HOW SUSTAINABLE ARE ELASMOBRANCH CATCHES IN CANADIAN PACIFIC COMMERCIAL FISHERIES?

By

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Abstract

Few elasmobranchs are subject to directed commercial fisheries in Canada, but some are incidentally caught in fisheries targeting teleosts (DFO, 2007). Here I estimate the interception of elasmobranchs within Canadian Pacific commercial fisheries over the last 30 years (1980-2013) through a critical review of fisheries management and analysis of DFO catch statistics. A total of 208,642 tonnes of elasmobranches was recorded, with 93% of weight comprised of the commercially valued elasmobranchs: Spotted Spiny Dogfish, Big Skate, and Longnose Skate. Catch retention changed little over the last 30 years, with an average of three-quarters of the catch being retained. 1,824,792 individual elasmobranchs were annually intercepted within the past decade (2003-2013). In this past decade there has been a steep decline in elasmobranch catch. This is unlikely to be due to unsustainable fishing of declining populations. Instead, declining market demand and improved management has contributed to the emergence of sustainable elasmobranch fisheries.

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Introduction

A key challenge for fisheries is to ensure that all catch is managed and harvested sustainably by 2020 (Convention on Biological Diversity, 2014). This challenge is particularly pressing for those species with slower, less resilient, life histories that are intercepted (caught, and either landed for value or released at sea) alongside target species. One such group, chondrichthyans (sharks, skates, rays, and chimaeras), make up between one and two percent of total global marine fisheries landings since 1950 (Worm et al., 2013). Sharks initially made up over half of the catch, but since the 1970s skates and rays have dominated the landed catch (Dulvy et al., 2014). Global demand for elasmobranch (sharks, skates, and rays) products, particularly fins, since the 1980s has resulted in increased exploitation rates that have led to overfishing at the global scale (Vannuccini, 1999). This increase in fishing intensity combined with intrinsic life characteristics of elasmobranchs (late maturity, slow growth, and low fecundity) have led to concern of drastic declines in biomass worldwide. Indeed, fisheries interactions are often listed as the primary threat to the conservation and survival of elasmobranchs (Dulvy et al., 2008; Worm et al., 2013). Global awareness in the plight of elasmobranch populations and the subsequent need for their conservation and protection has increased significantly in the past two decades.

Global landings of fisheries catch have been reported each year to the Food and Agricultural Organization (FAO) (Worm et al., 2013). It is estimated that 63 to 273 million sharks are killed annually in global fisheries, based on data from the FAO (Worm et al., 2013). Similarly, a fisheries-independent study estimated that 26 to 73 million sharks, or between 1.21 and 2.29 million metric tons, were traded annually; at the time, this amount was three to four

times higher than shark catch records reported in the FAO database (Clarke et al., 2006). While the degree to which catch data reflects population trajectories can be debated, it is often the best source of information to work from and may provide a reasonable indicator of population trajectory for less valuable as well as less managed species (Froese, Zeller, Kleisner, & Pauly, 2012; Newton, Côté, Pilling, Jennings, & Dulvy, 2007; Worm et al., 2013). What is clear is that the median biomass of 112 shark and ray fisheries declined by between 81% and 89% by 2009 (Costello, Ovando, Hilborn, Gaines & Deschenes, 2012) and that one-quarter of the world's sharks and rays were threatened with an elevated risk of extinction (Dulvy et al., 2014).

There are 26 elasmobranchs that are known to use Canadian Pacific waters (Figure 1), composed of 14 shark, 11 skate, and one ray species (Table 1; McFarlane, McPhie, & King, 2010). In addition, there is one chimaera species known in Canadian Pacific waters, the Spotted Ratfish (*Hydrolagus colliei*), which was not included in this study. While studies have been conducted to understand extent of elasmobranch catch in global fisheries (Clarke et al., 2006; Worm et al., 2013), little emphasis has been put at the regional level in Canadian Pacific waters. The following paragraphs highlight the conservation status of elasmobranchs in Canadian pacific waters, provide an overview of fisheries management particularly as it relates to elasmobranch species within Canadian Pacific waters, and outlines the research objectives of this study.

Conservation Status of Elasmobranchs in Canadian Pacific Waters

There are a number of methods used to determine the threatened or conservation status of flora and fauna. The International Union for Conservation of Nature (IUCN) Red List is well known as the international authority for evaluating the conservation status of flora and fauna (Butchart et al., 2004). The IUCN Red List uses quantitative criteria to assign species to one of

the seven categories of relative extinction risk ranging from Least Concern to Extinct (or, to Data Deficient for those species that are poorly known) (Figure 2; IUCN 2012; Bubb et al., 2009). One-quarter of chondrichthyans are threatened globally as per IUCN Red List criteria, largely due to overfishing (Dulvy et al., 2014).

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was established in 1977 to determine extinction risk of species within Canada (COSEWIC, 2011a). COSEWIC uses quantitative criteria consistent with IUCN to determine the status of assessed species (Figure 3), based on population size, rate of decline, and area of distribution; however, it includes an additional element to determine the extent of population within Canada. In 2003, Canada's *Species at Risk Act* (SARA) came into effect, providing legal protection for species listed under the Act (Government of Canada, 2014).

Under SARA, COSEWIC is responsible for providing its recommendation to the Government of Canada for consideration of legal protection under SARA. The Act has three purposes: (1) to prevent species from becoming extirpated or extinct, (2) to recover those species that are Extirpated, Endangered or Threatened; and (3) to manage species of Special Concern to prevent them from becoming further threatened (Species at Risk Act, 2002). The Government of Canada considers the socioeconomic costs and benefits in addition to scientific analysis in its decision whether to list (or not) a species under SARA, contrary to the process followed by the IUCN Red List and COSEWIC.

Commercial fisheries in Canada must adhere to requirements under all relevant legislation, most notably the *Fisheries Act,* SARA, and the *Oceans Act*. A key threat for many SARA-listed marine species is interactions with fisheries, including directed and non-directed

catch, vessel strikes and entanglement. To date, no commercially valued species in Canadian Pacific waters have been listed under SARA; in fact, socioeconomic considerations for commercial exploitation was listed as the rationale to not list under SARA in almost 60% of marine fishes (Schultz, Darling & Côté, 2013). Nonetheless, measures have been taken over the past 30 years to improve the management of elasmobranchs incidentally captured in commercial fisheries (Figure 4).

Overview of Fisheries Management within Canadian Pacific Waters

The bulk of fisheries management effort in Canadian Pacific waters focuses on salmon species and the groundfish fishery. Over the past century, 12 species comprised up to 90% of the total catch in Canadian Pacific waters, including: five species of salmon – Sockeye (*Oncorhynchus nerka*), Pink (*Oncorhynchus gorchuscha*), Chum (*Oncorhynchus keta*), Chinook (*Oncorhynchus tshawytscha*), and Coho (*Oncorhynchus kisutch*), as well as groundfish species – Halibut (*Hippoglossus stenolepis*), rockfish species (Sebastes spp.), Pacific Herring (*Clupea pallasii pallasii*), and Spotted Spiny Dogfish (*Squalus suckleyi*) (Beamish, Benson, Sweeting, & Neville, 2004). Catch statistics have been collected since the early 1900s; with reliable statistical reporting established in 1951 though these infrequently identified sharks at the species level (Fisheries and Oceans Canada (DFO), 2012a). While this system accounted for the quantity of the catch, value, and species, it did not account for the quantity of species released at sea or compliance (adherence to the fishery licence) issues. To address this issue, the groundfish fisheries introduced at-sea observers in the late 1980s, compulsory dockside monitoring by 1994, and 100% at-sea coverage implemented for the groundfish trawl fleet by 1996 (DFO, 2012a). The other fisheries in BC do not follow this rigorous approach, but use at-sea observers and

dockside monitors periodically. The extent of monitoring requirements varies per fishery, based on the fleet size and location.

The groundfish trawl fleet targets species such as Pacific Cod (*Gadus macrocephalus*), Pacific Ocean Perch (*Sebastes alutus*), other rockfishes, and Pacific Hake (*Merluccius productus*). This sector is a key source of incidental elasmobranch catch. This sector expanded in the early 1980s, and by 1999 total catches of groundfish had increased four-fold (Beamish et al., 2004). By 1994, the value of groundfish landings exceeded that of Pacific salmon for the first time (Gough, 2007). This trend of increasing value for the groundfish fisheries continued into the 2000s.

DFO introduced Integrated Fisheries Management Plans (IFMPs) in 1995 that provide the framework for the conservation, management, and sustainable use of fisheries resources (DFO, 2010a). The IFMPs were further improved over the years, and by 2012 included new emerging issues such as climate change, aquatic invasive species, marine protected areas, species at risk, as well as components of the Sustainable Fisheries Framework. In 2009, DFO produced its Sustainable Fisheries Framework, which was advanced in 2013 with a policy on managing bycatch (DFO, 2013a). Bycatch is defined as the non-targeted catch which may either be retained for sale or that which is discarded or released at sea, depending on the species and situation (FAO, 1997); it is used interchangeably with the term ‘incidental’ in this study.

In 1997, the groundfish fleet moved to an individual vessel quotas (IVQ) system, intended to allocate all groundfish species subject to TAC (DFO, 2014). In the IVQ system, each groundfish trawl licence holder received two initial IVQ allocations (one for White Hake, and one for all other groundfish species), which are expressed as a percentage applied to each

species-specific TAC to produce the relevant IVQ allocations. These allocations are reviewed annually prior to the fishery opening, with consideration for adjustment to TAC as well as allocation for research purposes, before determining the amount of fish that a vessel may fish during the given season. In addition, the groundfish fleet moved to a co-management regime, with industry paying for at-sea and dockside monitoring through third-party observers. Third-party observers support compliance with licence conditions, including reporting requirements for directed and non-directed catch, a well as biological sampling in support of stock assessments for commercially exploited species. Improvements had been made to improve selectivity of the fleets by the late 1990s; nonetheless fisheries openings dropped by the late 1990s, largely driven by the precautionary approach.

A key issue in the analysis and understanding of catch data is that DFO has internal guidelines for the release of fishery data, referred to as a "3 party rule", to meet requirements of the *Access to Information Act*; however, these guidelines are not publicly available (K. Rutherford, personal communication, March 19, 2014). The intent of these guidelines are to protect information that may be confidential, which can include fisheries data should it be traceable to an individual vessel or trip. Thus, DFO does not publicly share detailed catch data where less than three fishing vessels were within an area for the given period that the fishing trip occurred. This includes restrictions on actual catch landed on an individual licence, aggregated catch data if it does not meet the "3 party rule", detailed fishing location, or Aboriginal fisheries catch effort.

Evolving Management of Elasmobranch Catch in Canadian Pacific Waters

Chondrichthyan landings rose steeply from the 1950s through the late 1990s, after which they declined somewhat. Possibly due to the many changes to fisheries management that occurred in the 1990s, within Canada and globally (Godin & Worm, 2010; Worm et al., 2013). In 1995, 80 countries (including Canada) adopted the Food and Agricultural Organization of the United Nations (FAO) Code of Conduct for Responsible Fisheries (DFO, 2007). This motivated a shift towards the sustainable use of aquatic systems, and recommended the adoption of measures to minimize catch of non-target species, waste, and discards. In 1996, the FAO released technical guidelines for applying the precautionary approach to fisheries (FAO, 1996).

There were no specific restrictions on the interception of sharks, skates or rays in Canadian fisheries prior to June 1994, when shark finning (removing the fins and discarding the remains at sea) was banned in Canadian waters (DFO, 2007). However, commercial interest in these species grew in the 1990s as other fisheries such as groundfish declined. Consequently, Canada's National Plan of Action for the Conservation and Management of Sharks was published in 2007, which provides an overview of sharks in Canadian waters, identifies priorities, and outlines measures to monitor, assess, and manage these populations.

The 2014/15 TAC is partitioned by geographic areas and sectors for each of the three commercially valued elasmobranch species in Canadian Pacific waters (Table 2). For Spotted Spiny Dogfish, there is a total TAC of 14,000 tonnes across all sectors and areas; within groundfish management area 4B (inside waters), the TAC is set at 2,000 tonnes, and 12,000 tonnes for the remainder of Canadian Pacific waters. For Big Skate (*Raja binoculata*), the TAC is set at 567 tonnes within groundfish management area 5C/D (Hecate Strait) exclusively. For

Longnose Skate (*Raja rhina*), the TAC is set at 47 tonnes within groundfish management area 5C/D exclusively.

Research Objectives and Questions

The ultimate goal of this research study is to develop an understanding of the extent and pattern of interception of elasmobranchs within commercial fisheries over the past three decades within Canadian Pacific waters. This small, regional focus of comparably well-managed and documented fisheries could shed the light on the extent to which interception within commercial fisheries may threaten elasmobranchs in Canadian Pacific waters.

Research objectives. The first research objective is to conduct a critical review of fisheries within Canadian Pacific waters over the period of 1980-2013 (herein referred to as the past 30 years), with the intent of understanding trends within these fisheries and relationship with shark and skate populations. The second research objective is to determine whether patterns exist within the catch data to suggest whether there are trends in that have changed over time with respect to species composition, gear types or areas of interception. This would include reviewing available commercial catch statistics for directed, non-directed, and incidental catch within commercial fisheries. The third objective is to estimate the number of elasmobranch individuals by species intercepted within the commercial fisheries, annually and cumulatively over the last 30 years.

Research questions. This study proposes to answer the following question: “what are the patterns of interception of elasmobranchs within commercial fisheries in Canadian Pacific waters, and has this interception changed over the past 30 years with respect to species composition, gear types or geographic areas?” The study will explore a hypothesis of “ the

patterns of interceptions of elasmobranchs within commercial fisheries in Canadian Pacific waters have not changed over the past 30 years". Seven sub-questions are put forward to support this overarching question:

- Has the proportion of fishing trip records where data were withheld ("three-party rule") changed over time?
- Has the pattern of weight retained and released changed over the time period?
- Has the elasmobranch catch composition changed over the time?
- How many elasmobranchs were intercepted in commercial fisheries over the time period?
- Has the proportion of weight changed over the time period by fishing sectors?
- How has the pattern of location of catch changed over time?
- Where is the catch of threatened species most prevalent?

Methods

First, I undertook a critical review of fisheries management in Canadian Pacific waters particularly as it relates to elasmobranchs (Figure 4). Then I describe the sourcing, standardization, and analysis of the fisheries catch landings statistics.

Literature Review and Critical Analysis of Commercial Fisheries in Study Area

I reviewed both peer-reviewed and grey literature on elasmobranchs in Canadian Pacific waters, fisheries management efforts over the past 30 years, as well as general studies on elasmobranchs globally. This included a review of the fisheries sectors within Canadian Pacific waters, gears used, records that were available as well as whether there are management efforts for elasmobranchs within the fleet (Table 3). The list of study species was determined from

Distribution and life history parameters of elasmobranchs in British Columbia waters (McFarlane, McPhie, & King, 2010).

Data Collection and Standardization

A request was submitted to DFO Catch Statistics for all DFO commercial fisheries data from 1980 to present of all sharks, skates and rays within Canadian Pacific waters, including all records of all species listed in Table 1 (as well as general terms such as "shark", "skate", "mud shark", "school shark"). It was assumed that catch data will vary per fishery, and that the majority of interactions occur within Groundfish fisheries (DFO, 2012b). Note that the reliability of this data is assumed to vary amongst the fisheries, as a result of the extent of third body observation and ability of individuals to best estimate the weights and properly identify species. The extent of reliability of the data was not considered in the analysis. It was also assumed that all data for elasmobranchs released at sea (discarded) are conservative estimates (K. Rutherford, personal communication, March 19, 2014). It is to be noted that recreational and Aboriginal fisheries are beyond the scope of this study.

Data were received from different DFO staff in batches, with some data taking as long as six months to receive from the original request date. In total, 8 datasets with a total of 9,842 records were received with data for the various sectors with year, species, weight (retained, or landed, weight; weight released at sea; as well as the total weight representing the retained and released weight), area where species was caught, as well as whether data were withheld subject to DFO's "3 party rule" (Table 4).

An additional request was made for logbook data (information submitted to DFO by fishers about their catch and effort), and results of elasmobranch catch that were returned for the

commercial Albacore Tuna (1988-2013), Salmon (2011-2013), and Sardine (2001-2013) fisheries. No other elasmobranch records were found in logbooks from other fisheries. Due to the lateness of receiving this information, the data from these logbooks are captured only in the narrative in the Results section, rather than in the systematic analysis.

