourage bottom trawlers from catching them, non-commercial marine species – which may play important roles in marine ecosystems – will continue to be caught and tossed overboard, with no thought to the possible ecological repercussions. Clearly, this approach is not compatible with Canada's commitments to the ecosystem approach to fisheries.

***Based upon the results of this study,
Living Oceans Society recommends the following actions:***

1. Establish an immediate moratorium on the directed fishery for longspine thornyhead, until an ecosystem-based management plan and a stock assessment are completed

2. Build upon recent policy work to develop an ecosystem-based Bycatch Policy that takes into consideration all species, including those that do not have commercial value, and that takes into consideration the ecosystem roles played by such species.

1. The need for this study

With the Oceans Act of 1997, Canada committed to an ecosystem approach to conserving marine biodiversity and ecosystem productivity.[1] As of yet, Canada has no standardized ecosystem approach to fisheries (EAF) methodology. However, Fisheries and Oceans Canada (DFO) has identified managing and monitoring "the effects of fishing on species and habitat" as a core component of their developing EAF.[2] Thus, it will be essential for Canada's emerging EAF methodology to include indicators and methods for understanding and managing the ecosystem impacts that occur as a result of a fishery's removal of living organisms from ecosystems. This will require not only understanding and managing those ecosystem impacts that are caused by removing commercial species, but also those that occur as a result of removing non-commercial, incidentally-caught "bycatch" species.

The Canadian gear type with the most landings is the bottom trawl. Bottom trawl gear is composed of a net with heavy protective gear, designed to be dragged over the seafloor. It is a highly unselective gear that catches anything in its path that happens to be too large to escape through the net's meshes. Much of what a groundfish bottom trawl net catches may be discarded once it reaches the boat, because either it has insufficient economic value or because regulations prohibit its retention (e.g., below minimum size). This fishing gear is known to have serious impacts on habitat, benthic sessile fauna, and incidentally-caught fish and invertebrate species. It is widely considered to have the greatest impact on marine ecosystems of any fishing gear used in Canada.[3]

This paper seeks to assess some of the potential impacts of bycatch by Canada's Pacific groundfish bottom trawl fleet from a basic EAF perspective. To do so, we look at spatial and temporal patterns, and trends in species composition, in the bycatch data for this fishery. We then discuss the potential ecosystem effects of these patterns and we offer policy recommendations to address these potential effects. Biomass that is unintentionally caught and discarded at sea is referred to as "bycatch" in this report.

2. Bottom trawling in Canada's Pacific waters

From 1996 to 2005, the Pacific groundfish bottom trawl fleet fished over 38,000 km^2 of Canada's Pacific Ocean floor.[4] During this time, there was a general decline in the area trawled annually.[4] However, this time period also saw the initiation and expansion of a deep sea (500+ meter) bottom trawl fishery for longspine thornyhead.[4] Following the inception of this fishery during the late 1990s, the footprint of deep sea bottom trawl fishery in B.C.'s waters expanded from roughly zero to 7,300 km^2 by 2005.[4]

Currently there are approximately 70 active groundfish bottom trawl licenses operating in Canada's Pacific region.[5] This fleet catches a variety of groundfish, including flounder and sole, rockfish, lingcod, spiny dogfish, Pacific cod, and skates.[5] From 1996 to 2006 the total weight of catch landed by the bottom trawl fleet remained relatively stable. Total landings ranged from a low of 30,722 tonnes in 1998 to a high of 47,091 tonnes in 2005. The Pacific groundfish bottom trawl fleet has been estimated to have a 23% bycatch rate.[5]

Since 1997, bottom trawlers in the Pacific have had individual vessel quotas (IVQs) for commercial species, based upon total catch (landings plus bycatch). The fleet also has full observer coverage (100% of trips). The guiding management document for the Pacific bottom trawl fleet is the groundfish Integrated Fisheries Management Plan (IFMP). The IFMP defines the total allowable catches (TACs) for each managed species and allocates them among the groundfish sectors. The current IFMP does not have a section that addresses the issue of non-commercial species bycatch. This shortcoming should be addressed in a new IFMP template that DFO has developed.

3. Ecosystem impacts of bycatch

From an EAF perspective, the removal of species from the ecosystem via bottom trawl bycatch may affect ecosystem stability and productivity by potentially altering species composition and diversity, altering the structure and function of food webs (trophic systems), and changing the spatial distribution of large quantities of biomass in the water column.

There is overwhelming evidence to suggest that commercial fishing has radically altered the dynamics of many coastal ecosystems.[6,7] One primary pathway through which fisheries affect ecosystems is by altering the species composition of marine trophic systems. This can be caused by unsustainable removal of predator species,[8] forage species,[9] or combinations thereof, caused by both targeted and bycatch mortality. When fisheries alter the populations of certain species, predator-prey relationships can be thrown out of balance and the resulting population effects can cascade throughout the ecosystem to have serious effects on other species and ecosystem components that were not directly affected by the initial fishery impacts.[9] In some cases, the ecosystem may change so much as to be fundamentally different after the shift.[9, 10] Such situations can have devastating impacts on seemingly distant and unrelated fisheries.[11]

Bottom trawling can also change biodiversity by removing food available to marine predators and providing a food subsidy to marine scavengers. Catching large quantities of biomass near the ocean's floor and discarding much of it at the ocean's surface represents a large-scale redistribution of biomass that would not normally occur in nature. It reduces biomass available to demersal predators, and it increases the quantity of benthic faunal biomass available to both pelagic and demersal scavengers. Numerous studies have found that discards from trawlers selectively benefit scavenging bird, fish, and invertebrate species.[12, 13, 14] Seabirds may scavenge up to 25% of fish discarded at the surface,[12] while benthic scavengers, including starfish,[15] crabs,[16] and some fish species,[12, 14] have been found to move into trawl and dredge tracks to feed upon dead and damaged organisms.

Beyond the identifiable and quantifiable bycatch that is brought on deck by bottom trawl nets, bottom trawls may cause substantial mortality to benthic fauna that remain on the sea floor after the net has passed.[12] The amount of dead or moribund benthic faunal biomass available to scavengers after the pass of a bottom trawl net can be substantial: in one estimate, researchers calculated that North Sea flatfish beam trawlers left 8.3 kg of dead and dying benthic faunal biomass on the seafloor for every 1 kg of fish that was landed.[12] By killing non-targeted species and either leaving them behind on the seafloor or discarding them at the water's surface, bottom trawlers may simultaneously reduce populations of some non-targeted species and provide a food subsidy that may benefit some scavenging organisms, such as starfish. Both of these impacts may contribute to shifts in biodiversity.

4. Purpose, data, and methods

As Canada moves ahead with its commitments to the ecosystem approach, the ecosystem impacts of catching and discarding non-targeted species will have to be addressed and managed.

Box 1: Data

All data used in this analysis are from the Fisheries and Oceans Canada data unit. Living Oceans Society acquired the following three data sets:

Set 1

In 2007, Living Oceans Society acquired groundfish bottom trawl landings and discard data for the entire B.C. coast for 1996 to 2006, summarized by statistical area. These data did not include depth information, and were used in this analysis to identify species that are discarded vs. species that are retained by fishermen.

