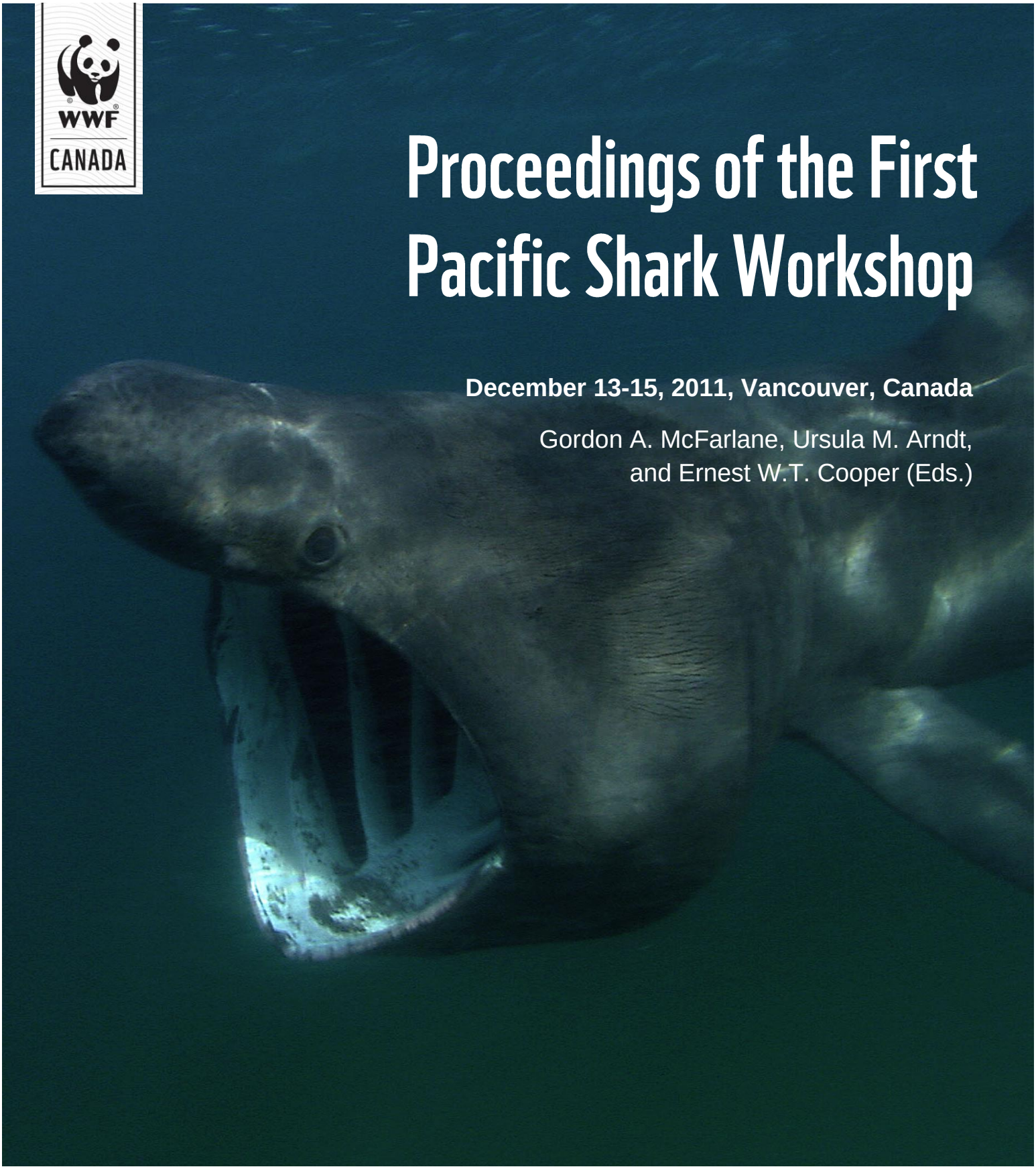
WWF CANADA

Proceedings of the First Pacific Shark Workshop

December 13-15, 2011, Vancouver, Canada

Gordon A. McFarlane, Ursula M. Arndt,
and Ernest W.T. Cooper (Eds.)



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Cover photo of a basking shark (*Cetorhinus maximus*): © Florian Graner / WWF-Canon(GPN #225022)

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Introduction

Background

Shark conservation and management is being recognized as a major environmental concern, emerging as a new priority in marine conservation. In 1999 the Food and Agriculture Organization (FAO) developed an international framework for shark conservation. This framework recommended that all States with fisheries that impacted shark species should participate in their management and develop National Plans of Action (NPOA) to identify information gaps, issues and priorities for their conservation and management. Until recently, there has been little action undertaken to manage and protect elasmobranch[1] species in Canadian waters. Canada developed a NPOA; however, the plan does not specify actions, priorities or timelines to assess or mitigate threats to non-commercial or most other threatened species. Recently Canada listed three species of shark found in the waters off its Pacific coast under the Species at Risk Act (SARA): the basking shark (Cetorhinus maximus), tope (Galeorhinus galeus) and bluntnose sixgill (Hexanchus griseus). The recovery and management plans for these species can be found at www.sararegistry.gc.ca. Recommendations in these plans identified the need for more stakeholder input on issues relating to elasmobranch research needs, management and conservation.