The requirements under the "3 party rule" resulted in weight or value data being withheld where three or less vessels were within a given area. As a result, an additional request was submitted for the data to be provided as aggregated catch data that contained the full weight per species, year, and sector. Seven new datasets were provided with the area and gear types removed, and the records aggregated to species and sector by year so as to ensure the request was not subject to the "3 party rule" (Table 5). This allowed for the total weight be obtained for elasmobranch catch for the past 30 years.

The data from the 15 separate datasets were standardized to ensure consistent spelling and definitions of geographic areas and species; codes for species, gear types, and geographic areas; and units of weight (e.g., kilograms, pounds, and various counts). Areas were all standardized to the Pacific Fisheries Management Area (PFMA) structure as it is now the standard within the Pacific region, with description of these areas provided in the *Pacific Fisheries Management Area Regulations, 2007* (DFO, 2014b). The PFMAs were regrouped into larger geographic areas so they could be easily viewed in map format (Figure 1). Weight was summarized as retained (landed), released (at sea), and total catch (in kilograms as well as in tonnes). Subsequently, I merged the datasets into two master dataframes: one where data were withheld (which provides the area and gear types), and one where I had the full weight (but not area or gear type).

Data Analysis

The data were analyzed to identify trends of elasmobranchs intercepted in commercial fisheries within Canadian Pacific waters over the past 30 years. An overview of the total catch (in tonnes) was provided by summarizing the data by retained and released catch per year for the past 30 years. For this, the data were summarized by year and species to show trends over the time period of the proportion of catch that was retained and released, the species composition, geographic areas of interception, and conservation status levels.

To determine proportion of data withheld, I created a new dataset for the years 1996-2013 (when the "3 party rule" was in effect) and created a new column that captured whether data were, or were not, withheld. I reviewed the data in this manner to examine patterns in the application of data withheld (the 3-party rule) by species, area, and gear type.

The number of individual elasmobranchs intercepted within commercial fisheries was calculated by dividing the catch biomass of each species by the average individual species weight, and rounding up to provide a whole number, which followed the approach taken in the study by Worm et al. (2013). Average weights and discard mortality rates were sought for the 26 species. As a result, this study looks at the number of individuals intercepted, rather than killed, and assumes some survival of individuals released at sea.

Results

Has the Proportion of Fishing Trip Records where Data were Withheld ("three-party rule") Changed Over Time?

Since 1996, the "three-party rule" policy (the rule) was applied to 9.2% of commercial fishing trip records, the majority of which were commercially valued elasmobranch species

fished on line or trawl gears (Figure 5). The proportion of records subject to the rule does not appear to have changed over time. The rule was applied to 23.2% of the data by total weight from 1996-2013, by comparing the data subject to the rule against the full weight information provided with the area and gear criteria removed (Table 6). The following paragraphs describe the application of this rule across species, geographic areas, and gear types.

The rule was applied most frequently to fishing trips that record one of the three commercial species (Spotted Spiny Dogfish, Big Skate, and Longnose Skate). These three species make up 85.6% of the fishing trips where data were withheld (Table 7). It is most frequently applied to Spotted Spiny Dogfish, and initially applied infrequently to Longnose Skate and Big Skate records until 2005, whereupon the application of the rule to these increasingly valued species increased slightly. The rule minimally applied to the “other” species.

The rule was applied mostly (98.6%) to fishing trip records using line or trawl gears (Table 8). This may suggest that gear types influence the rule, which could be a reflection of the scale and/or remoteness of the fleet. The rule was applied relatively consistently for line gears through the years. The rule was applied infrequently for the trawl gears throughout 1996-2013, with a slight increase in 2007.

The application of the rule varied geographically, particularly in the Central Coast region, which had the highest proportion of trips subject to the rule with one quarter of records with data withheld (Table 9). The rule was also often applied within East Coast Vancouver Island (ECVI, or inside waters) and Haida Gwaii and it was not applied to a small percentage of records within the other areas. The proportion of the application of rule has changed little among geographic

areas over time, with the exception of more frequent application since 2006 throughout WCVI, Hecate Strait, ECVI (inside waters), and Central Coast.

Has the Pattern of Weight Retained and Released Changed Over the Time Period?

Over the past 30 years, 208,642.5 tonnes of elasmobranchs were recorded in commercial fleets within Canadian Pacific waters (Table 10, Figure 6). Three-quarters of catch was retained (landed for sale), while one-quarter was released at sea. Greater catch was released at sea than retained in only two years – 1982 and 1993. This is not surprising, as the bulk of the weight retained is comprised of commercially exploited species. Total catch rose peaking 2003 followed by a steady decline in recorded catch through to 2013 (Figure 6). The retained catch for the past 30 years follows the bimodal pattern shown in total catch, whereas the total released catch appears to have less variability throughout the years. The catch prior to 1995 made up 43.5% of the total catch, and the catch from 1996 onwards made up 56.5% of the total catch (Table 11). Similarly, the composition of retained catch and released catch was consistent in both periods. This suggests that the improvements to fisheries management in the mid-1990s did not influence overall catch by increased records; however, it did influence species identification.

There has been a steep decline in elasmobranch catch (in tonnes) over the period of 2003-2013 (herein referred to as the past decade) (Figure 7). The smoothed line of the linear regression model shows catch increased from 1980 through to 1989, stabilized through to 1997, increased through to 2000, stabilized to 2002, and then steeply declined within the past decade. Of importance, this model shows an 80% decline in total catch of elasmobranchs over the last 10 years, from 9,934.2 tonnes in 2003 to 1,974.7 tonnes in 2013.

Has the Elasmobranch Catch Composition Changed Over the Time?

The proportion of total catch (in tonnes) followed a bimodal pattern over the past 30 years with a noticeably steep decline within the last decade. Most elasmobranch catches (93.1%) were of commercially valued species (Table 12, Figure 8). Identification at the species level increased in the mid-1990s. Apart from the commercial species, Spotted Spiny Dogfish, Big Skate, Longnose Skate, and unidentified skate, the "other" species comprise only 0.4% of the total weight.

Spotted Spiny Dogfish comprise the bulk (80.2%) of the elasmobranch catch over time; however, the total weight per year has varied with an apparent bimodal pattern occurring (Figure 8). "Unidentified skate" was recorded in low numbers but consistently from 1980 through to 1996, with fewer records from 1997-2002, and then very few records after 2002. Big Skate was not documented in catch records at the species level until 1994, and was subsequently documented in low numbers within the records from 1997 through to 2013. Longnose Skate catch was first recorded in 1994, and has been documented consistently since 1996. Other shark and skate species have been recorded throughout the past 30 years; however, the bulk of the weight has been recorded from 1996 onwards, with an increase in recorded weight from 1996 through to a peak in 2004, followed by a decline in weight captured through to 2008, and a relatively stable record through to 2013. Of the "Other" category, the bulk of the weight it composed of three species: Sandpaper Skate (*Bathyraja interrupta*), Roughtail Skate (*Bathyraja trachura*), and Pacific Sleeper Shark (*Somniosus pacificus*).

The bulk of the catch (93.1%) is taken by commercially valuable species (Spotted Spiny Dogfish, Big Skate, and Longnose Skate), which are managed fisheries (Figure 9, Table 13). The

managed catch experienced the same bimodal pattern described earlier, a result of the Spotted Spiny Dogfish catch. The non-directed catch has maintained a relatively constant level over the past 30 years. “Unidentified skate” is captured in the non-directed category, which would make up much of the catch in this category prior to 1996.

How Many Elasmobranchs Were Intercepted in Commercial Fisheries Over the Time Period?

An estimated 69,720,987 elasmobranchs were intercepted over the past 30 years, with 88.9% of these being sharks with skates comprising the remainder (Table 14). Spotted Spiny Dogfish made up over 99.9% of the number of sharks intercepted, and 95.7% of the skates and rays intercepted were Big Skate, Longnose Skate, and unidentified skate. Published discard mortality rates were only found for 13 of the 26 species (including only 3 of the 14 skate and ray species), representing 11.2% of the catch released at sea within the past 30 years.

The catch pattern in the most recent decade is similar; over the last decade an estimated 1,824,792 individual elasmobranchs were intercepted annually, with 86.6% of these being sharks (Table 15). Similarly, the majority of the catch in individuals is comprised of the commercially exploited elasmobranch species. Spotted Spiny Dogfish made up 99.9% of the number of sharks intercepted, with an estimated 1,835 other sharks being intercepted each year. Big and Longnose Skates represented 85.8% of the skates and rays intercepted, with an estimated 36,524 other skates and rays being intercepted each year.

Has the Proportion of Weight Changed Over the Time Period by Fishing Sectors?

The bulk of the elasmobranch catch (95.4%) was recorded from three groundfish fleets (Groundfish Trawl, Spotted Spiny Dogfish, and Groundfish Line sectors), with much of the

remainder of the catch recorded in the salmon and shellfish fleets. The proportion of weight has changed over the time period for the various fishing sectors (Figure 10, Table 16). Most (57.5%) of the catch recorded is from the Groundfish Trawl sector and this catch peaked in 1988, declining in 1993, remaining relatively stable through to 2001, after which it declined steeply through to 2013. The bulk of catch within the Groundfish Trawl fleet is Spotted Spiny Dogfish. Nonetheless, the majority of Big Skate, Longnose Skate catch, and "other" species catch are recorded within the Groundfish Trawl fleet. Data for unknown sectors within Fish Slips were provided from 1982-2004, and the bulk of the catch recorded was Spotted Spiny Dogfish.

The Spotted Spiny Dogfish fleet represented 23.5% of the catch by weight (Figure 10, Table 16). The Spotted Spiny Dogfish sector started recording catch in 1996, rose to a peak in 2003, followed by a general decline through to 2013. The bulk of the elasmobranch catch within the Spotted Spiny Dogfish fleet is, unsurprisingly, Spotted Spiny Dogfish. There was some catch in 1996 recorded as "unidentified skate", as well as minimal levels of Big Skate and Longnose Skate recorded.

The Groundfish Line records were provided for the years 1995-2013, and make up 4.6% of the overall catch by weight (Figure 10, Table 16). Throughout this period, the catch per year remained relatively stable. The bulk of the catch is Spotted Spiny Dogfish, followed by Longnose Skate, Big Skate, Unidentified skate, and minimal catch of "Other" species.

The salmon and shellfish fleets recorded very little elasmobranch catch in comparison to the other four categories described above. Records for the Salmon fleet represents 0.1% of the elasmobranch catch by weight, and includes recorded catch in Fish Slips from 1982 through to 2000. Bycatch data from the salmon fleet are provided voluntarily in fishing trip logbooks, with

minimal observer coverage to confirm the numbers provided. The Shellfish sector recorded 0.01% of the catch by weight; shown in Fish Slip data. There were no records of elasmobranch catch in Pacific Herring or smelt (*Osmeridai* spp.) fisheries, as shown in Table 3.

The following information provides a review of commercial salmon, tuna, and sardine fisheries logbook records, which are not included in plots and overall catch data, as the information was provided after analysis was completed. No catch records of elasmobranchs were found in commercial shellfish, Herring or smelt logbooks (L. Biagini, personal communication, May 2, 2014).

Commercial Salmon Fisheries logbook records were available from 2002-2013, but records were only provided for 2011-2013 at the time of writing. These records showed 4,591 elasmobranchs were intercepted during this period, mostly of Spotted Spiny Dogfish (98.9%) with most being released at sea (Table 17). This equates to 14.5 tonnes of recorded elasmobranch catch, based on average weight per the species given (Table 14).

Commercial Albacore Tuna fisheries logbook records were provided for the years 1998-2013, with 33 records of sharks (Table 18). The majority of these sharks were retained, and most were Bigeye Thresher Sharks (*Alopias superciliosus*). It is estimated that this represents 2.33 tonnes of elasmobranchs were recorded within the Tuna fleet for this period. Logbook data were available from 1988 onwards; however, no elasmobranchs were recorded until 1998.

Commercial Sardine fisheries logbook records were provided for the years 2001-2012, as there was no sardine fishery in 2013 (Table 19). In total, the sardine fleet caught 23.6 tonnes of elasmobranchs within the period of 2001-2012, comprising mainly (99.4%) Spotted Spiny Dogfish.

How has the Pattern of Location of Catch Changed Over Time?

Elasmobranchs are intercepted in commercial fisheries throughout Canadian Pacific waters (Figure 1, Figure 11). The bulk of the elasmobranch catch (49%) is being intercepted within the southern waters around Vancouver Island; with decreasing amounts of catch being caught the further north the geographic area (Table 20).

The number of records of fishing trips that intercepted elasmobranchs on the WCVI increased over the past 30 years, peaking at 166 trips in 2003, and decreasing by 2013. The East Coast Vancouver Island (ECVI, or inside waters) shows a bimodal pattern, with peaks in 1987 and 2004. Very few fishing trips were recorded prior to 1996 in Queen Charlotte (QC) Sound, Hecate Strait, Central Coast, North Coast, and Haida Gwaii. There appeared to be an increase in fishing trips recorded in all areas after 1995, with the exception of ECVI.

The bulk of the trips recorded prior to 1995 consisted of Spotted Spiny Dogfish and unidentified skate, with Big Skate, Longnose Skate, and "other" species being more consistently recorded after 1995 (Table 21). Fishing trips within the WCVI was well represented by the main species groups and 30.6% of the fishing trip records identified catch of "other" shark species. The ECVI (inside waters) and Central Coast records were largely compiled of Spotted Spiny Dogfish (47.3% and 42.4%, respectively). The QC Sound and Hecate Strait areas recorded high levels of "other" species (38.1% and 32.8%, respectively). 40.5% of trips without area identified recorded catch as "other" species.

Spotted Spiny Dogfish was most often (55.5%) caught in southern waters around Vancouver Island (Table 22). The "other" species were caught throughout the coast, but 38% of these records were within the WCVI area. Big Skate and Longnose Skate were intercepted most

often within WCVI (26.9% and 28.9%, respectively). Unidentified skate was recorded most frequently (29.48%) in ECVI.

Where is the Catch of Threatened Species most Prevalent?

All 26 elasmobranchs have been assessed by the IUCN Red List at the global level; however, only 9 of the 26 have been assessed by COSEWIC (Table 1, Tables 23-26). The Basking Shark (*Cetorhinus* maximus) and Shortfin Mako (*Isurus oxyrinchus)* are the only species to have been IUCN Red List assessed at the regional level, which highlights the importance of the more regionally specific COSEWIC assessments. Most of the catch categorized as IUCN Vulnerable status, as well as the COSEWIC Special Concern status, is largely the result of Spotted Spiny Dogfish comprising the bulk of the catch by weight (Figure 12). Of the three Deficient species by COSEWIC, there appears to be more Brown Catshark (*Apristurus brunneus*) intercepted (*n* = 1,429) than Blue Shark (*Prionace glauca*) (21) or White Shark (*Carcharodon carcharias*) (0) (Table 24). Similarly, of the 17 species not yet assessed by COSEWIC, the most prevalent in fisheries catches is Sandpaper Skate followed by Roughtail Skate, Abyssal Skate (*Bathyraja abyssicola*), and Pacific Sleeper Shark.

The distribution of conservation status of non-commercially exploited species per geographic region was identified (Figure 13). The bulk of the catch is recorded in the WCVI area, with the majority not yet assessed by COSEWIC. Seven records for Basking Shark (COSEWIC assessed as Endangered) were provided, and were shown to occur throughout the coast (WCVI, QC Sound, Hecate Strait and Haida Gwaii); note that the estimate number of Basking Sharks intercepted based on average weight, however, is just three (Table 14). The majority of the fishing trip records for species deemed by COSEWIC as Special Concern were

recorded in WCVI, QC Sound, and Hecate Strait. Species deemed Deficient were mostly recorded in WCVI, with a number of records throughout the other areas. Records for species deemed not at risk were found throughout the coast, notably in WCVI, QC Sound, Hecate Strait and North Coast. 65.4% of the species in Canadian Pacific waters have yet to be assessed by COSEWIC (Table 25), and the majority of the fishing records for these occurred in WCVI, QC Sound, and Hecate Strait.

Discussion

A key element of this study was to estimate the extent and pattern of interception of elasmobranchs within commercial fisheries over the past three decades within Canadian Pacific waters. Two key findings emerged: (1) records suggest a steep decline in elasmobranch catch over the past decade, and (2) the minimum number of elasmobranchs intercepted, is estimated to be 1,824,792 annually over the past decade, or a total of 69,720,987 individuals over the past 30 years. This leads to a series of questions: as to why there has been a recent steady decline in catch?; whether there is an the emergence of sustainable elasmobranch fisheries within Canadian Pacific waters?; what the significance is of the number of elasmobranchs identified at the species level as well as the number intercepted overall?;and what considerations should be made within these waters given the conservation status of the species?