Set 2

In 2003, Living Oceans Society received groundfish trawl observer data for 1996 to 2002. In order to protect privacy, no vessel identifiers were given; and spatially, only midpoints of the trawls were provided (halfway between the start and end points). These data itemise species caught per bottom trawl tow in the Pacific, the latitude and longitude of the midpoint, and the tow depth, but do not indicate whether species were landed or discarded. These data were used in this analysis to quantify biomass removed in the deep sea, and to assess the species diversity of deep sea catches.

Set 3

Living Oceans Society also received non-spatial data for 1996 to 2004 that list species discards and landings for each tow without tow location. These data were used to determine "always discarded" species and to fill in missing species names in the 1996 to 2002 dataset.

We combined the 'always discarded' species list developed from data Set 3 with tow locations in data Set 2 to develop a map of bycatch 'hotspots.'

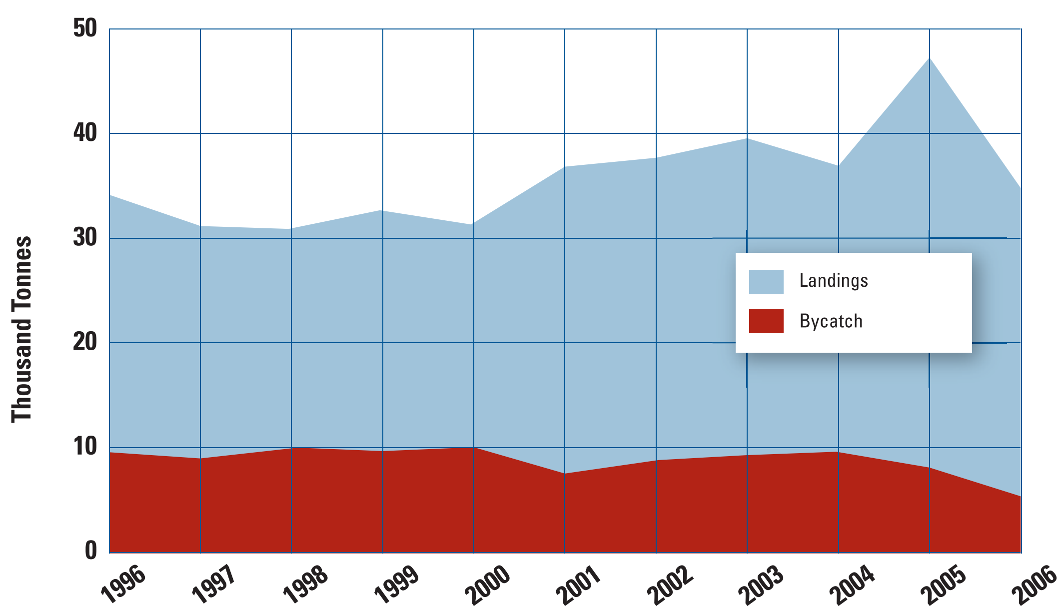

Figure 1 Pacific groundfish bottom trawl landings and bycatch, 1996-2006.

In this paper, we seek to contribute to Canada's efforts to develop and implement EAF by bringing attention to potential ecosystem impacts of bycatch in the Pacific bottom trawl fishery. We identify spatial, temporal, and species composition patterns in the bycatch of the Pacific bottom trawl fleet, and we discuss the potential ecosystem impacts of these patterns. We then recommend several policy alternatives to address the causes of these patterns.

The midwater trawl fishery for Pacific hake is not included or addressed in the landings or bycatch data for this report.

5. General trends

From 1996 to 2006, Pacific groundfish bottom trawlers brought over 490,000 tonnes of biomass onto their decks, and discarded nearly 100,000 tonnes of this biomass right back over the sides of their boats as bycatch (Figure 1). Approximately 20% of all biomass caught during these years was bycatch. Although most of this bycatch consisted of undersized fish of marketable species, 31% consisted of species of no commercial value, which are not managed.

Of the 450 species and species groups listed in the fisheries observer database, over 70% were discarded *more than 99% of the time*. This means that over 70% of the species and species groups that are caught by bottom trawlers were **always discarded**. We refer to these species as **always discarded** throughout this report.

Bycatch was dominated by fish species. Nearly 75% of all bycatch (by mass) was composed of rockfish, Pacific hake, gadoids and similar species, and flatfish. Flatfish alone made up roughly half of all bycatch (Figure 2). Mortality rates probably vary greatly between and within these groups.

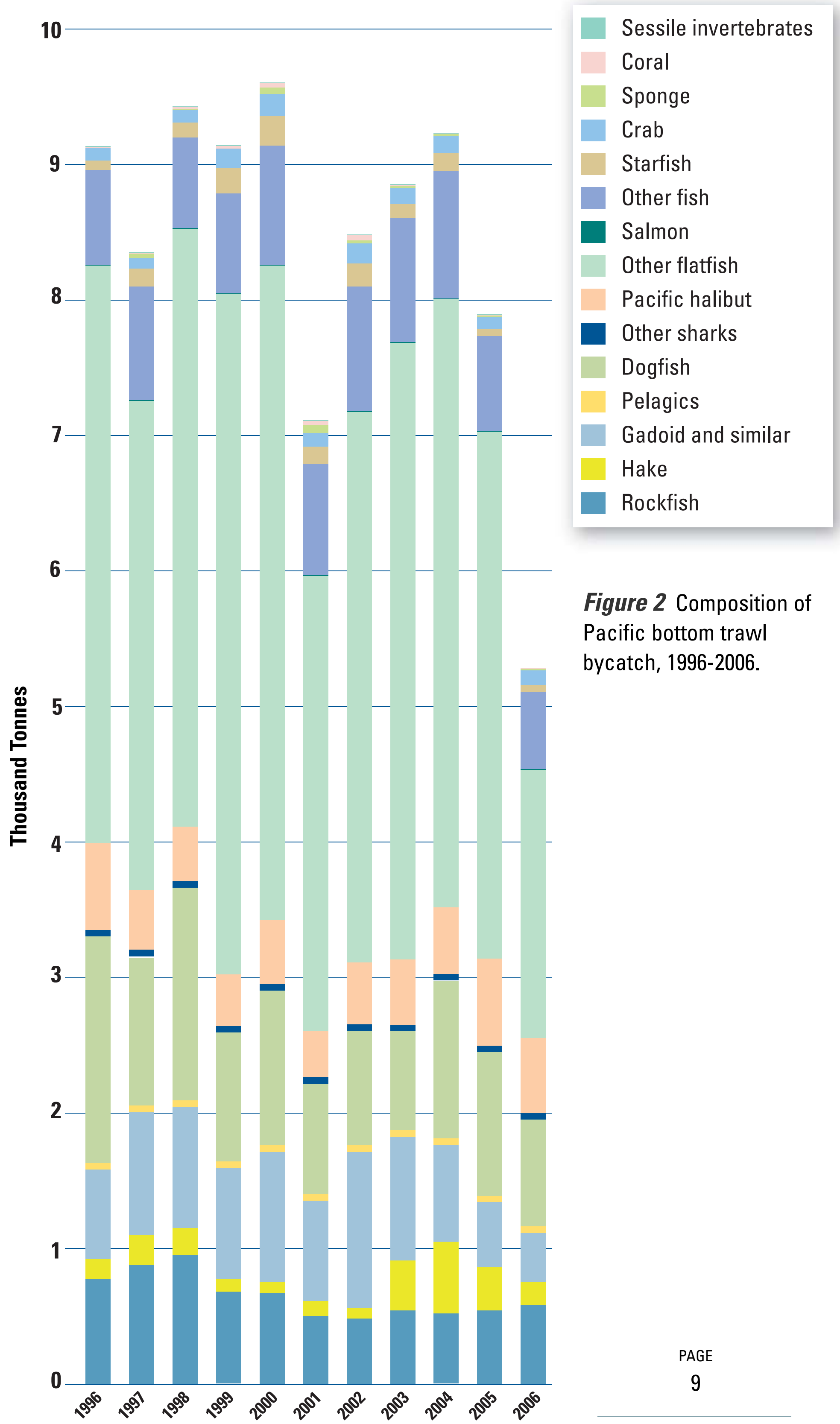

Figure 2 Composition of Pacific bottom trawl bycatch, 1996-2006.