In response to this, WWF-Canada hosted a regional shark forum (workshop) on the Atlantic (see Top priorities for future conservation and management for sharks in Atlantic Canada, WWF http://atlanticsharks.org/) and Pacific coasts. The Pacific workshop brought together relevant stakeholders, (including several international experts) from academia, government, NGOs and industry to discuss the most pressing issues within three overarching categories in regards to shark conservation: science, policy/management and on-the-water practice.

The workshop agenda included 1.5 days of presentations, followed by a day of break-out groups and discussion regarding the major priorities around shark conservation and management in Pacific Canada and adjacent regions. Presentations provided the background on current biological, management and conservation concerns as well as identifying industry and other stakeholder issues. Participants were provided with draft priority lists for the most pressing issues, gaps, and/or questions serving as a "straw-man proposal" or starting point to help seed and focus discussion and debate.

[1] Elasmobranchs include all species of sharks, skates, rays and chimaeras

Goal

The *Pacific Shark Workshop* was intended to bring together relevant stakeholders, including several sections of Fisheries and Oceans Canada (DFO), key fishermen and fisheries representatives from relevant gear sectors, Non-governmental Organizations (NGOs), academics and shark specialists from the US and Mexico, to discuss the most pressing issues for sharks in Pacific Canada within three overarching categories: science, policy/management and on-the-water practice.

The specific goal of the workshop was to produce a top-ten list of issues, gaps, and/or questions within these categories as well as a cross-cutting list of priorities which would advance the conservation and management of shark species in Pacific Canadian waters. As well, participants identified a number of "next steps" which, it is hoped, will lead to further collaborative initiatives.

As discussions at the workshop proceeded it was clear that the issues, gaps and priorities identified for sharks applied equally to skates, rays and chimaeras, therefore the priorities and next steps apply to all Elasmobranchs, and are presented as such.

Presentation Summaries

Sharks in Pacific Canada: Research, Bycatch and Distribution

Jacquelynne R. King
Canadian Pacific Shark Research Lab

There are 14 species of sharks recorded in British Columbia waters. Several of these species are encountered infrequently, or rarely, with reported encounters occurring only once. The rare species include common thresher shark (*Alopias vulpinus*), shortfin mako shark (*Isurus oxyrinchus*), great white shark (*Carcharodon carcharias*), sevengill shark (*Notorynchus cepedianus*), green eye shark (*Etmopterus villosus*) and smooth hammerhead shark (*Sphyrna zygaena*). It is important to note that some of these recordings have occurred only once, as for shortfin mako shark, or have occurred only historically, such as two records of smooth hammerhead shark in the 1950s. The green eye shark was documented several times in the 1990s, however confirmation of this species' identification has not been made. The bigeye thresher shark (*Alopias superciliosus*) occurs infrequently throughout British Columbia waters. Of special note is the basking shark (*Cetorhinus maximus*), which is a migratory species inhabiting the California Current System. It used to occur in large numbers off the British Columbia coast in summer, however due to a Canadian eradication program in the 1960s and historical Canadian and US fisheries, it is rarely seen in our waters. The basking shark has been listed as Endangered in Pacific Canada under the *Species at Risk Act*, and is now legally afforded complete protection.

Remaining are seven shark species that are commonly encountered in British Columbia waters: spiny dogfish (*Squalus suckleyi*), blue shark (*Prionace glauca*), salmon shark (*Lamna ditropis*), bluntnose sixgill shark (*Hexanchus griseus*), tope shark (*Galeorhinus galeus*), Pacific sleeper shark (*Somniosus pacificus*) and brown cat shark (*Apristurus brunneus*). Life history parameters, depth and spatial distribution of each common shark species were reviewed. These common sharks range in size from 68 cm in maximum length (brown cat shark) to 4.8 m in length (bluntnose sixgill shark). Of species for which we currently have age estimation methods, the oldest maximum age is for the spiny dogfish (100+ years) and the youngest maximum age is for blue shark (20 years). For some species, such as the brown cat shark and the Pacific sleeper shark, age estimation methods have yet to be discovered, and for only the spiny dogfish are there validated age determination methods. Catch per unit effort data available from groundfish trawl (kg/hour) and from groundfish bottom longline (kg/hooks) were used to identify areas of relative high encounters (hot spots) for these common sharks.