There were many benefits to conducting this analysis on a small regional scale within the Canadian Pacific region; most notably the fisheries catch data was derived from well-managed fisheries with high observer coverage and a high degree (99.9%) of species-level catch reporting. This also allowed for an in-depth examination of trends in the fisheries data, including changes in weight and species composition over the 30-year period, geographic location of catch, and

extent of influence changes to policies related had on management of fisheries and elasmobranchs.

While there are many positive improvements to fisheries management as highlighted above, there are opportunities for improvement. In addition, there are inconsistent reporting requirements and observer coverage across the commercial fleets with most observation on the groundfish fisheries with minimal records for other fisheries. It is unknown whether this is the result of lack of reporting, or whether the gears or locations used within the other fisheries truly catch less sharks. Further, the three-party rule greatly limited this study's ability to see the distribution and weight composition of the catch geographic area, which can have consequences beyond this study for the scientific integrity of the data used.

Why have Elasmobranch Catches Declined Recently?

The catch of elasmobranchs in Canadian Pacific waters has declined by 80% within the past decade (Figure 7), which is substantial in comparison to the 2.1% reduction in global catch and mortality of sharks from 2000-2010 (Worm et al., 2013). There have been significant improvements in the management of directed and non-directed catch of elasmobranchs globally and within Canadian Pacific waters over the past three decades (Figure 4). However, a steady decline was seen over the past decade in catch both retained and released at sea (Figure 6). Shifting fishing effort, in response to species redistribution due to climate change or greater costs due to fuel price shocks, could influence the catch of elasmobranchs within commercial fisheries; though the extent of this influence is unknown. Reduced market demand was likely a contributing factor to this steep decline (Marine Stewardship Council (MSC), 2011). There is a large market for meat of Spotted Spiny Dogfish, with the meat from Canadian Pacific fishery

largely being exported to Europe, notably both Germany as a smoked delicacy and to England where they are used in the "fish and chips" market, amongst others. Recent competition for the European market with the U.S. North Atlantic Spiny Dogfish fishery, also MSC certified, has reduced market demand for the Canadian Pacific fishery, which influences the reduced fishing effort. This is seen in reduced Canadian exports of shark fin trade volumes – the bulk of which was exported to China and Hong Kong – from 2000-2011, with a peak in exports in 2005 at 175 tonnes, reducing to 42 tonnes in 2010 (Clarke & Dent, 2014). Reduced market demand alone does not completely account for the decline in elasmobranchs released at sea. Given the increase in observer coverage and identification at species level, the steep decline in elasmobranchs released at sea is surprising. A key concern is that declining catch may indicate declining stock sizes due to overfishing.

Emergence of Sustainable Elasmobranch Fisheries within Canadian Pacific Waters

My study shows, instead, that there may be an emergence of sustainable elasmobranch fisheries in Canadian Pacific waters, most notably that the bulk (93.1%) of the elasmobranch catch over the past 30 years was comprised of the three commercially-exploited species. Spotted Spiny Dogfish, Big Skate, and Longnose Skate are the only commercially exploited elasmobranchs in Canadian Pacific waters, and management controls are in place for these species, including TAC and IVQ species caps (DFO, 2014). Given the increase in observer coverage and species identification over this time period, the data suggest that commercial fisheries are intercepting the non-commercially valued elasmobranchs in small quantities. The following six species are also currently permitted to be caught in the groundfish trawl fishery: Spotted Spiny Dogfish, Big Skate, Longnose Skate, Black Skate (*Raja kincaida*), Starry Skate

(*Raja stellulata*), and Deepsea Skate; as of 2011, all other species must be released at sea with the least possible harm and this incidental catch recorded in the catch logs (DFO, 2012b).

The highest annual recorded catch of Spotted Spiny Dogfish, coast-wide over the past 30 years was 8,674.6 tonnes in 1988 (Figure 8), was quite a bit lower than the current TAC. The total TAC for Spotted Spiny Dogfish is currently set at 14,000 tonnes, broken down to 2,000 tonnes for the inside stock, and 12,000 tonnes for the outside stock (Table 2). To date, the TAC has never been exceeded (Marine Stewardship Council (MSC), 2014). The MSC certified the BC spiny dogfish hook-and-line fleet in 2011 as a sustainable fishery (MSC, 2014); however, Spotted Spiny Dogfish was also assessed by COSEWIC as Special Concern in November 2011 (Government of Canada, 2014). This COSEWIC assessment was based on the high degree of uncertainty in the survey indices and the very slow life history of this species. The MSC certification was suspended in October 2013 at the fishery's request due to low market demand for the product. At time of writing, no further certification has been sought by the industry. There is an acknowledged discrepancy that within the same calendar year the MSC deemed the fishery sustainable and COSEWIC assessed the species as Special Concern noting it was intrinsically sensitive to overfishing. Nevertheless, my study shows that the overall catch of Spotted Spiny Dogfish appears to be from a well-managed and sustainable fishery, with catch levels well below the defined TAC levels.

The three-party rule hinders my ability to evaluate the sustainability of the major skate fisheries. While skates are intercepted throughout the coast, the existing TAC is set for only the Hecate Strait area. The highest annual recorded catch of Big Skate coast-wide was 2,152.8 tonnes in 2003, based on data between 1994 (the earliest record of Big Skate at the species level)

and 2013 (Figure 8). The highest annual recorded catch of Longnose Skate coast-wide from 1994-2013 was 610.4 tonnes in 2004. The catch could not be analyzed at a level relevant to compare against the TAC, as a result of data being withheld subject to the 'three-party rule' and thus, could not be provided at that geographic scale. Both of the coast-wide catches noted above exceed the current TACs established for Hecate Strait exclusively with a TAC of 567 tonnes for Big Skate and 47 tonnes for Longnose Skate (DFO, 2014a); while data were withheld to allow for an analysis of the Hecate Strait area specifically, it can be assumed that some portion of the total coast-wide catches of Big Skate and Longnose Skate would be attributed to the Hecate Strait area. Global trade in skate meat is poorly understood, but 85% of the chondrichthyan meat that Korea imports is comprised of skates and rays (Clarke & Dent, 2014). The increasing global market demand for skate and ray meat can be seen in the increased focus of skates in DFO's Pacific Groundfish IFMP each year. If this continues, it may be prudent for coast-wide TACs to be developed for the commercially valued species, and required monitoring and species identification for all skate and ray species.

Improved Species Identification in Canadian Pacific Waters

Only one-third (30%) of the global chondrichthyan catch is identified at the species level (Fischer, Erikstein, D'Offay, Barone & Guggisberg, 2012). In stark contrast, almost all (99.9%) of elasmobranch catch weight in Canadian Pacific waters was identified at the species level within the past decade, an improvement over 93.5% over the past 30 years. Elasmobranch identification in Canadian Pacific waters is significantly higher than that of the global chondrichthyan catch, aided both by low diversity, but also considerable scientific capacity. Generally, Pacific Canada is doing a good job in managing its commercial fisheries including

capturing data for species that are not commercially exploited, but it is fortunate in having so few species that are commercially viable. Should it be warranted in future improvements to these fisheries, a requirement could be made to record all elasmobranchs at the species level across all fisheries to ensure appropriate levels of data are obtained for those species that may have conservation concern.

Deriving the Number of Elasmobranchs Intercepted

This paper built upon similar approaches for estimating number of elasmobranchs intercepted in fisheries catch data used by Clarke et al. (2006) and Worm et al. (2013) to provide an estimate of interception of elasmobranchs within a relatively small well-monitored geographic region. In my study, average weights were derived from published literature, where available, or estimated from either similar species or an average of all elasmobranchs (described in Table 14 and 15). The Clarke et al. paper (2006) provided the first fisheries-independent estimate of global shark catch based on converting factors of auctioned shark fin weights to whole shark equivalents in a Bayesian estimation framework, an estimate of shark biomass represented in this data, and than extrapolated to estimate global trade volumes of shark fins. Worm et al. (2013) found published estimates of average shark weights belonging to four species groups: pelagic, large coastal, small coastal, and deep-water sharks; the authors then converted the total mortality in tonnes by the median estimated weight of sharks within each group to get an estimate of number of sharks killed. While the focus of the two studies differed from this paper, they nonetheless provided invaluable approaches to consider in estimating the number of sharks intercepted in Canadian Pacific commercial fisheries.

The Worm et al. paper (2013) used available information for sharks from reported landings and discards (FAO data) as well as an estimate of illegal, unregulated, and unreported (IUU) landings. I was not able to consider discard mortality rates due to limited data available for the 26 species within my study, which resulted in an estimation of the number of sharks 'intercepted' in in Canadian Pacific commercial fisheries rather than an estimate of the number of sharks 'killed', as reported in the larger global studies (Clarke et al., 2006; Worm et al., 2013).

What is the Significance of the Number of Elasmobranchs being Intercepted?

My study estimated the minimum number of elasmobranchs intercepted – 1,824,792 annually within the past decade, or 69,720,987 individuals over the entire 30-year period (Table 14 and 15). These are considered to be conservative estimates, and likely an underestimate of the actual number of elasmobranchs intercepted. Six times more sharks are intercepted than skates and rays each year (1,568,277 versus 256,515). Two studies have estimated annual global catch of sharks in global fisheries at 63-273 million (Worm et al., 2013) and 26-73 million sharks (Clarke et al., 2006). While the degree to which catch data reflects population trajectories can be debated, it is often the best source of information to work from and may provide a reasonable indicator of population trajectory for less valuable as well as less managed species (Froese, Zeller, Kleisner, & Pauly, 2012; Newton, Côté, Pilling, Jennings, & Dulvy, 2007; Worm et al., 2013). Further, deriving the number of elasmobranchs intercepted, as opposed to just the total weight, can be important in assessing population viability where age structure, size, and number of animals are required. This can assist with rare species or those with conservation concern; for example, intercepting one Basking Shark may have larger repercussions for management than one Spotted Spiny Dogfish.

Considering that most 93.1% of the recorded catch in my study is derived from the three commercially-exploited which are subject to well-managed fisheries and subject to the TAC described above, it can be assumed that a minimum of 93.1% of this catch overall is sustainable. This includes 99.9% of the sharks (Spotted Spiny Dogfish) sustainably intercepted as well as 85.9% of the skates and rays (Big Skate and Longnose Skate) sustainably intercepted. The Worm et al. paper notes that the global fisheries catch of sharks is unsustainable, and needs to be significantly reduced to support rebuilding of depleted shark populations and restoration of marine ecosystems (Worm et al., 2013). While this may seem like a contrast, Worm et al. considered exploitation and rebound rates before coming to their conclusion that the global fishery catch of sharks was unsustainable, whereas my study looked at a geographically specific region that is relatively well-managed and has taken progressive actions to improve its fisheries management over the past 30 years.

Where should Further Effort be Placed on Conservation Status of Elasmobranchs?

The non-commercially exploited elasmobranch species represent a small fraction of the total weight of elasmobranchs intercepted, but this catch is diverse and represents 23 species across various taxonomic groups. It has been argued that skates are “the most vulnerable of exploited marine fishes” and the conservation of elasmobranchs requires monitoring at the species level (Dulvy, Metcalfe, Glanville, Pawson & Reynolds, 2000). This may raise cause for concern due to the threat of serial depletion, whereupon facing declining resources fishing effort moves towards areas or alternative species that were previously unexploited (Cardinale, Nugroho & Jonson, 2011). A further consideration can be made in ensuring opportunistic exploitation does not occur, that is, where commercially valued species decline to the point of potential

extinction risk due to overfishing, and alternative species are then targeted (Branch, Lobo, & Purcell, 2013). My study may support COSEWIC species prioritization in upcoming assessments by considering available data. For example, prioritizing species previously assessed as Data Deficient but as shown in this study such data may exist, such as the Brown Catshark (1,429 estimated to be annually intercepted in commercial fisheries), Sandpaper Skate (32,875 annually intercepted), Roughtail Skate (1,248 annually intercepted), Abyssal Skate (520 annually intercepted), and Pacific Sleeper Shark (260 annually intercepted) before other species (Table 15, Table 26).

The only species with an endangered status – the Basking Shark – is legally protected in Canada under SARA, resulting in numerous recovery measures for this species as well as a published SARA Recovery Strategy. Basking Sharks are very rarely encountered in commercial fisheries in Canadian Pacific waters (Table 24, 25). Spotted Spiny Dogfish is the only species out of the five IUCN Vulnerable elasmobranchs in Pacific Canada that has a substantial number of individuals intercepted by fisheries each year. Big Skate totals 120,902 individuals intercepted per year and have a status level of Near Threatened (globally) under IUCN, but a COSEWIC status of “not at risk”. This could suggest that the COSEWIC status is more relevant as a conservation measure for regional fisheries management as it provides a more specific, regional snapshot for a population.

Conclusion

This study estimated the number of elasmobranchs intercepted within Canadian Pacific commercial fisheries over the last 30 years. For this, the study explored a hypothesis of “the patterns of interceptions of elasmobranchs within commercial fisheries in Canadian Pacific

waters have not changed over the past 30 years". Five sub-questions were put forward to support this by looking at patterns over the time period where data were withheld due to the three-party rule, in retained and released weight, and proportion of weight by species, gear type, and area, as well as where the catch of threatened species was most prevalent. As was shown in the earlier sections, this hypothesis was not proven. Patterns emerged within these areas as a result of changes to fisheries management as well as other measures. While similar studies have occurred globally (e.g., Worm et al., 2013), this is the only local scale assessment of catch numbers I am aware of.

This small, regional focus of comparably well-managed and documented fisheries showed that there appears to be minimal interception of non-commercially exploited elasmobranchs within commercial fisheries in Canadian Pacific waters. The study was limited in the availability of catch statistics, most notably for reliable data outside of the commercial groundfish fleet, as well as in the data that were withheld from the application of the three-party rule. As noted earlier, recreational and Aboriginal fisheries were outside the scope of this study, but it is assumed some catch occurs within these fisheries but is unknown.

The key findings included the total weight of elasmobranchs intercepted in commercial fisheries over the past three decades, the catch trajectory over this period, the proportion of catch on average that was retained compared with that released at sea, an estimate of the number of individuals intercepted each year, as well as the species composition. 208,642.6 tonnes of elasmobranchs were recorded as catch in commercial fleets over the past 30 years, with the bulk (93%) of this weight being commercially exploited species. Approximately 75% of this catch was retained, while 25% was released at sea. It is estimated that an average of 1,824,792

individual elasmobranchs were intercepted each year within the past decade. There was steep decline in elasmobranch catch within the past decade that is most likely due to reduced market demand rather than overfishing and declining stocks.

The bulk of the catch intercepted was comprised of the three commercially exploited species, all of which are well monitored and managed. With the improvements to fisheries management highlighted in this study, this could be seen as an emergence of sustainable elasmobranch fisheries within Canadian Pacific waters. In particular, given the increase in species identification, the data suggest that elasmobranchs are not being intercepted in commercial fisheries in high numbers.

Whether the steep decline in elasmobranch catch within the past decade is the result of declining populations or presence within these waters remains unknown. The fisheries appear to be managed sustainability and are likely causing a decline in stock, though it is noteworthy that fisheries remain the primary known threat to elasmobranchs within Canadian Pacific waters. Indeed, catch data are often the best source of information for elasmobranch populations, and while the degree to which this data reflect population trajectories is uncertain, it may provide a reasonable indicator of population trajectory for less valuable as well as less managed species.