Box 2: Direct impacts on species of interest

The Pacific bottom trawl fleet caught as bycatch several species that are currently listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Table 1).

Table 1 Bycatch of species of interest by Pacific bottom trawl fleet, 1996-2006

Bycatch Species	COSEWIC Status	Total bycatch (tonnes)	Number of bycatch incidents (large animals)
Basking shark	Endangered	4.67	7
Bocaccio	Threatened	95.43	-
Canary rockfish	Threatened	45.25	-
Northern fur seal	Threatened	0.04	1
Yelloweye rockfish	Special Concern	64.36	-
Rougheye rockfish*	Special Concern	33.12	-
Steller sea lion	Special Concern	17.10	50
Sixgill shark*	Special Concern	10.04	73
Green sturgeon*	Special Concern	14.73	80
Soupfin shark*	Special Concern	3.38	71

* = SARA species of special concern

Basking sharks have been virtually extirpated in Canada's Pacific waters, largely as the result of a dedicated eradication program that was literally spearheaded by the Canadian government from 1945 to 1970.[17] This eradication program combined with vessel strikes and fishing gear entanglements to cause a 90% reduction in basking shark population in less than two generations.[17] With only six confirmed live sightings since 1996[17], the removal of even one individual is a substantial blow to the species' outlook in the Pacific.

The four rockfish species, and sixgill and soupfin sharks, are generally characterized by slow growth, long lives, poor recruitment and/or low fecundity. These life history characteristics make these species especially susceptible to the effects of overfishing. Bocaccio and canary rockfish populations are known to have been substantially reduced during the past two decades. Population trends for yelloweye and rougheye rockfish and sixgill and soupfin sharks are not known, but their life history characteristics and the impacts of fishing put them at risk.[18]

In addition to these species of interest, the fleet also caught and discarded California sea lions (three incidents, 0.77 tonnes), harbour seals (16 incidents, 1.34 tonnes), northern elephant seal (one incident, 1.58 tonnes), eared seals and walruses (six incidents, 1.83 tonnes), other pinnipeds (32 incidents, 7.82 tonnes), Pacific white-sided dolphins (five incidents, 0.28 tonnes), common dolphins (one incident, 0.14 tonnes), and unidentified porpoises and dolphins (eight incidents, 0.37 tonnes). Seabird bycatch by the bottom trawl fleet was minimal. Identified bycatch of seabirds was composed of cormorants (79 kilograms) and Leach's storm-petrel (45 kilograms).

Box 3: Managing bycatch: the importance of economic incentives and disincentives

During the course of fishing, fishermen may make many small decisions based upon economic considerations. The sum of these small decisions can add up to larger trends. These economic considerations need to be taken into account when developing a policy for managing bycatch. The case of bocaccio bycatch by the Pacific bottom trawl fleet illustrates this point very well.

Prior to 2004, fishermen could land and sell bocaccio as they could any other commercial species. Very few bocaccio were discarded from 1996 to 2003. In 2004, conservation concerns for this species led the Pacific bottom trawl fleet to enter into an agreement with the Government of Canada in which all revenue generated by bocaccio landings was given for bocaccio research. This agreement was meant to reduce total bocaccio catch, and it has indeed done so. However, as Figure 3 shows below, discards of bocaccio skyrocketed in 2004, from less than 300 kg to nearly 40 tonnes – an increase of more than two orders of magnitude relative to 2003. This occurred even though total bocaccio catch declined substantially in 2004 and onwards. The number of incidents in which bocaccio were discarded also increased, from fewer than 22 incidents per year from 2001 to 2003 to over 125 incidents per year from 2004 to 2006. Thus, while the overall bocaccio catch was substantially reduced in 2004 to 2006, the amount that was wasted as discarded bycatch increased dramatically relative to 1996 to 2003 levels.

Our interpretation of this event holds that following the 2004 agreement, there were no economic incentives for fishermen to keep bocaccio – in fact, there was an obvious economic disincentive to devote effort and hold space to fish that would not bring the fishermen any economic reward. When fishermen did catch bocaccio, the sudden lack of economic incentive led an increased number to discard the bocaccio, rather than keep it. Thus, while the agreement may have led to substantially reduced overall bocaccio catch, it did also lead, at least initially, to increased waste of the bocaccio that was caught.

This trend is indicative of the importance of economic considerations to fishermen's behaviour on the water. Even though the 2004 agreement reduced overall bocaccio catch, it created an economic feedback that encouraged discarding a marketable species at sea. Wasting valuable seafood is not in anyone's best interest, and Canada's management of bycatch issues must take economic incentives into account when determining management strategies.

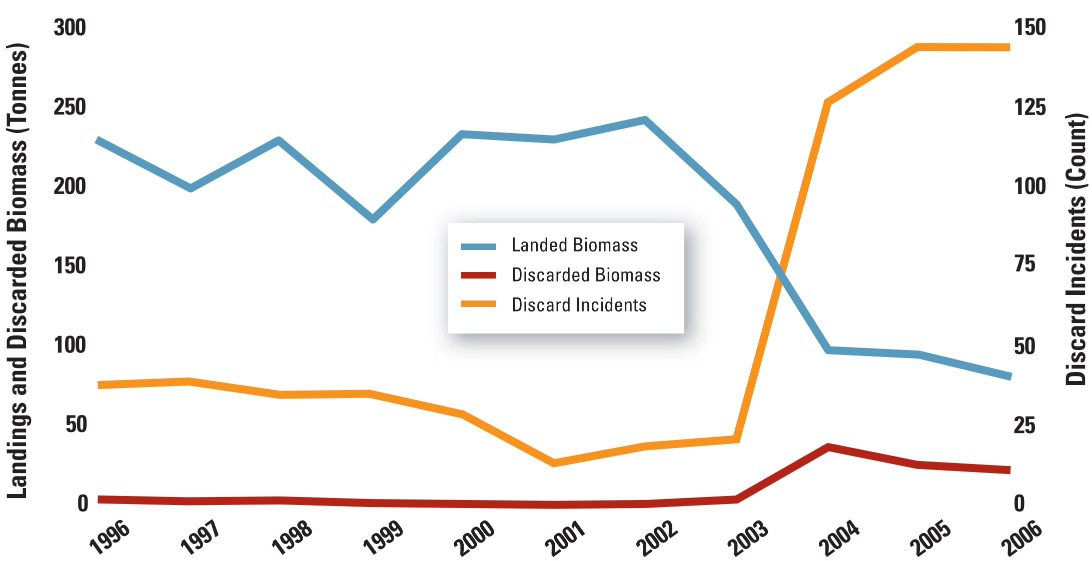

Figure 3 Coast-wide bocaccio landings and discarded bycatch, and number of discard incidents, by Pacific bottom trawlers, 1996-2006.

6. Identifying hotspots for bycatch of always discarded species

An important aim of this study was to identify potential hotspots where **always discarded** bycatch was highest. Hotspots for **always discarded** species groups were identified through a spatial density analysis. First we plotted a point for every tow between 1996 and 2002. The points represent the midpoint of each tow. Each point was weighted by the sum of the weight of **always discarded** species in that tow. To get an idea of the concentration of the discards in different trawled areas, a kernel density analysis was performed using the Spatial Analyst extension of the ArcGIS mapping software. This analysis spreads the weight of bycatch associated with each point over a circular area (as an approximation of the area actually covered by the tow), adds them all up when they overlap in space, and calculates the overall density of discards for each grid cell (100m x 100m) in the study area. We used a five km radius for tow points shallower than 500 meters and a 15 km radius in deeper waters, because the average length of a tow is 10 km on the continental shelf[19] and 30 km in deeper waters.[5] As we cannot know the true direction of the tows without start and end points (we were only given midpoints), this roughly estimates the area covered by each tow for the density analysis. We present these analyses for both shallow-water (0-500 m) and deep sea (500+ m) bottom trawl tows.

We also overlaid all the trawl midpoints, buffered by a five or 15 km radius, to illustrate the overall footprint of the trawl fishery on the coast. Although it is unlikely that every square meter of area within this footprint has been trawled, it provides a reasonable illustration given the resolution of the data we were provided.

The results highlight a hotspot of highest density of **always discarded** species in shelf waters located in northern Hecate Strait (Figure 4). A similar analysis of landings per tow revealed that the same area contains the highest densities of landed species as well as **always discarded** species. This area is obviously a hotbed of diversity and high commercial and non-commercial species mixing. A closer look at the tows in this area indicated that bottom trawlers in the Hecate Strait hotspot were mostly landing big skate, arrowtooth flounder, and English sole. The most common **always discarded** bycatch species groups in descending order were starfish species, Pacific halibut, and Dungeness crabs. Bottom trawlers discard large amounts of Pacific halibut because they are a prohibited species for trawl licence holders and can only be kept by longliners.

Three deep sea hotspots for **always discarded** species were grouped along the continental slope on the west coast of Vancouver Island. These were areas of high longspine thornyhead catch. While the density of **always discarded** species was lower in the deep sea hotspots than in the Hecate Strait hotspot, keep in mind that the deep sea from which these **always discarded** species were removed is much more unproductive than shelf waters, and that biomass at depths greater than 500 meters is very widely dispersed.

To investigate whether we could identify any simple spatial solutions to the bycatch problem, we also mapped the midpoints of all tows where discarded bycatch outweighed landings (Figure 5). Specifically, these are the tows (1996 to 2002) where the total kilograms of **always discarded** species actually outweighed that of the landed species. Presumably, fishing in areas where more than half of the catch must be discarded, as it lacks commercial value, is neither economically efficient nor indicative of healthy ecosystem management. However, as Figure 5 illustrates these instances were not uncommon and were widespread within the bottom trawl footprint in the Canadian Pacific from 1996 to 2002.

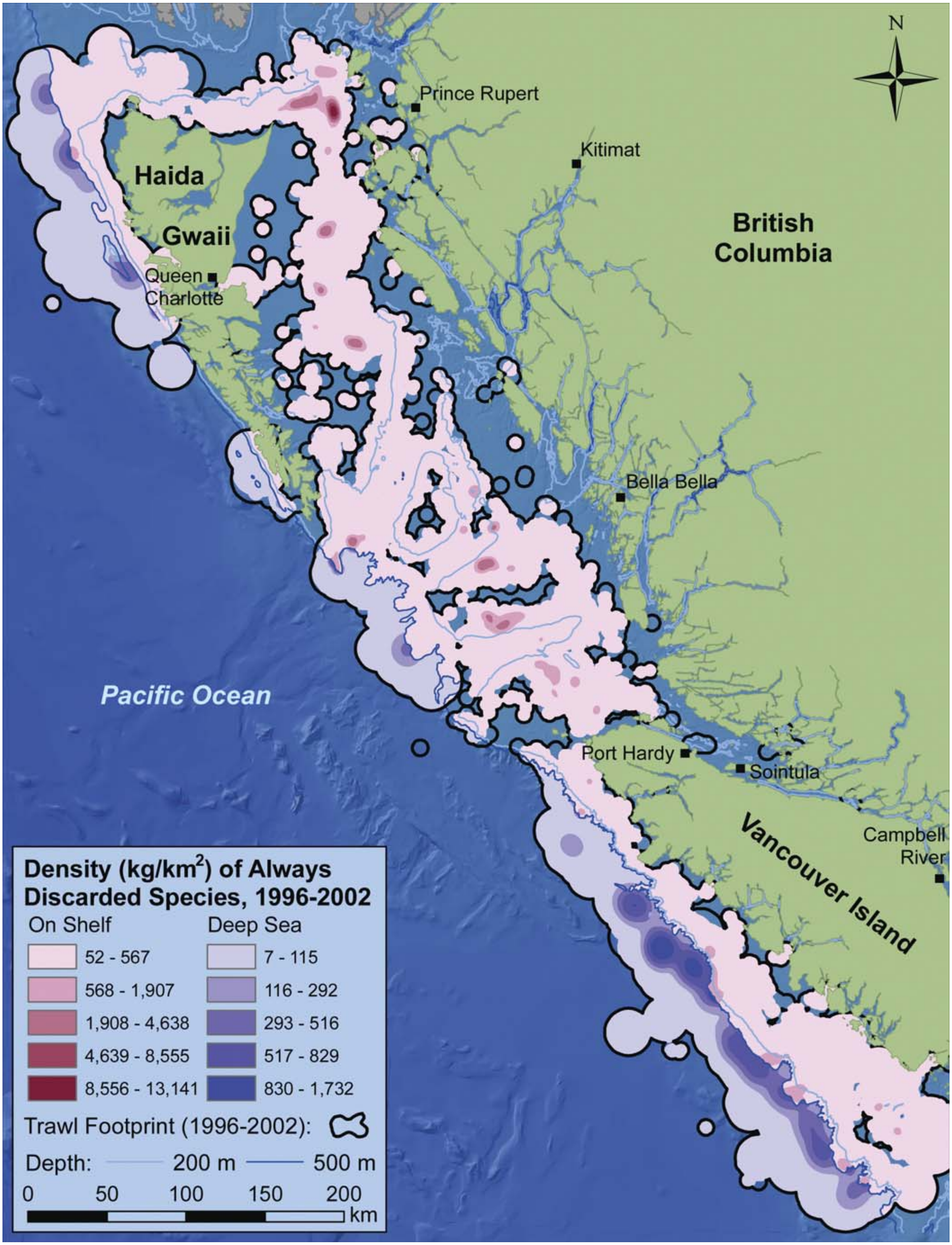

Figure 4 Hotspots of high densities of always discarded species caught in Pacific groundfish bottom trawl fishery, 1996-2002