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Figures

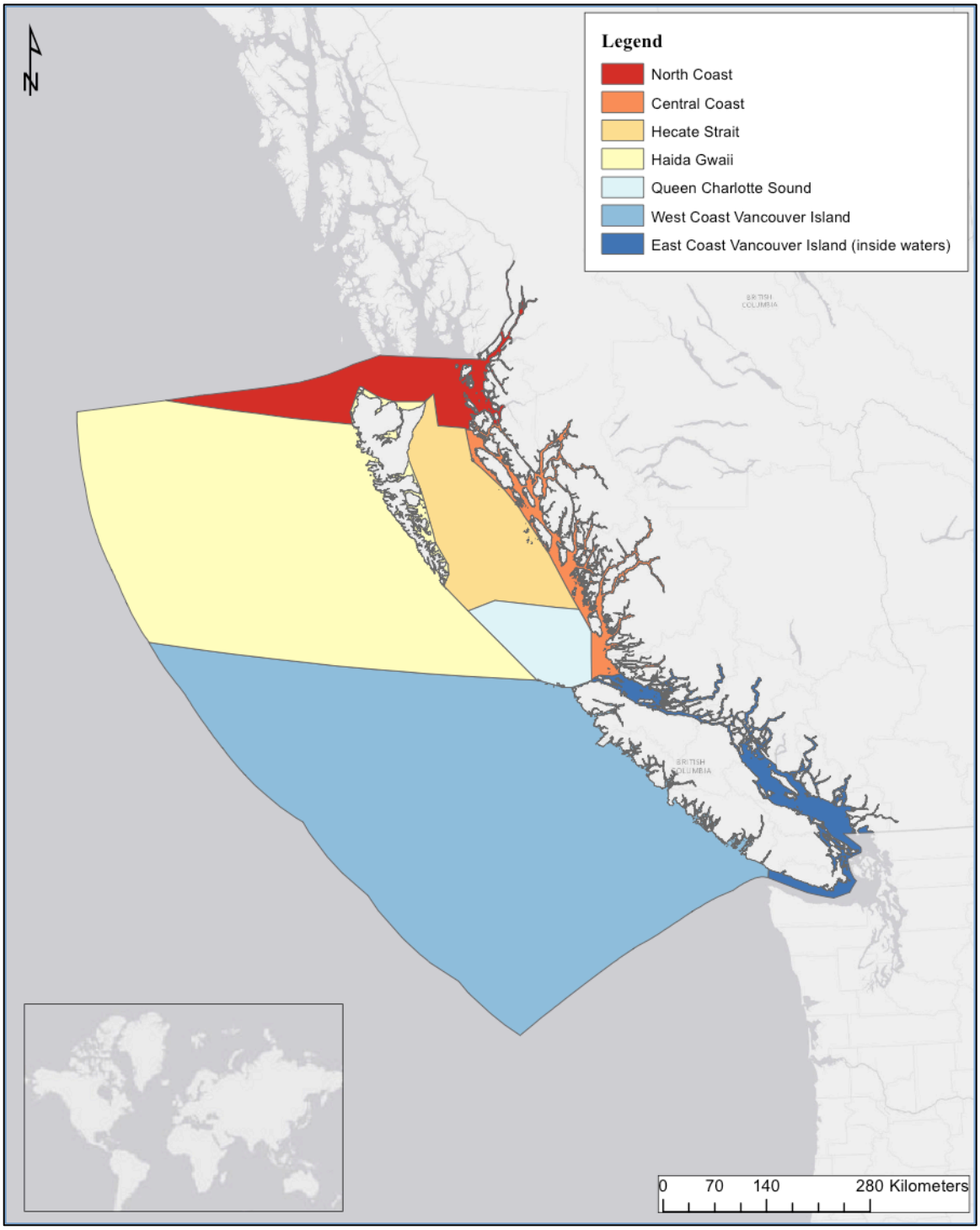


Figure 1. Map of general geographic areas within Canadian Pacific waters. Developed in ESRI ArcGIS using DFO's Pacific Fisheries Management Area (PFMA) boundaries, modified to capture the larger geographic areas.

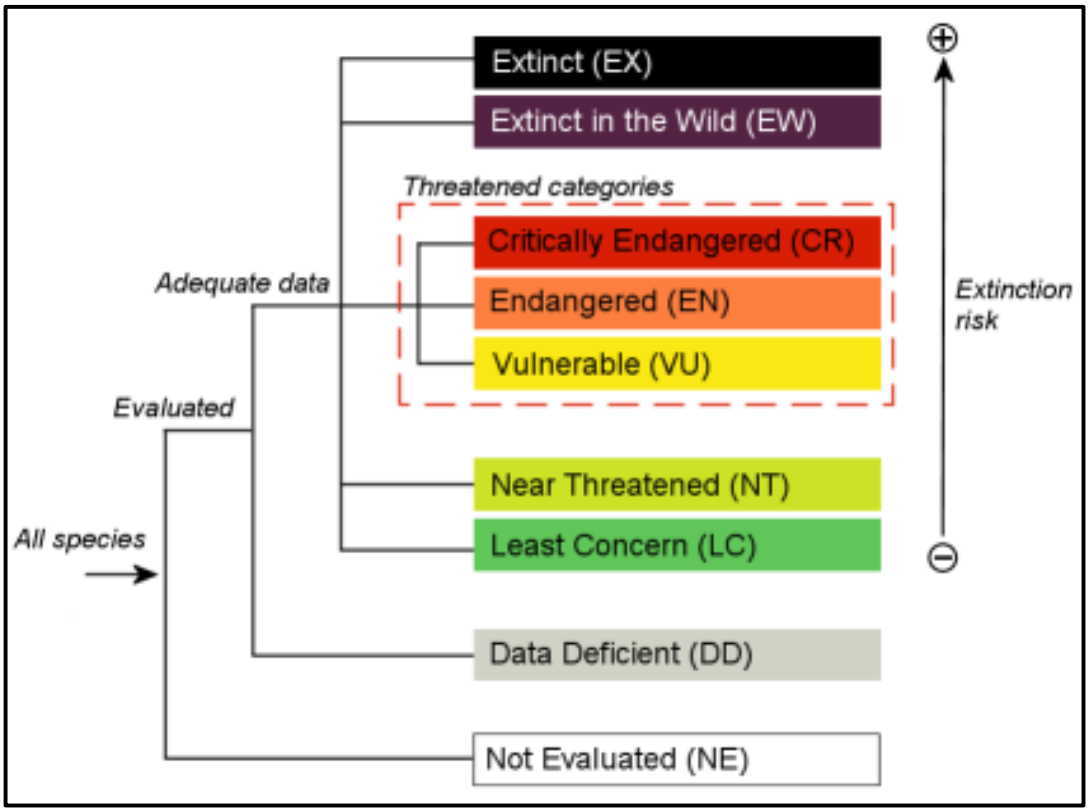


Figure 2. The Structure of IUCN Red List Categories. From "*IUCN Red List Categories and Criteria: Version 3.1*" (p. 5), by the IUCN, 2012, Gland, Switzerland and Cambridge, UK: IUCN. Copyright (2001, 2012) International Union for Conservation of Nature and Natural Resources. Reprinted with permission.

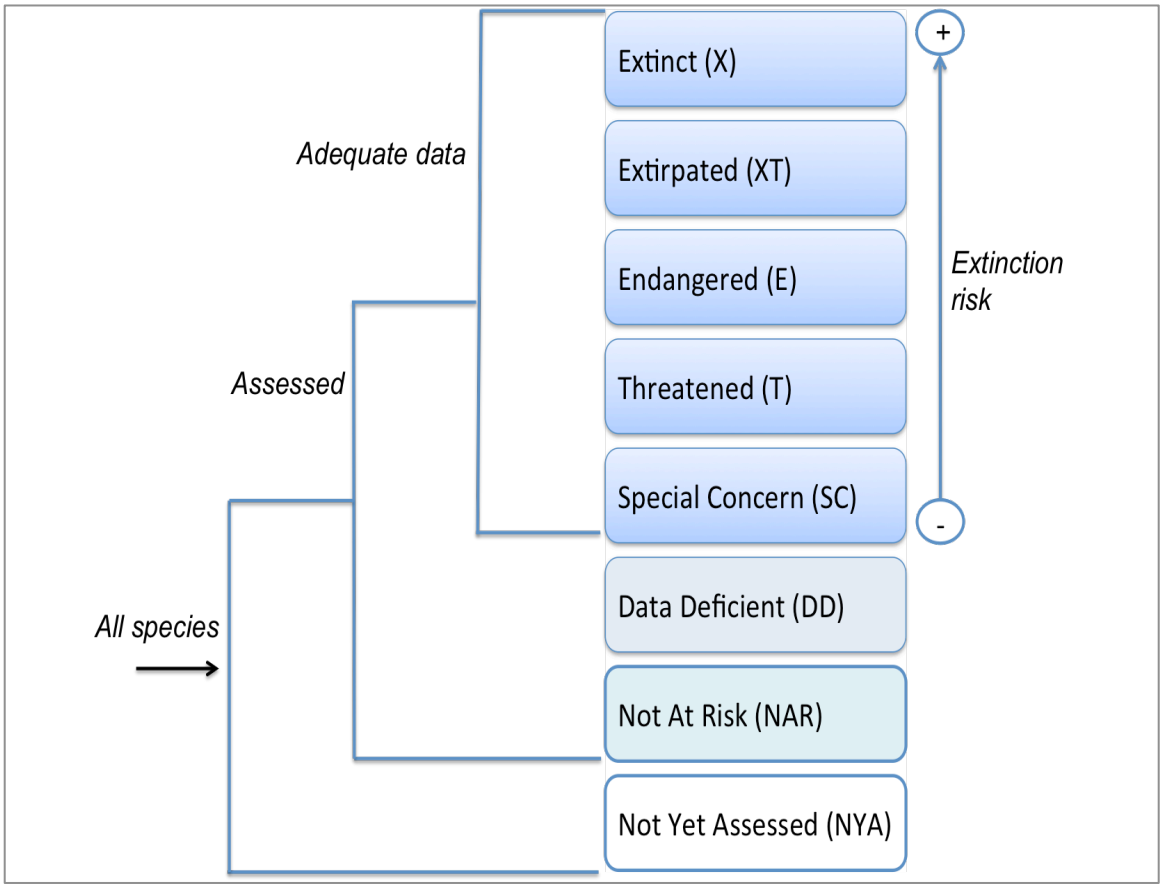


Figure 3. The Structure of COSEWIC Status Assessments. Interpreted from COSEWIC, 2011a.

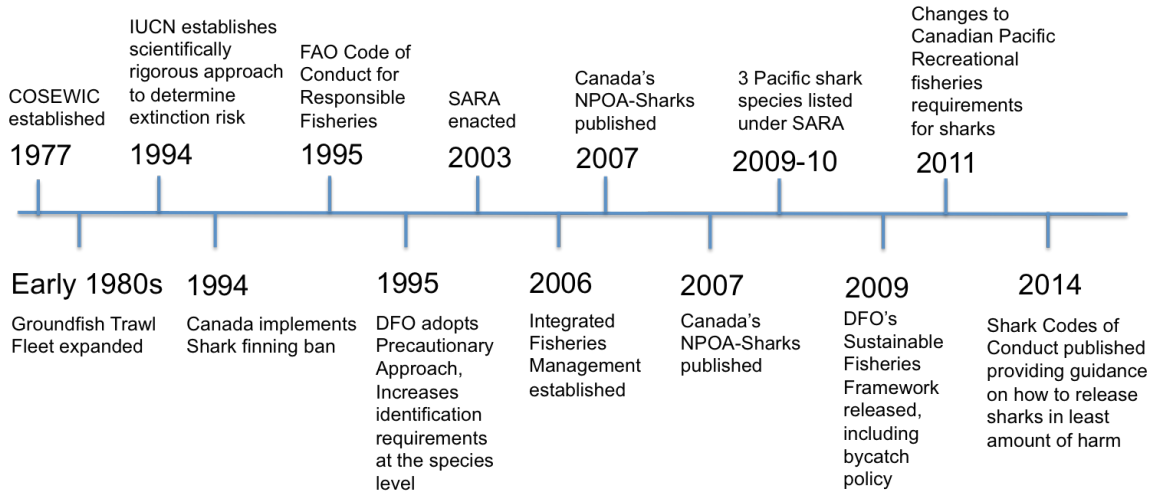


Figure 4. Timeline of major events affecting fisheries in Canadian Pacific waters.

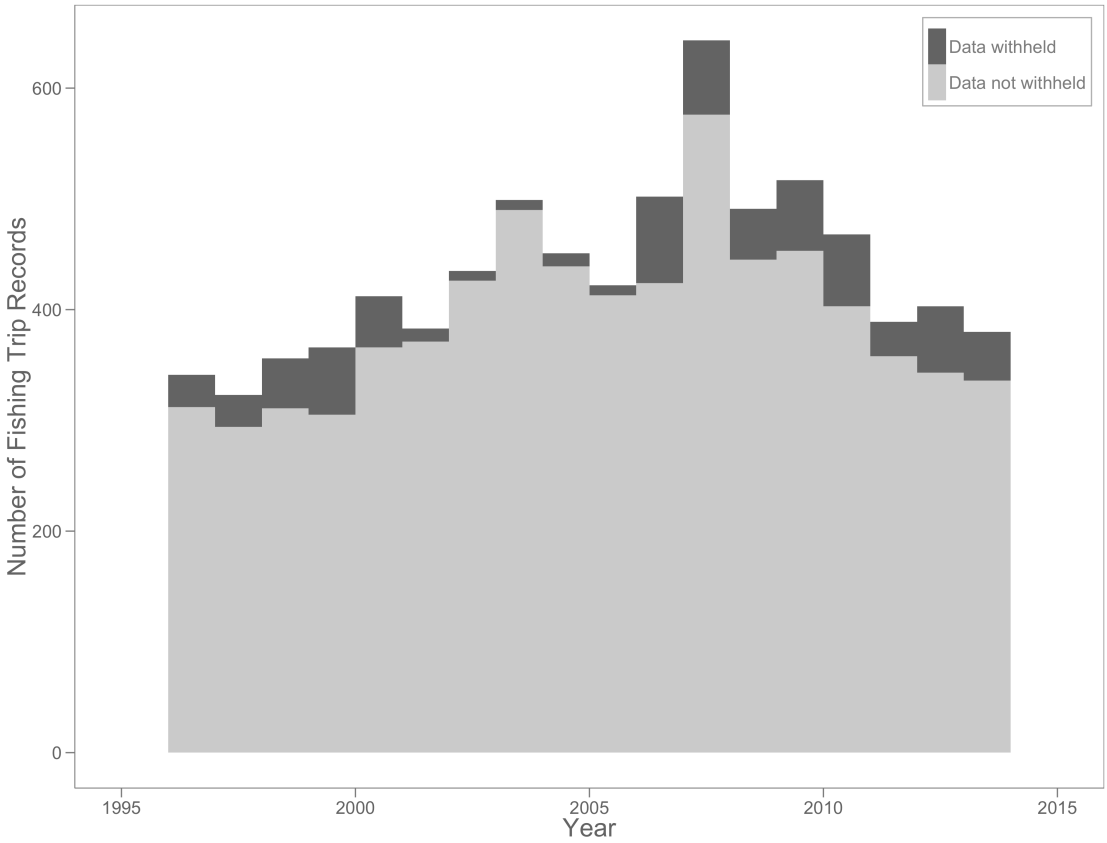


Figure 5. Fishing trip records where data were withheld, 1996-2013. The dark grey shade represents the proportion of data where weight and area criteria were withheld due to the "three-party rule".

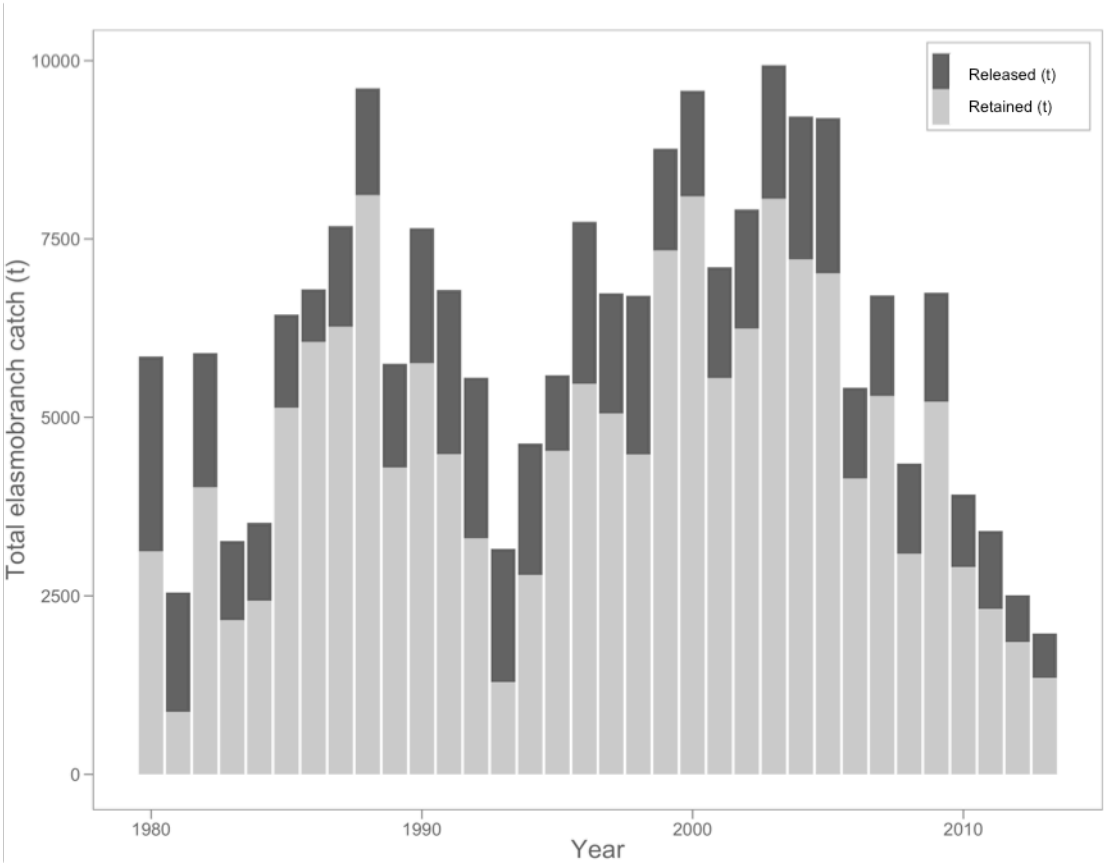


Figure 6. Elasmobranch catch within all DFO Fisheries records, showing proportion of catch retained and released (in tonnes), 1980-2013.

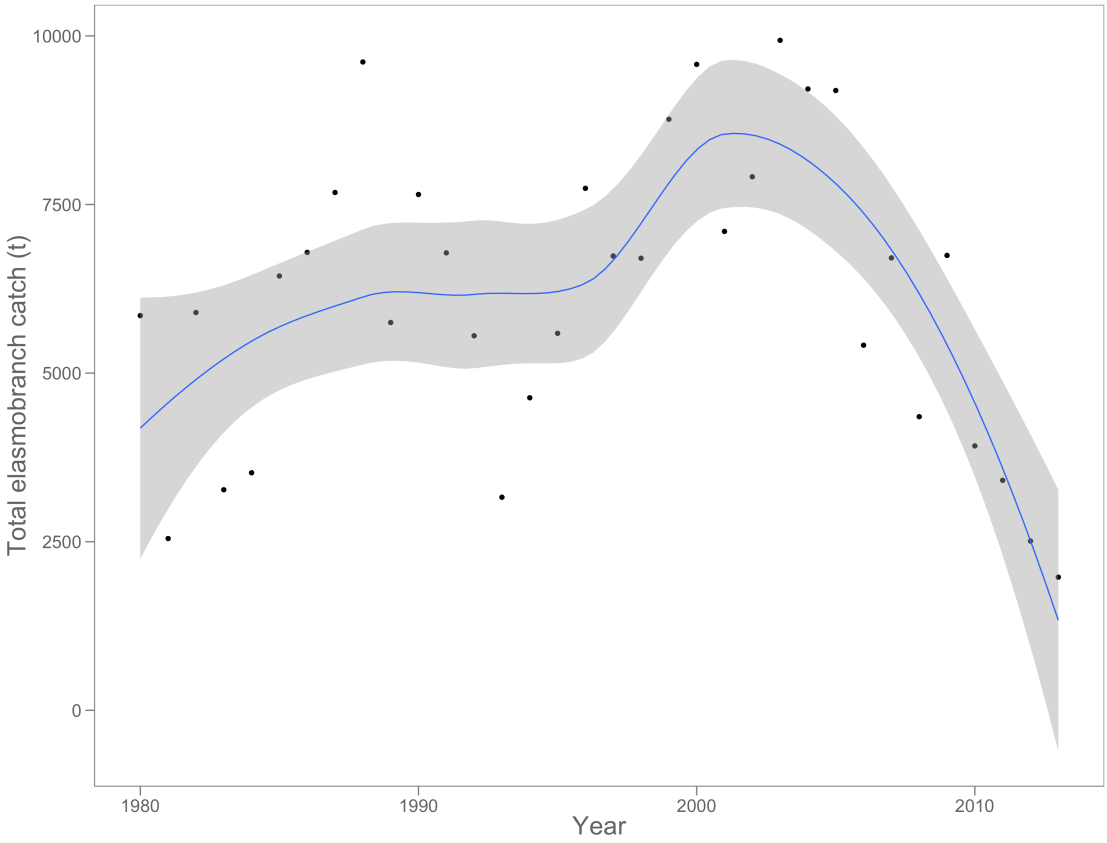


Figure 7. The overall trend in catch (in tonnes) for elasmobranch species in Canadian Pacific waters, 1980-2013. The blue line is a loess smoother with a span of 0.75, 95% confidence interval, and p <.0001.

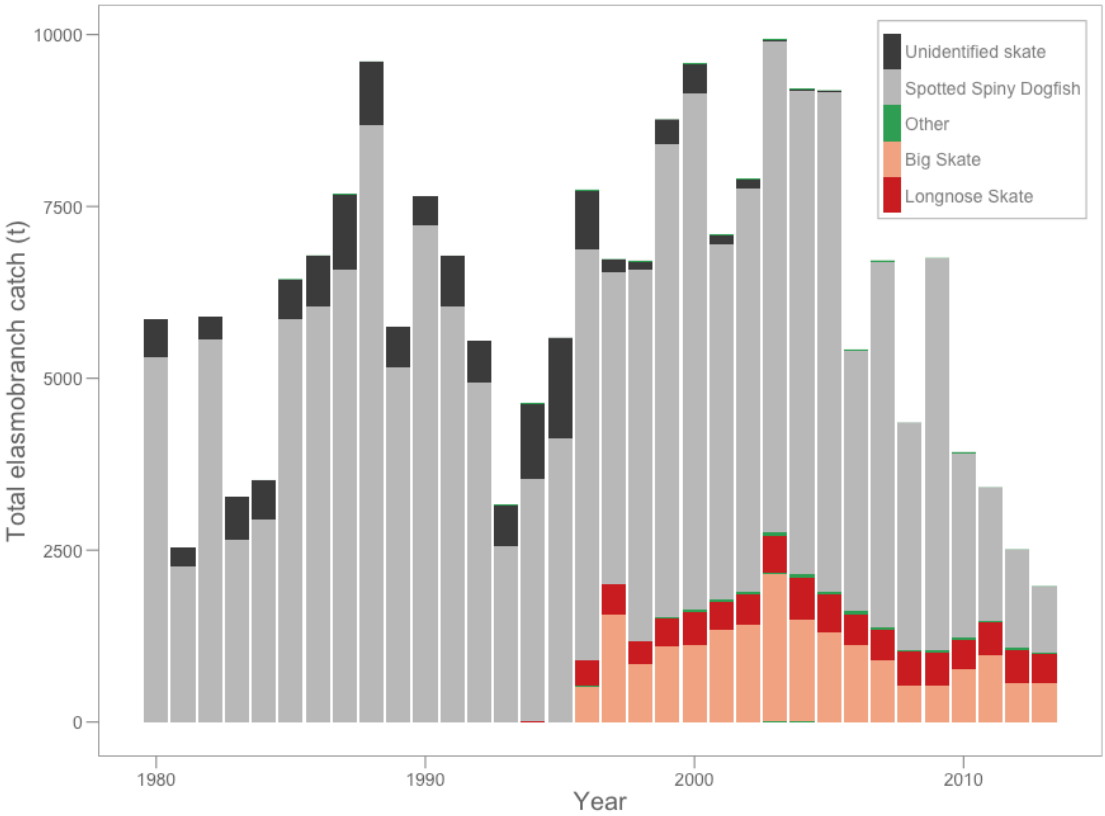


Figure 8. Catch composition (in tonnes) of four main elasmobranch species within Canadian Pacific waters, 1980-2013.

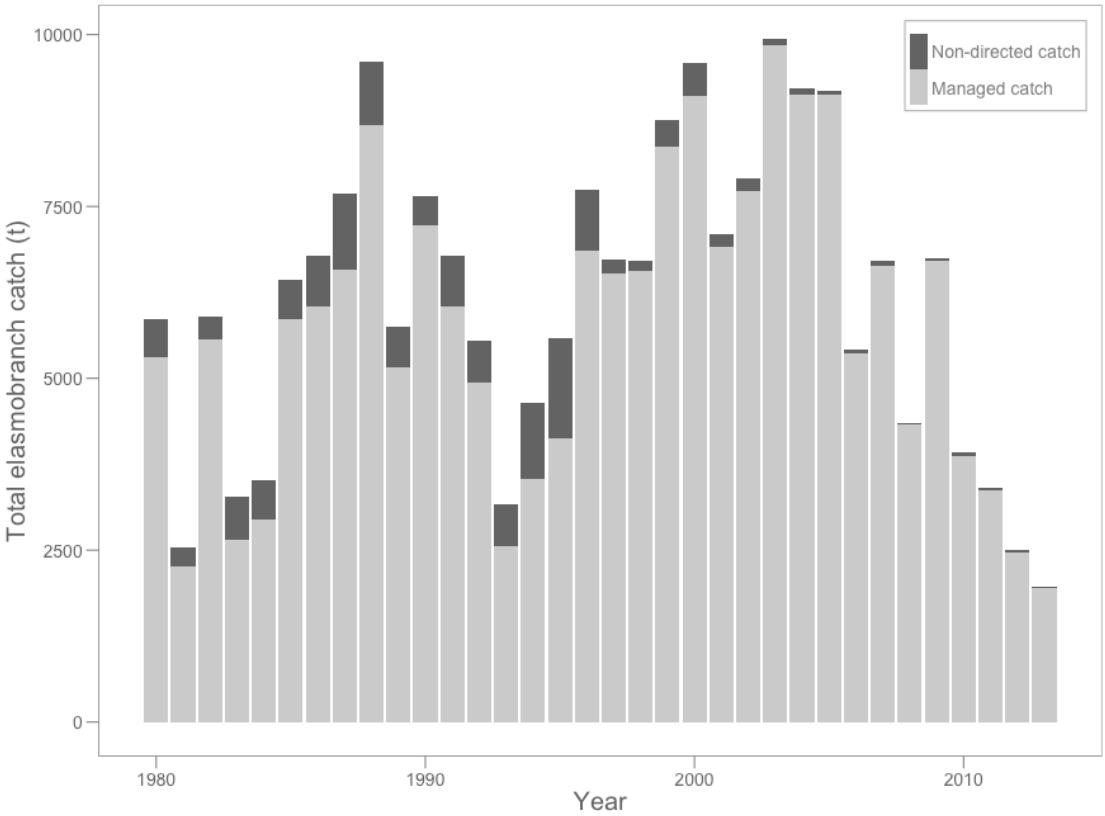


Figure 9. Managed and non-directed catch (in tonnes) within Canadian Pacific waters, 1980-2013.

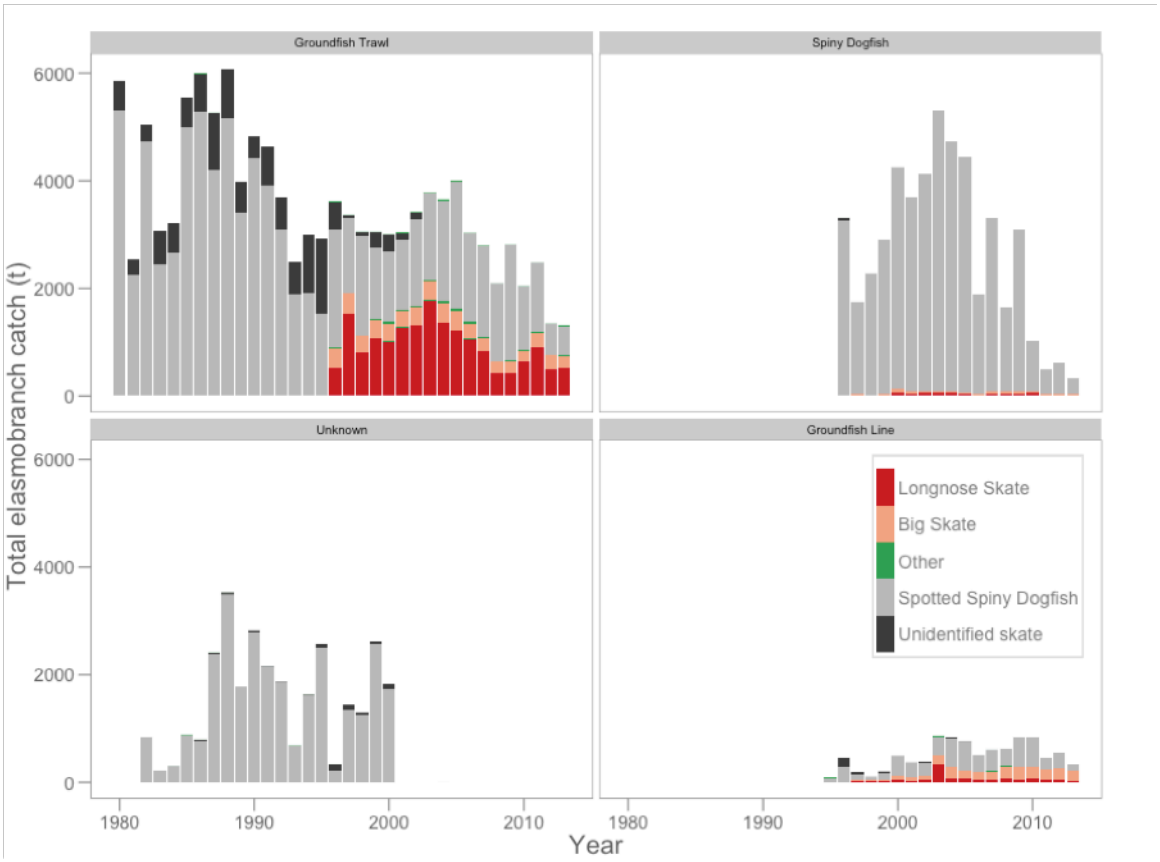


Figure 10. Elasmobranch catch (in tonnes) for the four main fleets recording elasmobranchs within Canadian Pacific waters, 1980-2013.