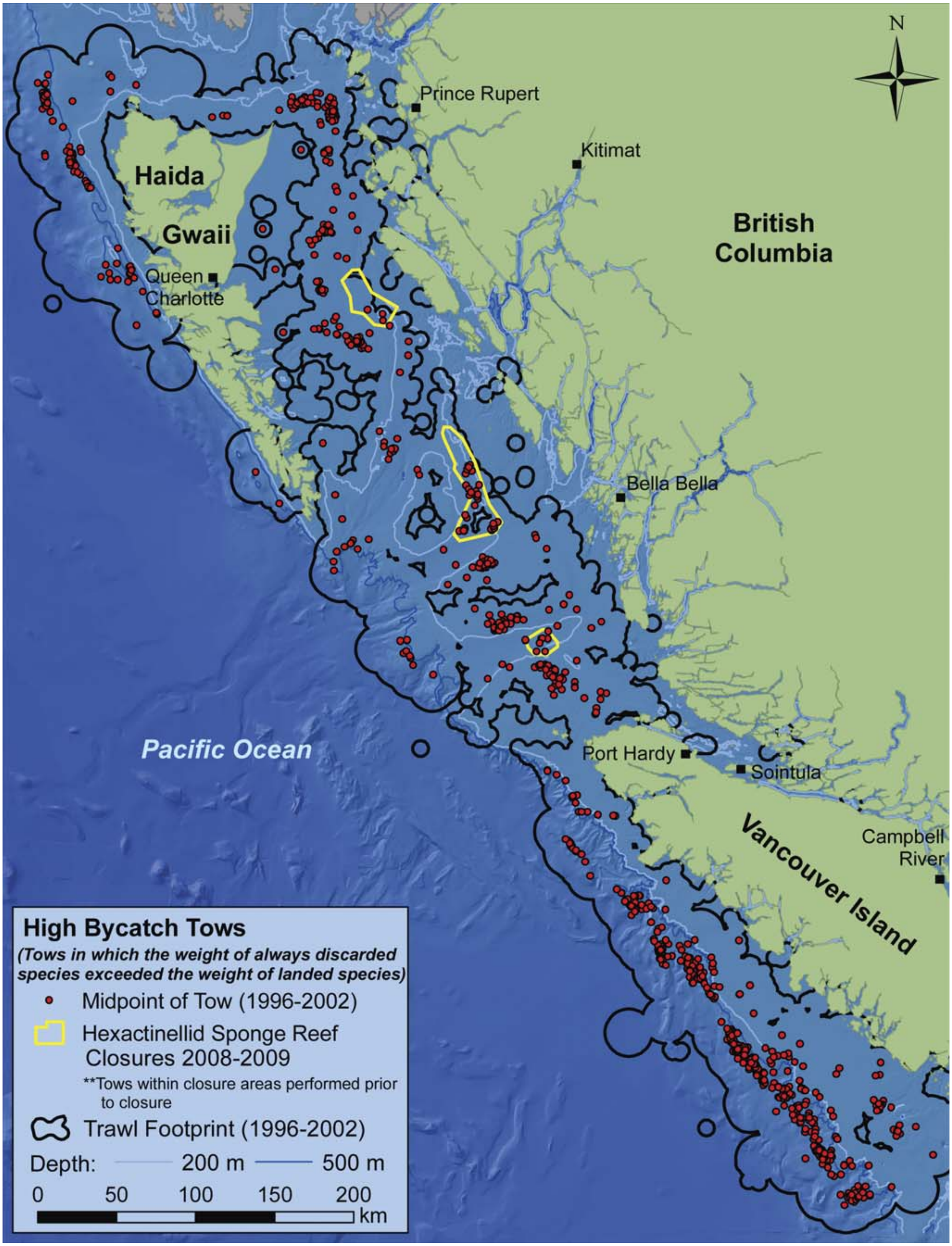

Figure 5 Midpoint locations of tows in which always discarded species biomass outweighed landings, 1996-2002

7. Ecosystem perspectives of Pacific groundfish bottom trawl bycatch

Perspective 1: Disruption of trophic systems

Commercial fisheries have depleted stocks of large predatory fish around the world.[7,20] Numerous studies have shown that the removal of large, predatory species can cause effects that cascade through marine trophic systems.[9,10] When predators are removed from marine ecosystems, prey species are released from predation pressure,[21] competing predatory species are released from competition pressure, and prey species are able to change their behaviour from being predator-averse to being aggressive foragers.[22] These factors have been implicated in historical examples in which large-scale removals of predatory groundfish[23] and sharks,[24] and redistribution of predatory pressure by apex marine mammals[9, 25] have been correlated with sudden population changes in forage and/or competing species and subsequent shifts in entire trophic structures and, ultimately, entire ecosystems. From an EAF perspective, the removal of higher trophic level predatory fish must be understood as having the potential to disrupt marine trophic systems by interrupting top-down control of other species. Thus, as part of EAF, the mean trophic level of a fleet's catch should be monitored in order to detect shifts in species composition.[26]

Complex trophic models are beyond the scope of this work, and the temporal scope of the data does not allow for meaningful analysis of overall shifts in mean trophic level. However, a basic depiction of the trophic levels of the top 31 species that contributed 94% of the Pacific bottom trawl fishery's total bycatch (by mass) shows that the bycatch was dominated by predatory fish, with an average trophic level of 4.08 (Figure 6). This depiction is based upon trophic levels of adult individuals and does not include ontogenetic trophic level variation, which would likely lower the mean trophic level as much of the bycatch was composed of undersized fish.