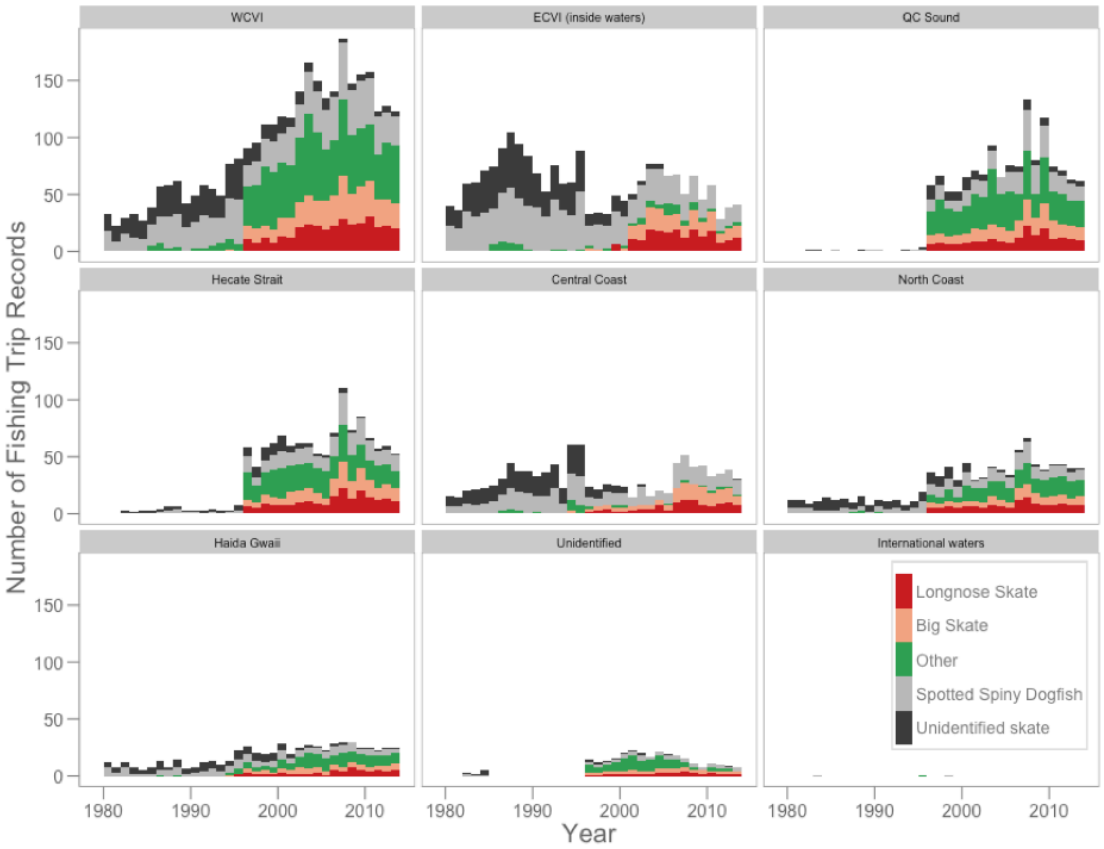
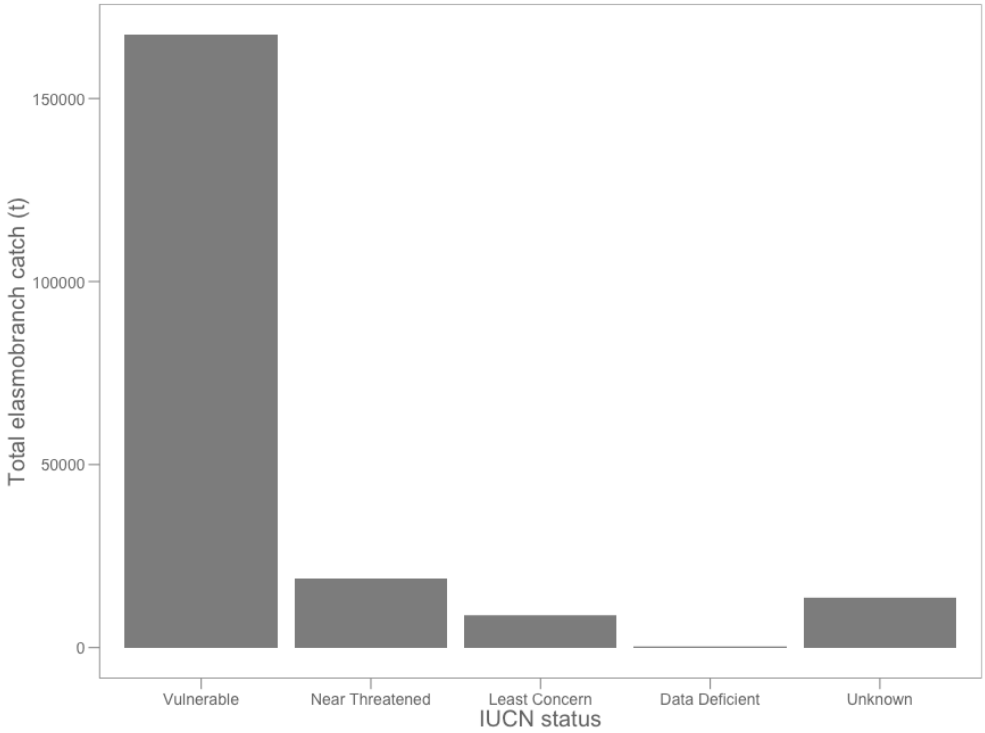


Figure 11. Geographical location of elasmobranch catches within Canadian Pacific waters, 1980-2013. The plots are ordered by volume of fishing trip records; with the highest number shown in the top left, and lowest number in the bottom right. This generally follows a trend from southern waters around Vancouver Island and going northward to the North Coast and Haida Gwaii.

A.



B.

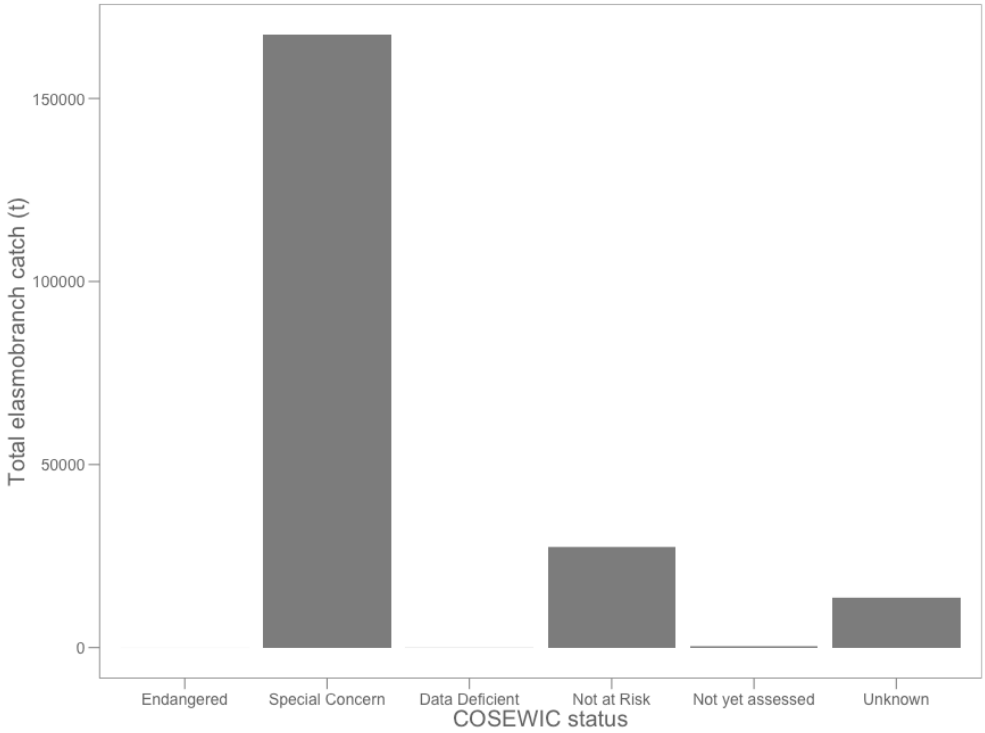


Figure 12. Elasmobranch catch (in tonnes) within Canadian Pacific waters at the (a) IUCN and (b) COSEWIC status level.

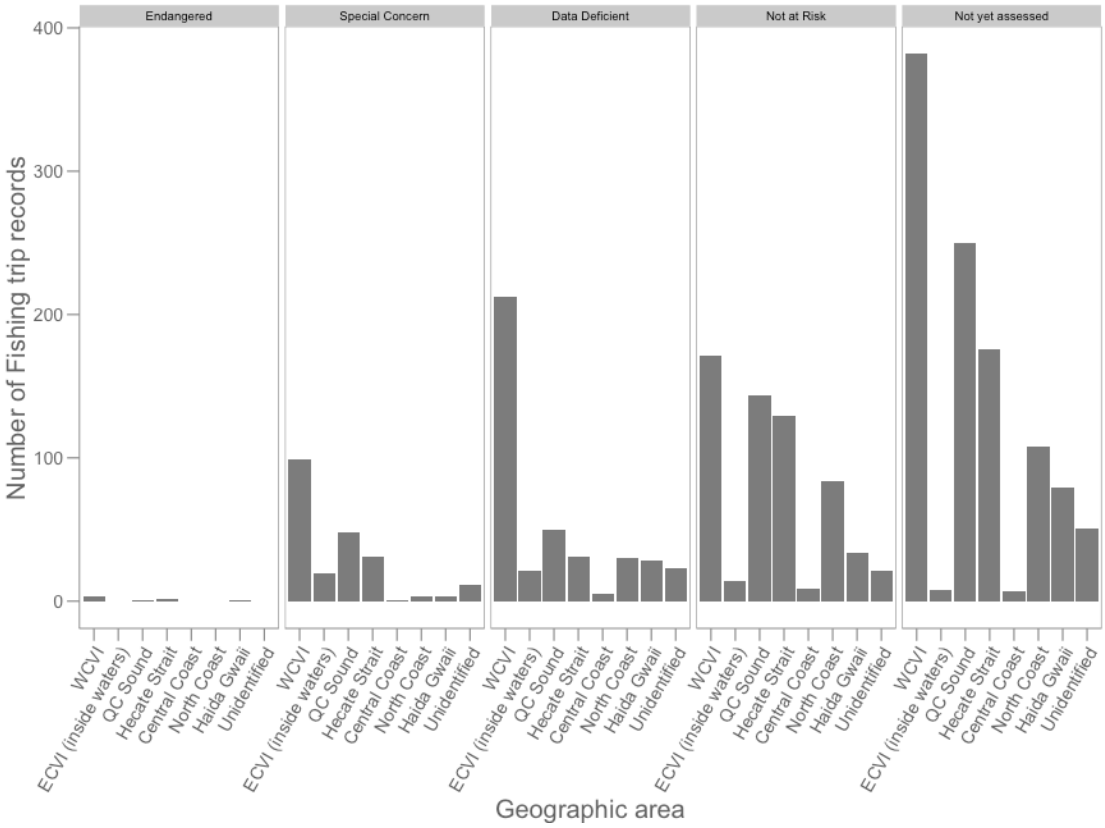


Figure 13. Proportion of COSEWIC status levels for non-commercial species intercepted within the large geographic areas within Canadian Pacific waters.

Tables

Table 1

Elasmobranchs in Canadian Pacific waters and their respective conservation status

Species	Distribution in BC waters	Presence in BC waters	COSEWIC Status	SARA status	IUCN status	IUCN trend
Sharks						
Basking Shark (*Cetorhinus maximus*)	Surface waters	Rare	Endangered (2007)	Endangered (2010)	Endangered (North Pacific subpopulati on, 2009), Endangered (2000) Vulnerable (Global, 2005, 1996), Insufficient-ly Known (1990)	↓
Bigeye Thresher Shark (*Alopias superciliosus*)	Depths surface to 65m	Infreque nt	Not yet assessed	N/A	Vulnerable (2009)	↓
Blue Shark (*Prionace glauca*)	Surface waters	Common	Data Deficient (2006)	N/A	Near Threatened (2009)	?
Bluntnose Sixgill Shark (*Hexanchus griseus*)	Depths to 2307 m	Common	Special Concern (2007)	Special Concern (2010)	Near Threatened (2005), Vulnerable (1996)	?
Broadnose Sevengill Shark (*Notorynchus cepedianus*)	Depths 135-570 m	Rare	Not yet assessed	N/A	Data Deficient (2005, 2000)	?

Species	Distribution in BC waters	Presence in BC waters	COSEWIC Status	SARA status	IUCN status	IUCN trend
Brown Catshark (*Apristurus brunneus*)	Depths 33-950 m	Common	Data Deficient (2006)	N/A	Data Deficient (2004)	?
Common Thresher Shark (*Alopias vulpinus*)	Depths surface to 366 m	Rare	Not yet assessed	N/A	Vulnerable (2009), Data Deficient (2002, 2000)	↓
Greeneye Shark (*Etmopterus villosus*)	Depths 406-911 m	Rare – unconfirmed	Not yet assessed	N/A	Least Concern (2009)	?
Spotted Spiny Dogfish (*Squalus suckleyi*)	Depths surface to 1460 m	Common	Special Concern (2011)	TBD (currently being considered for SARA listing)	Vulnerable (2006, as *Squalus acanthias*)	?
Pacific Sleeper Shark (*Somniosus pacificus*)	Depths surface to 245 m	Common	Not yet assessed	N/A	Data Deficient (2009)	?
Salmon Shark (*Lamna ditropis*)	Depths surface to 375 m	Common	Not yet assessed	N/A	Least Concern (2009), Data Deficient (2000)	–
Shortfin Mako Shark (*Isurus oxyrinchus*)	Depths surface to 740 m	Rare	Not yet assessed	N/A	Near Threatened (Eastern North Pacific	↓

Species	Distribution in BC waters	Presence in BC waters	COSEWIC Status	SARA status	IUCN status	IUCN trend
					population, 2009) Vulnerable (Global, 2009)	
Tope (Soupfin) Shark (*Galeorhinus galeus*)	Depths surface to 471 m	Common	Special Concern (2007)	Special Concern (2010)	Vulnerable (2006, 2000)	↓
White Shark (*Carcharodon carcharias*)	Depths surface – 1280 m	Rare	Data Deficient (2006)	N/A	Vulnerable (2009, 2000, 1996), Insufficientl y Known (1990)	?
Skates						
Abyssal Skate (*Bathyraja abyssicola*)	Depths 360-2900 m	Rare	Not yet assessed	N/A	Data Deficient (2009, 2000, 1996)	?
Alaska Skate (*Bathyraja parmifera*)	Depths 20-1400 m	Rare	Not yet assessed	N/A	Least Concern (2009)	?
Aleutian Skate (*Bathyraja aleutica*)	Depths 15-1600 m	Infreque nt	Not yet assessed	N/A	Least Concern (2009)	?
Big Skate (*Raja binoculata*)	Depths 3-800 m	Common	Not at Risk (2007)	N/A	Near Threatened (2005)	?
Broad Skate (*Amblyraja*	Depths 845-2325 m	Rare	Not yet assessed	N/A	Least Concern	?

Species	Distribution in BC waters	Presence in BC waters	COSEWIC Status	SARA status	IUCN status	IUCN trend
badia)					(2009)	
California Skate (*Raja inornata*)	Depths 20-670 m	Rare	Not yet assessed	N/A	Data Deficient (2009)	?
Longnose Skate (*Raja rhina*)	Depths 20-660 m	Common	Not at Risk (2007)	N/A	Least Concern (2009)	?
Roughtail Skate (*Bathyraja trachura*)	Depths 400-2000m	Infrequent	Not yet assessed	N/A	Least Concern (2009)	?
Sandpaper Skate (*Bathyraja interrupta*)	Depths 55-1400 m	Common	Not at Risk (2007)	N/A	Least Concern (2009)	?
Starry Skate (*Raja stellulata*)	Depths 20-730 m	Rare	Not yet assessed	N/A	Least Concern (2009)	?
Whitebrow Skate (*Bathyraja minispinosa*)	Depths 150-1400 m	Rare	Not yet assessed	N/A	Least Concern (2009)	?
Rays						
Pacific electric ray (*Torpedo californica*	Depths 0 – 425 m	Rare	Not yet assessed	N/A	Least Concern (2005)	?

Note. Data from columns 1, 2, and 3 were adapted from "Distribution and life history parameters of elasmobranch species in British Columbia waters," by G.A. McFarlane, R.P. McPhie, and J.R. King, 2010, Canadian Technical Report of Fisheries and Aquatic Sciences 29078. Copyright (2010) Her Majesty the Queen. Data from columns 4 and 5 were obtained from "Species at Risk Public Registry," by the Government of Canada (retrieved August 31, 2013, from http://www.sararegistry.gc.ca/default_e.cfm). Data from columns 6 and 7 were obtained from the "IUCN Red List of Threatened Species," by the IUCN Red List (retrieved August 31, 2013, from

from http://www.iucnredlist.org). Symbols for column 7: ↓ = decreasing,? = unknown, and – = stable.

Table 2

2014/15 Annual Commercial Total Allowable Catch (TAC) (in tonnes) for elasmobranchs

Species	Area	TAC All Sectors	Hook & Line / Trap	Trawl
Spotted Spiny Dogfish	4B	2,000	1,360	640
	Rest of Coast	12,000	8,160	3,840
	Coastwide Total	14,000	9,520	4,480
Big Skate	5C/D	567	N/A	567
Longnose Skate	5C/D	47	N/A	47

Note. Adapted from "Pacific Region – Groundfish Integrated Fisheries Management Plan" by Fisheries and Oceans Canada, 2014.

Table 3

Fishing sectors and reference to management efforts for elasmobranch species within Canadian Pacific waters

Sectors	Elasmobranch reference		Gear used	Records available
	Shark	Skates/ Rays		
Groundfish	Yes[1,3,4,5,6,7,8,13,14,15,16]	Yes[7,8,9,11,12]	Hook and line, Bottom trawl, midwater trawl	Fish Slip and Sector Records
Minor Finfish				
Eulachon	Yes[1,5]	No	-	No records
Surfperch	No	No	-	No records
Surf Smelt	No	No	-	No records
Pelagics				
Tuna	Yes[1,4,5,6,17,18]	No	Troll and/or Jig (hook and line)	Fish Slips; Logbook records (1988-2013)
Pacific Herring	Yes[6]	No	Seine, gillnet	No records
Sardine	Yes[1,5]	No	Purse seine	Fishslips; Logbooks (2001-2013)
Salmon	Yes	No	Seine (50%) Gillnet (25%) Troll (25%)	Fish slips (1980-2004), Logbooks (2011-2013)
Shellfish				
Intertidal clam	No	No	Hand digging	No records
Crab	No	No	Trap	Fish slips
Euphausiid	Yes[1]	N	Plankton nets	No records
Geoduck and Horseclam	N	N	Dive	No records
Prawn/Shrimp by Trap	Yes[1,2,3]	N	Trap	Fish slips
Razor Clam	N	N	Hand digging	No records
Sea Cucumber Dive	N	N	Dive	No records
Sea Urchin Green	N	N	Dive	No records
Sea Urchin Red	N	N	Dive	No records
Shrimp by Trawl	Yes[3,4,5]	N	Trawl	Fishslip records

Note. Major fisheries groups are bolded. The various IFMPs provide various references to

management of shark, skates and rays. Description of these management activities are provided below.

[1] Basking Shark Sightings Network (reporting requirements)
[2] Basking shark entanglement protocol
[3] Licence holders are also permitted to fish for Schedule II species, as described in Schedule II Part 2 of the *Pacific Fishery Regulations*
[4] Basking Shark Conditions of Licence (SARA-compliant Fishing Licences)
[5] *Species at Risk Act* (SARA) elements, including three shark species listed under SARA
[6] Codes of Conduct for viewing Basking Sharks and/or disentangling sharks in various fishing gears
[7] Total Allowable Catch (TAC) set for Spotted Spiny Dogfish, Big Skate, and Longnnose Skate
[8] "Species of interest" program – sharks and skates highlighted as priority for logbook entries
[9] Big Skate and Longnose Skate Allocation Process
[10] Species for Schedule II include Spotted Spiny Dogfish, Skate (Rajidae)
[11] Trip limits of 6000 lbs for skates (for each licence: schedule II, Outside ZN Rockfish, Halibut, Sablefish); 50 lbs for skates (Inside ZN Rockfish licences)
[12] Request for logbooks to have gear/skate details filled in accurately
[13] Prohibition of Finning of Sharks (Groundfish trawl fleet)
[14] Prohibited species (Groundfish trawl) include Basking Shark, Tope (Soupfin) Shark, and Bluntnose Sixgill Shark
[15] Permitted species (Groundfish trawl): Big Skate, Longnose Skate, Starry Skate, Deepsea Skate, and Spotted Spiny Dogfish
[16] Species at Risk Shark Encounter Protocol
[17] All bycatch of sharks to be recorded in logbooks (Albacore Tuna Fleet)
[18] Species which have no commercial value may be returned to the sea alive immediately after hooking, as fish are caught individually and barbless hooks are commonly used, so stress and injuries can be kept to a minimum (Albacore Tuna Fleet)

Table 4

Datasets provided with all requested data categories where data were subject to "three-party rule", 1996-2013

	Dataset	# records	Categories of data (columns)					Source of data (Extent of reliability)
			Area captured	Gear	Weight	Species	Data withheld	
1	Fishslips (1982-1995)	1472	Stat Area Code	Code	Retained (lbs)	Code, common name	No	Fish slips (Reliable) *Note:* also includes value ($)
2	Fishslips (1996-2004)	497	DFO Area	Code	Retained (lbs)	Code, common name	Yes	Fish slips (Reliable) *Note:* also includes value ($)
3	Trawl (1980-1995)	1030	Major and Minor areas	Text	Retained, discarded (kg)	Code, common name	No	Fisher logbooks and sales slip data (Reliable) OR Dockside monitoring (less reliable)
4	PHT Trawl (1996-2007)	3268	PFMA	Text	Landed, Discarded (kg)	Code, common name, scientific name	Yes	At-sea observer coverage and dockside monitoring (Reliable)
5	FOS Trawl (2007-2013)	1434	PFMA	Text	Landed, Discarded (kg)	Code, common name, scientific name	Yes	At-sea observer coverage and dockside monitoring (Less reliable) *Note:* dataset is unmanaged

	Dataset	# records	Categories of data (columns)					Source of data (Extent of reliability)
			Area captured	Gear	Weight	Species	Data with held	
6	PHL Lines (2000-2006)	462	PFMA	Text	Catch (kg, pieces), Discarded (kg)	Code, common name, scientific name	Yes	Fisher logs and DMP (Reliable) *Note:* discards are likely incomplete and therefore an underestimate of what was actually released
7	PHS Lines (2000-2006)	207	PFMA	Text	Landed, Discarded (kg)	Code, common name, scientific name	Yes	Fisher logs and DMP (Reliable)
8	FOS Lines (2006-2013)	1472	PFMA	Text	Landed (kg, count), released (kg, count)	Code, common name, scientific name	Yes	Fisher logs and DMP *Note:* dataset is unmanaged (Less reliable) *Note:* count also provided for liced and bait fish

Table 5

Sector datasets provided with full weight, where categories were removed so "three-party rule" would not apply, 1996-2013

	Dataset	# records	Categories of data (columns)			Source of data (Extent of reliability)
			Sector	Weight	Species	
1	Fishslips (1996-2004)	68	Gear code (6 types)	Retained (pounds)	Code, common name	Fish Slips database New file, 3PR removed (reliable) *Note:* also includes value ($)
2	Trawl (1996-2007)	222	Sector (1 type)	Landed (kg), Discarded (kg)	Code, common name, scientific name	PHT database At-sea observer coverage and dockside monitoring (Reliable) *Different from above (1996 data onwards instead of 2000) (reliable)
3	FOS Trawl (2007-2013)	135	Sector (1 type)	Landed, Discarded (kg)	Code, common name, scientific name	FOS database At-sea observer coverage and dockside monitoring (Less reliable) *Note:* dataset is unmanaged
4	PHL Lines (2001-2006)	72	Sector (4 types)	Landed (kg), retained (pieces), discarded (kg)	Code, common name, scientific name	PHL database Merge of at-sea logbooks and landings data Discards likely underestimated (reliable)
5	PHS Lines (2000-2006)	57	Sector (1 type)	Landed (kg), discarded (kg)	Code, common name, scientific name	PHS Fisher logs and DMP (Reliable)

6	DMP Lines (1995-2005)	179	Sector (8 types)	Landed (kg), Landed (count)	Code, common name, scientific name	Landings data from the Dockside monitoring program (DMP) (less reliable) *Note:* no released data Includes line gears pre-2001, Halibut 1995-2005
7	FOS Lines (2006-2013)	216	Sector (7 types)	Landed (kg, count), released (kg, count)	Code, common name, scientific name	FOS database Fisher logs and DMP *Note:* dataset is unmanaged (Less reliable) *Note:* count also provided for liced and bait fish

Note: Categories removed included area and gear type, and data were rolled up into species by year, sector and weight. Further, note that two datasets provided data prior to 1996, in which the "3 party rule" was not applied and data not withheld. These two datasets (Fishslips, 1980-1995 and Trawl, 1980-1995) were also captured in Sector analysis, but not all sectors were known for Fishslip data as it was provided at gear type only.

Table 6

Percentage of weight (in tonnes) and fishing trips where data were withheld, subject to "three-party Rule", 1996-2013

Year	Total weight, Data not withheld	Total weight, data withheld	Percentage of fishing trips with data withheld	Percentage of weight where data was withheld
1996	7,740.1	3,887.7	8.5%	49.8%
1997	6,736.2	4,741.3	9.0%	29.6%
1998	6,703.5	4,293.9	12.6%	35.9%
1999	8,764.1	5,575.4	16.7%	36.4%
2000	9,578.4	4,705.7	11.2%	50.9%
2001	7,101.3	6,696.0	3.1%	5.7%
2002	7,911.4	7,549.2	2.1%	4.6%
2003	9,934.3	9,137.1	1.8%	8.0%
2004	9,213.8	8,430.9	2.7%	8.5%
2005	9,190.5	8,540.3	2.1%	7.1%
2006	5,413.8	3,456.2	15.5%	36.2%
2007	6,708.1	5,365.5	10.4%	20.0%
2008	4,353.8	3,486.0	9.4%	19.9%
2009	6,745.5	5,831.6	12.4%	13.6%
2010	3,920.3	2,988.3	13.9%	23.8%
2011	3,409.9	2,813.2	8.0%	17.5%
2012	2,509.9	1,679.6	14.9%	33.1%
2013	1,974.7	1,325.7	11.6%	32.9%
Total	117,909.6	90,503.6	9.2%	23.2%

Table 7

Percentage of fishing trip records where data were withheld per species, 1996-2013

Species	# of fishing trips	Percentage of fishing trips where data withheld
Spotted Spiny Dogfish	2112	15.9%
Big Skate	1272	9.8%
Longnose Skate	1379	11.0%
Unidentified skate	617	11.0%
Other species	2401	1.5%
Total	7781	9.2%

Table 8

Percentage of fishing trip records where data were withheld per gear types, 1996-2013

Gear Type	Number of fishing trips per gear type	Percentage of fishing trips where data withheld
Line	556	21.8%
Trawl	150	2.9%
Trap	6	7.3%
Net	4	57.1%
Total	716	9.2%

Table 9

Percentage of fishing trips where data were withheld per geographic region, 1996-2013

Geographic area	Percentage of fishing trips within area	Percentage of fishing trips where data withheld
WCVI	30.8%	7.2%
QC Sound	17.3%	3.9%
Hecate Strait	14.8%	6.5%
ECVI (inside waters)	11.9%	15.8%
North Coast	9.4%	6.6%
Central Coast	6.8%	25.6%
Haida Gwaii	5.7%	15.2%
Unidentified	3.4%	2.3%
International waters	0.01%	100%

Table 10

Weight (in tonnes) and percentage of catch records retained and released, 1980-2013

Year	Total catch	Catch retained	Percentage of catch retained	Catch released	Percentage of catch released
1980	5,852.6	3,125.3	53.4%	2,727.4	46.6%
1981	2,547.2	877.5	34.5%	1,669.7	65.6%
1982	5,898.3	4,022.2	68.2%	1,876.1	31.8%
1983	3,270.3	2,161.8	66.1%	1,108.5	33.9%
1984	3,522.5	2,433.2	69.1%	1,089.3	30.9%
1985	6,440.2	5,135.6	79.7%	1,304.6	20.3%
1986	6,790.0	6,055.3	89.2%	734.7	10.8%
1987	7,678.3	6,269.9	81.7%	1,408.4	18.3%
1988	9,613.7	8,115.2	84.4%	1,498.5	15.6%
1989	5,750.3	4,297.0	74.7%	1,453.3	25.3%
1990	7,648.4	5,759.0	75.3%	1,889.4	24.7%
1991	6,783.2	4,485.7	66.1%	2,297.5	33.9%
1992	5,553.6	3,305.6	59.5%	2,248.0	40.5%
1993	3,159.9	1,291.4	40.9%	1,868.4	59.1%
1994	4,634.6	2,794.7	60.3%	1,839.9	39.7%
1995	5,590.0	4,532.4	81.1%	1,057.6	18.9%
1996	7,740.1	5,469.1	70.7%	2,271.0	29.3%
1997	6,736.2	5,053.4	75.0%	1,682.9	25.0%
1998	6,703.5	4,478.3	66.8%	2,225.2	33.2%
1999	8,764.1	7,338.6	83.7%	1,425.4	16.3%
2000	9,578.2	8,098.1	84.6%	1,480.1	15.5%
2001	7,101.4	5,550.2	78.2%	1,551.3	21.8%
2002	7,911.4	6,243.3	78.9%	1,668.1	21.1%
2003	9,934.2	8,063.6	81.2%	1,870.6	18.8%
2004	9,213.8	7,212.0	78.3%	2,001.8	21.7%
2005	9,190.5	7,015.0	76.3%	2,175.5	23.7%
2006	5,413.8	4,142.3	76.5%	1,271.5	23.5%
2007	6,708.1	5,298.8	79.0%	1,409.3	21.0%
2008	4,353.8	3,089.6	71.0%	1,264.2	29.0%
2009	6,745.5	5,219.0	77.4%	1,526.5	22.6%
2010	3,920.3	2,904.7	74.1%	1,015.6	25.9%
2011	3,409.9	2,319.0	68.0%	1,090.9	32.0%
2012	2,509.9	1,855.8	73.9%	654.1	26.1%
2013	1,974.7	1,352.8	68.5%	621.9	31.5%
Total	208,642.5	155,365.4	74.5%	53,277.2	25.5%

Table 11

Comparison of total, retained, and released elasmobranch catch (in tonnes) before and after the changes to fisheries management in 1995

Years	Total catch	% of total weight	Retained	% Retained	Released	% Released
1980-1995	90,733.1	43.5%	64,661.7	71.3%	26,071.3	28.7%
1996-2013	117,909.5	56.5%	90,703.6	76.9%	27,205.9	23.1%
Total	208,642.6		155,365.3		53,277.2	

Table 12

Percentage of total catch (in tonnes) proportionate to species over period of 1980-2013

Species	Total catch	% of total
Spotted Spiny Dogfish	167,351.0	80.2%
Big Skate	18,766.6	9.0%
Unidentified Skate	13,437.9	6.4%
Longnose Skate	8,221.3	3.9%
Other species	865.8	0.4%
Total	208,642.6	

Table 13

Proportion of managed and non-directed elasmobranch catch (in tonnes) within Canadian Pacific waters, 1980-2013

Year	Managed catch	% of total catch for year	Non-directed catch	% of total catch for year
1980	5,313.5	90.8%	539.1	9.2%
1981	2,255.2	88.5%	292.0	11.5%
1982	5,571.5	94.5%	326.8	5.5%
1983	2,657.3	81.3%	613.0	18.7%
1984	2,937.7	83.4%	584.7	16.6%
1985	5,859.9	91.0%	580.3	9.0%
1986	6,053.5	89.2%	736.5	10.8%
1987	6,578.7	85.7%	1,099.6	14.3%
1988	8,674.6	90.2%	939.1	9.8%
1989	5,162.9	89.8%	587.4	10.2%
1990	7,225.0	94.5%	423.4	5.5%
1991	6,050.7	89.2%	732.5	10.8%
1992	4,933.1	88.8%	620.5	11.2%
1993	2,565.3	81.2%	594.6	18.8%
1994	3,529.6	76.2%	1,105.0	23.8%
1995	4,118.4	73.7%	1,471.6	26.3%
1996	6,856.6	88.6%	883.6	11.4%
1997	6,533.5	97.0%	202.8	3.0%
1998	6,562.6	97.9%	140.9	2.1%
1999	8,375.8	95.6%	388.3	4.4%
2000	9,103.2	95.0%	475.2	5.0%
2001	6,918.6	97.4%	182.6	2.6%
2002	7,720.4	97.6%	191.0	2.4%
2003	9,847.9	99.1%	86.4	0.9%
2004	9,119.1	99.0%	94.6	1.0%
2005	9,117.2	99.2%	73.3	0.8%
2006	5,355.8	98.9%	58.0	1.1%
2007	6,644.5	99.1%	63.6	0.9%
2008	4,321.8	99.3%	32.0	0.7%
2009	6,709.6	99.5%	35.9	0.5%
2010	3,876.5	98.9%	43.8	1.1%
2011	3,376.5	99.0%	33.4	1.0%
2012	2,469.8	98.4%	40.1	1.6%
2013	1,942.8	98.4%	31.9	1.6%
Total	194,339.1	93.1%	14,303.5	6.9%

Table 14

Estimated number of elasmobranchs intercepted in commercial fisheries, 1980-2013

Species	Total catch, 1980-2013 (tonnes)	Average weight per species (kg)	Estimated # of individuals intercepted
Sharks	167,673.9		62,014,305
Basking Shark	10.4	3,900.0[1]	3
Bigeye Thresher Shark	29.4	99.0[1]	297
Blue Shark	15.8	52.0[1]	304
Bluntnose Sixgill Shark	22.7	60.0[2]	379
Broadnose Sevengill Shark	0	40.5[3]	0
Brown Cat Shark	34.7	1.4[4]	24,786
Common Thresher Shark	0.1	122.0[1]	1
Cow Sharks (unspecified)	2.5	30.3[5]	83
Greeneye Shark	0	Unknown	0
Pacific Sleeper Shark	119.3	28.5[6]	4,186
Salmon Shark	9.2	12.1[7]	761
Shortfin Mako Shark	0	54.0[1]	0
Soupfin (Tope) Shark	7.1	27[2]	263
Spotted Spiny Dogfish	167,351.0	2.7[8]	61,981,852
White Shark	0	141[1]	0
Unidentified shark	71.7	51.6[9]	1,390
Skates and Rays	40,967.7		7,706,682
Abyssal Skate	32.1	3.9[10]	8,231
Alaska Skate	19.7	5.6[11]	3,518
Aleutian Skate	4.5	4.4[11]	1,023
California Skate	0	3.9[10]	0
Big Skate	18,766.6	8.2[12]	2,288,610
Broad Skate	0.7	3.9[10]	180
Longnose Skate	8,221.3	4.9[12]	1,677,817
Pacific Electric Ray	0.7	3.9[10]	180
Roughtail Skate	87.0	0.8[13]	108,750
Sandpaper Skate	397.4	2.3[14]	172,783
Starry Skate	0.0	3.9[10]	0
Whitebrow Skate	0	1.03[11]	0
Unidentified skate	13,437.8	3.9[10]	3,445,590
Total – elasmobranchs	208,641.6		69,720,987

Note. Bolded text represents the total number for sharks, skates and rays, and total elasmobranchs. Average weights were identified in published literature or estimated from average weights. This is considered a conservative estimate. Data for average weights are from

Kohler, Casey and Turner (1996)[1]; Fisheries and Oceans Canada (2012b)[2]; Vandykhuizen and Mollet (1992)[3]; Orlov and Moiseev (1999)[6]; McKinnel and Seki (1998)[7]; Fisheries and Oceans Canada (2014a)[8]; Orlov, Tokranov and Fatykhov (2006)[11]; Thorson (1958)[12]; Olov and Tokranov (2005)[13]; and Ainsley, Ebert and Cailliet (2011)[14]. Where no reference for average weights were found, weight was based on similar species, as follows: weight for Brown Cat Shark based on maximum total length (68cm) against Spotted Spiny Dogfish (130cm) derived from Fish Base, multiplied by the average weight of Spotted Spiny Dogfish (2.72kg) to get 1.42 kg[4]; weight for cow sharks (unspecified) based on average weight of the two Hexanchidae known in Canadian Pacific waters (*Hexanchus griseus* and *Notorynchus cepedianus*)[5]; average weight for unidentified shark was derived by taking the average weight of all other known shark species within Canadian Pacific waters, with the exception of Basking Sharks given their size and easy identification/rarity[9]; and an average weight for unidentified skates was derived by taking the average weight of all other known skate species within Canadian Pacific waters[10].