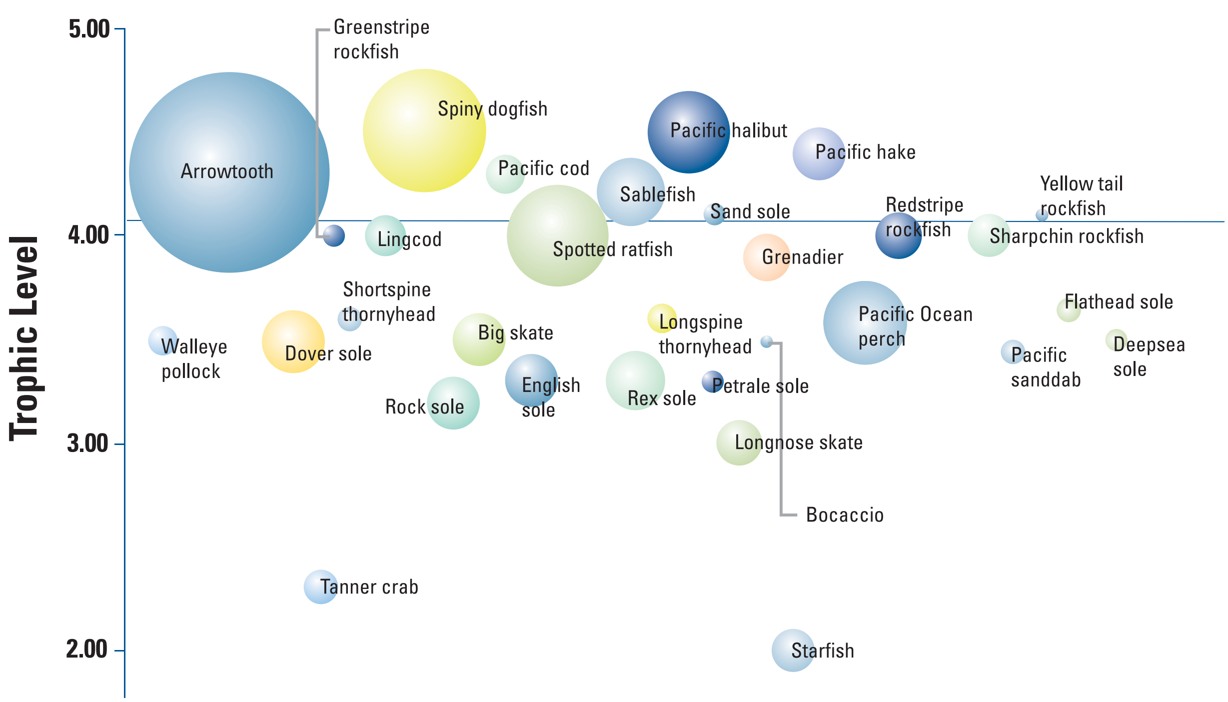

Figure 6 Trophic levels and biomass of the 31 most-discarded bycatch species (by mass) in Pacific bottom trawl fishery, 1996-2006. Circles represent the discarded biomass of each species. The gray line is the mean trophic level (4.08). Mortality rates are not taken into consideration in this figure. Trophic levels derived from Fishbase[26] and the Sea Around Us Project.[27]

Perspective 2: Discards in an unsustainable deep sea fishery

Changes in catch composition and the relationship between landings and discards can indicate shifts in community or population dynamics within an ecosystem.[28] The Pacific deep sea trawl fishery for longspine thornyhead may be an example of changes in an ecosystem being manifested as changes in catch composition.

Longspine thornyhead are medium-sized rockfish that inhabit the deep (500-1,200 meter), non-productive, oxygen-minimum waters of the North American Pacific coast. They are slow-growing, reaching sexual maturity at six years and living for up to 45 years.[29] Longspine thornyhead stay near the ocean floor, and they distribute themselves evenly over soft seafloor habitat.[29] A directed Canadian Pacific longspine thornyhead fishery began in 1996 to take advantage of a Japanese market.[5] Since longspine thornyhead are so widely dispersed in such deep water, the fishery that developed was a bottom trawl fishery characterized by extremely long (7 hour+) tows.[5] Almost as soon as the fishery started, bycatch rates of grenadier, tanner crab, and sub-legal longspine thornyhead began inching closer to total longspine landings. In the first four years discards by weight increased two-fold while longspine thornyhead landings fluctuated up and down (Figure 7). Longspine thornyhead landings reached a peak of more than 850 tonnes in 1999 and then began a steep decline. By 2004, the combined weight of discarded tanner crabs, grenadiers and sub-legal longspine thornyhead matched the weight of longspine thornyhead landings (Figure 7).

The collapse of this fishery could not possibly have come as a surprise. The deep sea ecosystem from which longspine thornyheads are caught is not a biologically productive place, with minimal oxygen concentrations and very little available energy (see Box 4). For this reason, longspine thornyhead have evolved to conserve energy, and thus they are very slow to grow and mature, and they have low reproductive rates. Examples from around the world have shown that deep sea fish with similar life history traits, such as the well-known "orange roughy" (*Hoplostethus atlanticus*), are very vulnerable to fishing pressure.[30] From an EAF perspective, the deep sea is an inherently non-productive place and this precludes the economic and environmental viability of many deep sea fisheries.

Box 4: British Columbia's deep sea ecosystem

By Dr. Scott Wallace, David Suzuki Foundation

The deep sea ecosystem is inherently vulnerable to disturbance. Species in the deep sea have evolved to exist in a unique, low energy, unproductive ecosystem with little natural disturbance and therefore lack the resilience to deal with drastic changes in their environment such as massive biomass removal and habitat damage associated with bottom trawling. As a result, direct linkages of ecosystem impacts to bottom trawling or other disturbances may be more obvious in a deep sea ecosystem than in shallower or near shore environments.

The most common bycatch species in the deep sea longspine thornyhead fishery are tanner crabs, grenadiers and sublegal longspine thornyheads. In Canada's Pacific deep sea ecosystem, tanner crabs are considered a keystone species, as such, a decline or increase in their population would have disproportionate impact on ecosystem function.[31] Tanner crabs are also the most important prey species for adult longspine thornyheads. The two most common grenadier species discarded in the Pacific bottom trawl fishery are the Pacific and giant grenadier. Both species are thought to be 'apex' predators as well as active scavengers.

Tanner crabs and grenadiers are not currently managed by DFO; there are no stock assessments and, thus, no knowledge of the impact of trawling on these species or their ecosystem. Changes in abundance of species with particular ecological importance, such as apex predators and keystone species, would almost certainly have significant impacts on ecosystem functioning.

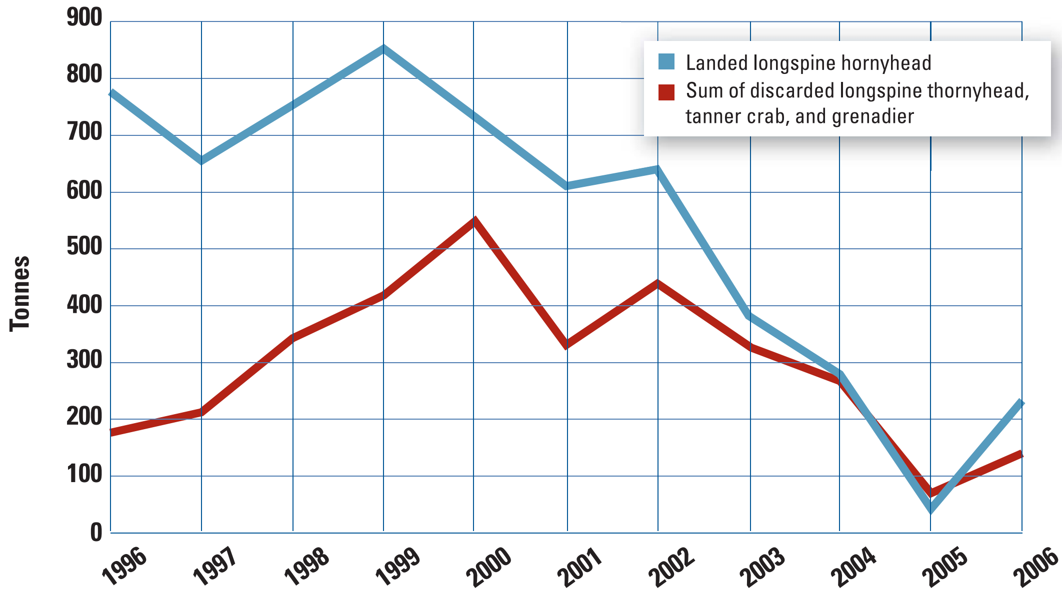

Figure 7 Landings and discards of three key species in the deep sea (>500 m) longspine thornyhead fishery, 1996-2006.

The increased discard rate of other species relative to longspine thornyhead landings is a clear indication that the abundance of legal-sized longspine thornyhead was substantially diminished, relative to the abundances of other key deep sea species, in just a few short years. Very simply, it appears that the fishery took legal-sized longspine thornyhead from the ecosystem at a much faster rate than that at which the ecosystem could replace them. Monitoring bycatch rates of both commercial and non-commercial species is essential for detecting such shifts in community structure.

Perspective 3: Altering species composition

Bottom trawling can alter biodiversity in several ways. Bottom trawl gear may selectively catch certain species more than others. Some species have much higher mortality rates than others when caught by trawl gear and discarded. Finally, bottom trawl bycatch can be a food subsidy for certain species of seabirds, fish, and invertebrates that scavenge in the tracks of trawlers. All of these pressures can selectively favour certain species over others and can thus alter the species composition of an ecosystem.

Two trends noted for the Hecate Strait bycatch hotspot (Figure 4) offer a glimpse at how this may look in practice. From 1996 to 2002, Catch Per Unit Effort (CPUE) of starfish, which are known to scavenge on trawl discards,[15] increased in the Hecate Strait bycatch hotspot at a greater rate than for the entire coast. This implies changes in starfish populations in this localized area. At the same time, CPUE for a potential commercial species, Dungeness crab, showed the opposite trend: it declined substantially in this area over these years, from over 18 kg/tow in 1996 to less than 1 kg/tow in 2002 (Figure 8). This suggests that the factors that were driving the surge in starfish abundance did not have a similar effect on Dungeness crab, which is primarily a predator.[31, 32]

There may be many factors that contributed to these different trends, including variability in local environmental conditions and normal population fluctuations. These trends might even just be noise that would even out in a data set with a broader temporal scope. However, since this small area (38 km^2) is an area of intense trawl activity, with a mean of 397 trawl tows per year during these years (Figure 8), it is certainly possible that the various effects of bottom trawling factored into these opposite CPUE trends.

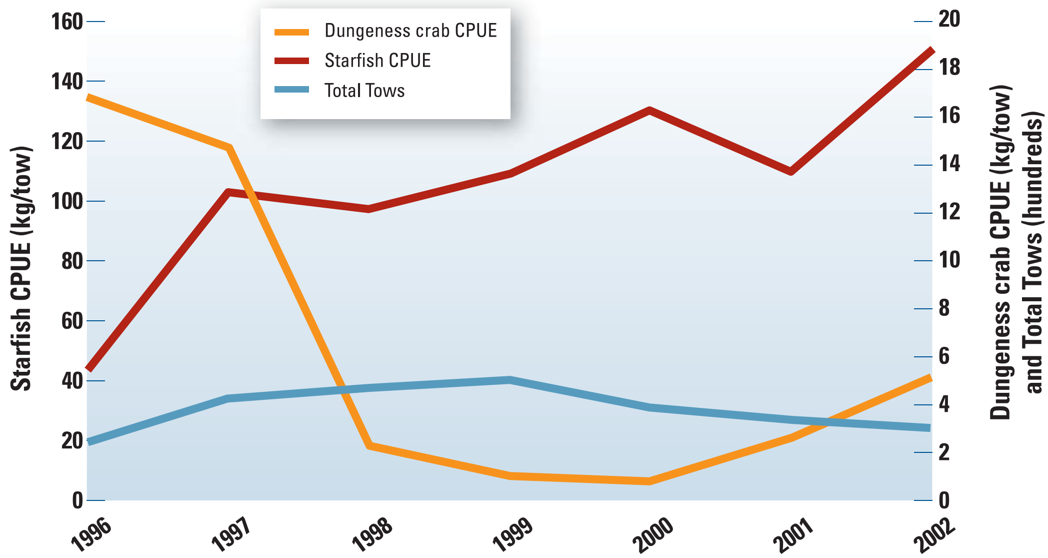

Figure 8 CPUE for discarded starfish and Dungeness crab, and total bottom trawl tows per year, in the Hecate Strait bycatch hotspot

Three of the potential effects of bottom trawling that may have influenced these CPUE trends have to do with bycatch. Starfish may be more resilient than Dungeness crab to the stresses of being caught by bottom trawl gear and discarded at the surface. Starfish biomass in this area of high bottom trawl effort may have increased due to immigration of starfish attracted by the opportunity to scavenge on detritus left over from the bottom trawlers.[15] Third, discarded bycatch biomass in this area may have acted as a food subsidy for starfish, which may have boosted their biomass by increasing the size of individuals and the number of individuals in the population.

Perspective 4: Removal of deep sea biomass

The deep sea is characterized by ecosystems adapted to little natural disturbance, low trophic energy throughput, and minimal oxygen concentrations. Deep sea fish tend to be slow-growing and long-lived, often with slow metabolisms. Thus, the deep sea is an inherently unproductive place, and the organisms that do live there are not adapted to cope with perturbations to their environment. For this reason, fishing activity is believed to cause greater impacts in the deep sea relative to similar activity in shallower waters.

From 1996 to 2002, 12% of all biomass (catch plus bycatch) caught by Pacific bottom trawlers was caught at depths greater than 500 meters (Figure 9). This amounts to over 60,000 tonnes of deep sea biomass that was removed from deep sea ecosystems by bottom trawlers over the course of these six years. If species-specific discard rates derived from non-spatial data (data set 1) are applied to the species caught at depths greater than 500 meters, the result shows that an estimated 8 thousand tonnes of biomass were removed from the deep sea and discarded as non-targeted bycatch from 1996 to 2002. Much if not all of the deep sea fishing effort was directed towards longspine thornyhead, so these deep sea discards are likely another component of this already unsustainable fishery (see Perspective 2).

Bycatch from depths greater than 500 meters should be absolutely minimized, and fishing activity should be managed with the burden placed on the fishing activity to prove that it is neither removing deep sea biomass at unsustainable rates, nor damaging deep sea ecosystems in a way that exceeds the low regenerative capacities of these ecosystems. For these reasons, fishing at depths greater than 500 meters should only occur in very specialized and highly monitored situations.