Table 15

Estimated number of elasmobranch species intercepted per year in commercial fisheries, 2003-2013

Species	Total catch, 2003-2013 (tonnes)	Average weight per species (kg)	Estimated number of individuals intercepted per annum
Sharks	46,687.4		1,568,277
Basking Shark	7.0	3,900.0[1]	<1
Bigeye Thresher Shark	0	99.0[1]	0
Blue Shark	11.6	52.0[1]	21
Bluntnose Sixgill Shark	6.9	60.0[2]	11
Broadnose Sevengill Shark	0.0	40.5[3]	0
Brown Cat Shark	22.0	1.4[4]	1,429
Common Thresher Shark	0	122.0[1]	0
Greeneye Shark	0	Unknown	0
Mackerel Sharks	0.1	51.6[5]	<1
Pacific Sleeper Shark	81.5	28.5[6]	260
Salmon Shark	7.2	12.1[7]	55
Shortfin mako shark	0	54.0[1]	0
Soupfin (Tope) Shark	5.7	27[2]	20
Spotted Spiny Dogfish	46,523.3	2.7[8]	1,566,442
White Shark	0	141[1]	0
Unidentified shark	22.0	51.6[5]	39
Skates and Rays	16,687.2		256,515
Abyssal Skate	22.3	3.9[9]	520
Alaska Skate	5.7	5.6[10]	93
Aleutian Skate	4.5	4.4[10]	93
California Skate	0	3.9[9]	0
Big Skate	10878.7	8.2[11]	120,607
Broad Skate	0.01	3.9[9]	<1
Longnose Skate	5379.4	4.9[11]	99,804
Roughtail Skate	53.5	3.9[9]	1,248
Sandpaper Skate	289.3	0.8[12]	32,875
Starry Skate	0	2.3[13]	0
Whitebrow Skate	0	3.9[9]	0
Pacific Electric Ray	0.3	1.03[10]	27
Unidentified skate	53.5	3.9[9]	1,248
Total – elasmobranchs (2003-2013)	63,374.6		1,824,792

Note. Bolded text represents the total number for sharks, skates and rays, and total elasmobranchs. Average weights were identified in published literature or estimated from average weights. This is considered a conservative estimate. Data for average weights are from Kohler, Casey and Turner (1996)[1]; Fisheries and Oceans Canada (2012b)[2]; Vandykhuizen and Mollet (1992)[3]; Orlov and Moiseev (1999)[5]; McKinnel and Seki (1998)[6]; Fisheries and Oceans Canada (2014a)[7]; Orlov, Tokranov and Fatykhov (2006)[10]; Thorson (1958)[11]; Olov and Tokranov (2005)[12]; and Ainsley, Ebert and Cailliet (2011)[13]. Where no reference for average weights were found, weight was based on similar species, as follows: weight for Brown Cat Shark based on maximum total length (68cm) against Spotted Spiny Dogfish (130cm) derived from Fish Base, multiplied by the average weight of Spotted Spiny Dogfish (2.72kg) to get 1.42 kg[4]; average weight for unidentified shark was derived by taking the average weight of all other known shark species within Canadian Pacific waters, with the exception of Basking Sharks given their size and easy identification/rarity[8]; and an average weight for unidentified skates was derived by taking the average weight of all other known skate species within Canadian Pacific waters[9].

Table 16

Total catch recorded (in tonnes) per fishing fleet for each year, 1980-2013

Year	Groundfish Trawl	Spotted Spiny dogfish	Unknown	Groundfish Line	Salmon	Shellfish
1980	5,852.6					
1981	2,547.2					
1982	5,048.2		849.5		0.6	0.0
1983	3,054.9		215.1		0.3	
1984	3,221.0		300.5		0.6	0.4
1985	5,554.4		878.2		7.2	0.5
1986	5,990.1		787.7		4.9	7.2
1987	5,266.0		2,403.3		8.6	0.4
1988	6,066.1		3,521.0		26.7	0.0
1989	3,970.8		1,768.5		11.0	0.1
1990	4,817.3		2,818.8			12.4
1991	4,633.6		2,149.6			0.0
1992	3,688.8		1,864.8		0.0	
1993	2,479.5		680.2		0.0	0.1
1994	3,005.7		1,623.2		5.7	
1995	2,916.7		2,569.4	84.8	18.1	0.9
1996	3,616.5	3,308.3	349.2	465.9	0.2	
1997	3,356.1	1,740.7	1,452.8	186.5		
1998	3,047.8	2,261.2	1,299.9	90.7	4.0	
1999	3,042.1	2,887.4	2,611.4	190.7	32.5	
2000	2,997.0	4,254.6	1,830.0	492.6	4.1	
2001	3,036.5	3,696.7		368.2		
2002	3,412.2	4,123.2		376.0		
2003	3,770.7	5,306.2	0.2	857.2		
2004	3,641.7	4,737.5	0.3	834.3		
2005	3,995.7	4,438.9		755.9		
2006	3,018.5	1,887.4		507.8		
2007	2,783.7	3,312.2		612.2		
2008	2,091.4	1,638.5		624.0		
2009	2,812.5	3,083.0		850.1		
2010	2,042.7	1,029.0		848.5		
2011	2,471.4	485.0		453.6		
2012	1,342.4	603.0		564.5		
2013	1,303.2	331.2		340.3		
Total	119,895.0	49,124.0	29,973.6	9,503.8	124.5	22.0
% of total (208,642.6 tonnes)	57.5%	23.5%	14.4%	4.6%	0.1%	0.0%

Table 17

Total elasmobranch catch (count) recorded within the Commercial Salmon Fisheries logbooks, 2011-2013

Year	Species	Retained	Released	Total catch (number of individuals)
2011	Blue Shark		28	28
2011	Salmon Shark		3	3
2011	Spotted Spiny Dogfish	179	3751	3930
2012	Blue Shark		4	4
2012	Salmon Shark		2	2
2012	Spotted Spiny Dogfish	31	342	373
2012	Unidentified skate		1	1
2013	Blue Shark		3	3
2013	Salmon Shark		2	2
2013	Spotted Spiny Dogfish	4	235	239
Total		214	4371	4585

Note. Commercial Salmon Fisheries logbook records are available from 2002-2013, but records were only provided for 2011-2013 at time of writing.

Table 18

Total elasmobranch catch (count) recorded within the commercial Albacore Tuna Fishery logbooks, 1998-2013

Year	Species	Retained	Released	Total catch (number of individuals)
1998	Bigeye Thresher Shark	1		1
1999	Blue Shark	1		1
2000	Unidentified shark	Unknown		Unknown
2003	Bigeye Thresher Shark	8		8
2005	Bigeye Thresher Shark	6		6
2010	Unidentified shark	1		1
2011	Bigeye Thresher Shark	9		9
2011	Shortfin Mako Shark	2		2
2013	Bigeye Thresher Shark	1	3	4
2013	Unidentified shark	0	1	1
Total		30	4	33

Note. Commercial Albacore Tuna Fisheries logbook records were available from 1988-2013, but there were no records of elasmobranch species until 1998.

Table 19

Total elasmobranch catch recorded within the Commercial Sardine Fishery logbooks, 2001-2012

Year	Species	Total catch (tonnes)	Average weight per species (kg)	Estimated number of individuals intercepted, 2001-2012
2001	Spotted Spiny Dogfish	0.1	2.7	37
2002	Spotted Spiny Dogfish	2.3	2.7	852
2003	Spotted Spiny Dogfish	0.1	2.7	37
2004	Spotted Spiny Dogfish	2.5	2.7	926
2005	Spotted Spiny Dogfish	3.2	2.7	1186
2005	Unidentified skate	0.0	3.9	0
2006	Spotted Spiny Dogfish	0.1	2.7	37
2007	Spotted Spiny Dogfish	0.4	2.7	149
2008	Spotted Spiny Dogfish	10.7	2.7	3963
2008	Pacific Electric Ray	0.0	3.9	0
2009	Spotted Spiny Dogfish	1.1	2.7	408
2010	Spotted Spiny Dogfish	2.0	2.7	741
2011	Bluntnose Sixgill Shark	0.1	20.0	5
2011	Blue Shark	0.0	66.0	0
2011	Spotted Spiny Dogfish	0.7	2.7	260
2011	Unidentified skate	0.0	3.9	0
2012	Spotted Spiny Dogfish	0.2	2.7	75
Total		23.6	NA	8,676

Note. There was no commercial Sardine fishery in 2013, thus no records of elasmobranch catch for that year.

Table 20

Number of fishing trips that intercepted elasmobranch species by geographic area

Area	Spotted Spiny Dogfish	Big skate	Longnose skate	Unidentified skate	All other species	Total # of trips	% of total trips
West Coast Vancouver Island (WCVI)	940	344	400	516	969	3,169	29.8%
East Coast Vancouver Island (ECVI, or inside waters)	968	195	185	589	110	2,047	19.2%
Queen Charlotte Sound (QC Sound)	305	191	222	122	518	1,358	12.8%
Hecate Strait	287	201	203	117	394	1,202	11.3%
Central Coast	449	110	139	313	48	1,059	10.0%
North Coast	249	132	123	182	235	921	8.7%
Haida Gwaii	176	64	69	140	164	613	5.8%
Unidentified areas	61	41	42	19	111	274	2.6%
International waters	2	0	0	0	1	3	0.0%
Total	3437	1278	1383	1998	2550	10,646	

Table 21

Species composition within each large geographic area as a percentage of fishing trip records, 1980-2013

Area	Spotted Spiny Dogfish	Big Skate	Longnose Skate	Unidentified skate	All other species
West Coast Vancouver Island (WCVI)	29.7%	10.9%	12.6%	16.3%	30.6%
East Coast Vancouver Island (ECVI, or inside waters)	47.3%	9.5%	9.0%	28.8%	5.4%
Queen Charlotte Sound (QC Sound)	47.3%	9.5%	9.0%	28.8%	5.4%
Hecate Strait	23.9%	16.7%	16.9%	9.7%	32.8%
Central Coast	22.5%	14.1%	16.4%	9.0%	38.1%
North Coast	27.0%	14.3%	13.4%	19.8%	25.5%
Haida Gwaii	28.7%	10.4%	11.3%	22.8%	26.8%
Unidentified areas	23.9%	16.7%	16.9%	9.7%	32.8%
International waters	66.7%	0.0%	0.0%	0.0%	33.3%

Table 22

Proportion of species within each large geographic area, 1980-2013

Area	Species				
	Spotted Spiny Dogfish	Big Skate	Longnose Skate	Unidentified skate	All other species
West Coast Vancouver Island (WCVI)	27.4%	26.9%	28.9%	25.8%	38.0%
East Coast Vancouver Island (ECVI, inside waters)	28.2%	15.3%	13.4%	29.5%	4.3%
Queen Charlotte Sound (QC Sound)	8.9%	15.0%	16.1%	6.1%	20.3%
Hecate Strait	8.4%	15.7%	14.7%	5.9%	15.5%
Central Coast	8.9%	15.0%	16.1%	6.1%	20.3%
North Coast	8.9%	15.0%	16.1%	6.1%	20.3%
Haida Gwaii	8.4%	15.7%	14.7%	5.9%	15.5%
Unidentified areas	5.1%	5.0%	5.0%	7.0%	6.4%
International waters	7.2%	10.3%	8.9%	9.1%	9.2%

Table 23

Proportion of elasmobranchs within each IUCN status level

Group	CR	EN	VU	NT	LC	DD	ALL
Sharks	0	1	5	3	2	3	14
Skates and Rays	0	0	0	1	9	2	12
Total species	0	1	5	4	11	5	26
Percentage of assessed	0%	3.8%	19.2%	15.4%	42.3%	19.2%	100%

Note. CR = critically endangered, EN = endangered, VU = vulnerable, NT = near threatened, LC = least concern, and DD = data deficient, as per IUCN Red List categories (Figure 12; IUCN, 2012).

Table 24

Estimated number of elasmobranchs per COSEWIC status level intercepted annually in commercial fisheries within Canadian Pacific waters, 2003-2013

COSEWIC status level	Species	Estimated # of individuals intercepted (rounded) annually
Extinct		0
Extirpated		0
Endangered	Basking Shark	<1
Threatened		0
Special Concern	Bluntnose Sixgill Shark	11
	Soupfin (Tope) Shark	20
	Spotted Spiny Dogfish	1,556,442
Data Deficient	Blue Shark	21
	Brown Cat Shark	1,429
	White Shark	0
Not at Risk	Big skate	120,607
	Longnose Skate	99,804
	Sandpaper Skate	32,875
Not Yet Assessed	Bigeye Thresher Shark	0
	Broadnose Sevengill Shark	0
	Common Thresher Shark	0
	Shortfin Mako	0
	Greeneye Shark	0
	Pacific Sleeper Shark	260
	Salmon Shark	55
	Abyssal Skate	520
	Alaska Skate	93
	Aleutian Skate	93
	Broad Skate	<1
	California Skate	0
	Pacific Electric Ray	27
	Roughtail Skate	1,248
	Sandpaper Skate	32,875
	Starry Skate	0
	Whitebrow Skate	0

Table 25

Proportion of elasmobranchs within each COSEWIC category

Group	E	T	SC	DD	NAR	NYA	ALL
Sharks	1	0	3	3	0	7	14
Batoids	0	0	0	0	2	10	12
Total species	1	0	3	3	2	17	26
Percentage of assessed	3.8%	0%	11.5%	11.5%	7.7%	65.4%	100%

Note. E = endangered, T = threatened, SC = special concern, DD = data deficient, NAR = not at risk, NYA = not yet assessed, as per COSEWIC status levels (Figure 12; COSEWIC, 2011).

Table 26

Estimated number of elasmobranchs per IUCN status level intercepted annually in commercial fisheries within Canadian Pacific waters, 2003-2013

IUCN category (Global, except where noted with * for regional)	Species	# of individuals intercepted annually
Extinct		0
Extinct in the Wild		0
Critically Endangered		0
Endangered	Basking Shark	<1
Vulnerable	Bigeye Thresher Shark	0
	Common Thresher Shark	0
	Spotted Spiny Dogfish	1,566,442
	Soupfin (Tope) Shark	20
	White Shark	0
Near Threatened	Blue Shark	21
	Bluntnose Sixgill Shark	11
	Shortfin Mako	0
	Big skate	120,607
Least Concern	Greeneye Shark	0
	Salmon Shark	55
	Alaska Skate	93
	Aleutian Skate	93
	Broad Skate	<1
	Longnose Skate	99,804
	Roughtail Skate	1,248
	Sandpaper Skate	32,875
	Starry Skate	0
	Whitebrow Skate	0
	Pacific Electric Ray	27
Data Deficient	Broadnose Sevengill Shark	0
	Brown Catshark	1,472
	Pacific Sleeper Shark	260
	Abyssal Skate	520
	California Skate	0
Not Evaluated		0