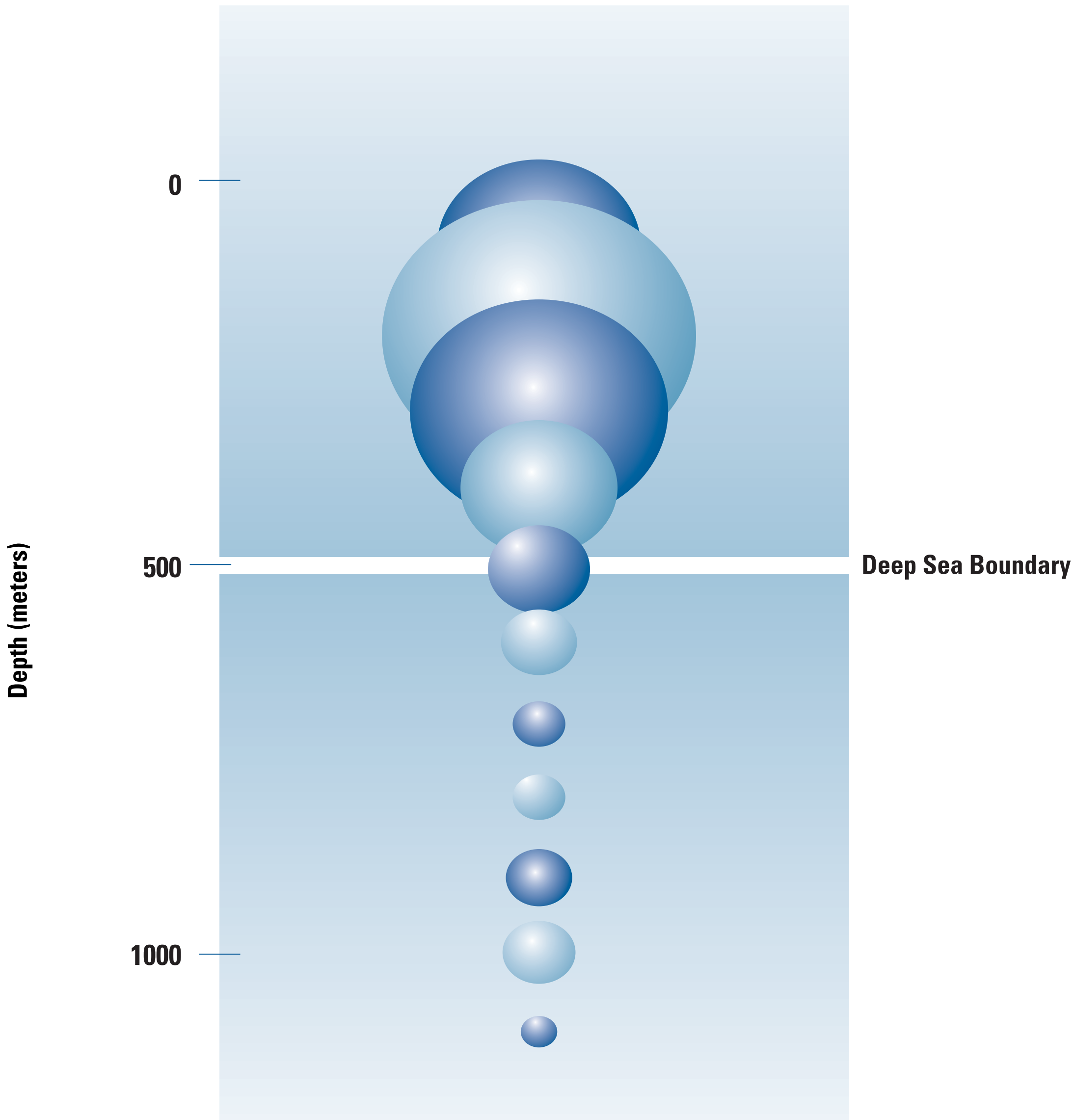

Figure 9 Pacific bottom trawl fishery biomass (catch and bycatch) removal by depth, 1996-2002. Circles represent biomass removed within each 100 meter depth stratum.

Box 5. Is it even worth fishing in the deep sea?

There are 61 species in the data that we identified as ***deep sea species*** (for these species, >95% of catch was caught at depths >500 m). Two of these 61 deep sea species were of marginal economic value (grenadier and deepsea sole), and only one (longspine thornyhead) can be considered economically valuable. Thus, 58 of the 61 deep sea species have no commercial value and are considered to be bycatch (Figure 10). These species are thrown back overboard, often dead or dying. If there were no bottom trawling in Canada's Pacific waters at these depths, these 58 species would virtually never be caught as bycatch.

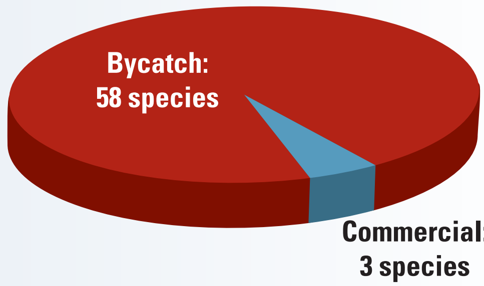

Figure 10. End use of deep sea species (species with >95% catch taken from >500 m).

In contrast, the vast majority of the commercially important species caught in the Pacific bottom trawl fishery are caught in shallower waters (Table 2). This shows that the Pacific bottom trawl fleet does not need to access the deep sea in order to pursue the most important commercial species. When they do fish in the deep sea, they catch and discard many species that would otherwise never encounter fishing gear. Thus, by not fishing below 500 m, the fleet could virtually eliminate their bycatch of many species without affecting their landings of most commercial species.

Table 2 Proportion of commercially important Pacific bottom trawl-caught groundfish species caught in deep sea, 1996-2002

Commercial species	*% bottom trawl landings caught at depths >500 m, 1996-2002*
Arrowtooth flounder	8%
Pacific ocean perch	1%
Dover sole	38%
Yellowmouth rockfish	< 1%
Yellowtail rockfish	< 1%
Lingcod	< 1%
Rock sole	< 1%
Silvergray rockfish	< 1%
Redstripe rockfish	< 1%
English sole	< 1%
Pacific cod	< 1%
Spiny dogfish	< 1%
Longspine thornyhead	> 99%
Shortspine thornyhead	79%
Sablefish	47%
Canary rockfish	< 1%
Rougheye rockfish	36%
Petrale sole	11%

8. Conclusions

Groundfish management in Canada's Pacific has taken significant steps forward over the past several years. With 100% observer coverage and Individual Vessel Quotas (IVQs) for all commercial species, fishermen are now much more accountable for the commercial species that they catch, when compared with years past. However, these steps forward still only address those commercial species that are managed and regularly assessed. In order for the Government of Canada to truly move ahead with their commitments to an ecosystem approach to managing fisheries, fisheries need to be managed for their effects on non-commercial species.

9. Recommendations

To move towards meeting its commitments to the ecosystem approach, Living Oceans Society recommends that DFO:

1 *Establish a moratorium on the directed fishery for longspine thornyhead, until an ecosystem-based management plan and a stock assessment are completed*

The deep sea bottom trawl fishery is inherently unsustainable for many reasons. The targeted species has shown that it likely cannot support even moderate fishing pressure. This is apparent in DFO's own science and it was most recently demonstrated by the decision to list longspine thornyhead as a "species of special concern" under the Species At Risk Act (SARA) – the only fish species listed under SARA to have recently been the target of a directed fishery. Furthermore, there is the issue of the use of appropriate gear: bottom trawl gear tends to be unselective and it is not well suited for fisheries that target single demersal species that do not aggregate. However, this is exactly the case with the fishery for longspine thornyhead: bottom trawl gear is used to target one species, individuals of which are widely distributed over the seafloor. This results in the bycatch of dozens of non-commercial species – many of which would never otherwise be directly affected by commercial fishing. Finally, the longspine thornyhead fishery may alter already energy-poor deep sea food webs by removing biomass, and it may further disrupt deep sea ecosystems by altering species diversity via bycatch of unwanted species.

Thus, we request that an immediate moratorium be placed on longspine thornyhead landings until an ecosystem-based management plan can be developed for this species. By placing a moratorium on landings of longspine thornyhead, Canada will, in one single motion:

- Reduce 95% of the bycatch for approximately 60 marine species,
- Discourage any remaining economic reliance upon a species that does not appear to be a sustainable target for commercial fisheries, and
- Ensure that deep sea ecosystems are not impacted by fishing gear.

2 *Build upon recent policy work to develop a Bycatch Policy that takes into consideration all species, including those that do not have commercial value, and that takes into consideration the ecosystem roles played by such species.*

DFO has made strides with the recent development of key fisheries policies, such as the sensitive benthic area policy. A policy to manage commercial fishing's impacts on non-commercial bycatch species will be a logical next step in the process of implementing Canada's commitments to an ecosystem approach to fisheries management. This policy must take into account the role of non-commercial species in marine ecosystems.

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