Of these sharks, only spiny dogfish has a targeted fishery. It has been commercially exploited in British Columbia since the 1870s and has several boom and bust eras: the lubrication and lighting era (1870-1916); the industrial oil and meal era (1917-1939); the great liver era for Vitamin A (1940-1960) during which annual removals ranged from 15,000-30,000 tonnes; the government subsidy era (1961-1974); the food fish era (1974-current). DFO conducted the largest known shark tagging study, with over 77,000 spiny

dogfish tagged in the 1970s. Results from recoveries helped to determine stock delineation, with two apparent stocks within Canadian waters: inside stock (Strait of Georgia which could include Puget Sound) and outside stock (all remaining British Columbia waters). Currently, the groundfish fishery harvests approximately 4,500 tonnes annually. The current total allowable catch (coast wide) is 14,000 tonnes. The spiny dogfish fishery received Marine Stewardship Certification in September 2011. In November 2011, the Pacific spiny dogfish has been recommended by the Canadian Committee on the Status of Endangered Wildlife in Canada to be listed as a Species of Concern under the *Species at Risk Act*. Life history characteristics such as longevity and low fecundity, coupled with a change in the size distribution (smaller individuals) of commercial landings for the inside stock flagged this species for recommendation. A decision on listing will likely be made in 2013. The spiny dogfish is one of the most well studied sharks, with the supportive research provided by DFO since the 1970s. It has a validate age methodology, which translates into robust growth curve estimates and age at maturity estimates. The fishery is well monitored, with discard data available from at sea observers or electronic-monitoring validated fisher logbooks.

Data sources for shark bycatch in commercial fisheries vary by fishery type and gear type, as does reliability. As mentioned, the groundfish fisheries are the most monitored and discards at sea are recorded by at sea observers (trawl gear are recorded in fisher logbooks (line or trap gear). All line and trap vessels have electronic monitoring which records the catch on video as it comes out of the water. A proportion of the video is watched by an independent observer and compared to logbook records as a means of validating. Erroneous logbook records can trigger 100% video watching, at the expense of the fisher. Sharks are encountered as bycatch in salmon gillnet, seine and troll fisheries; however all discards are recorded in logbooks. The accuracy of the salmon logbooks is unknown. Pelagic sharks, such as blue shark, are likely encountered by the tuna fleet, however discards are recorded in logbooks and the extreme low rate of reporting (3 sharks in 14 years) suggests these records are unreliable. Efforts to improve all bycatch reporting in tuna fisheries in 2011 have led to a dramatic increase (8 sharks) in the number of records. Spiny dogfish, blue shark and salmon sharks are encountered in the recreational fishery. However, creel survey programs do not include sharks as species of interest in dockside interviews so bycatch data are likely unreliable. Excluding spiny dogfish, only about 36 tonnes of sharks are caught as bycatch in commercial and recreational fisheries. The majority of this bycatch is comprised of Pacific sleeper shark, bluntnose sixgill shark and blue shark. However, when bycatch in tonnes is converted to bycatch in pieces using the fishery-specific average weight per species, brown cat shark is the dominate species of bycatch in British Columbia. In 2011, DFO produced the widely popular “Sharks of BC” identification guide and distributed it to commercial and recreational fishers in order to improve their identification of shark bycatch.

There are several research projects underway in DFO to address missing information on the biology and life history parameters of the sharks that occur in our waters. Specifically, projects on developing new age determination methods and estimating growth curve parameters for bluntnose sixgill, Pacific sleeper shark and brown cat shark. In addition, there are several projects using satellite tagging technology to determine migration or residency of several sharks, such as blue shark, tope shark and bluntnose sixgill and hopefully basking shark. Aerial surveys and boat survey counts for

blue shark have been investigated for their utility in providing abundance estimates. A targeted spiny dogfish survey is conducted every three years in the Strait of Georgia to provide an index of relative abundance and any relevant biological data. Stock delineation of blue shark, salmon shark, spiny dogfish and sixgill sharks are being determined using population genetics. All of the research conducted will hopefully translate into stock assessments to determine stock status of all sharks in British Columbia.

Though not formally presented, similar research efforts are underway for the skates and ratfish that inhabit British Columbia waters. Skates are caught as bycatch, primarily in the groundfish commercial fisheries. Targeted fisheries for big skate and longnose skate exist, and they are landed primarily by longline gear fisheries. Similar identification guide is being produced in order to distribute to on the water users in order to improve skate bycatch. Stock assessments for big skate and longnose skate will be undertaken in the next 1-2 years, and a stock assessment for ratfish is being planned in the next 5 years.

Shark Management and Monitoring in British Columbia

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Fisheries and Oceans Canada, Regional Manager - Groundfish

Background

There are no targeted commercial fisheries for sharks in British Columbia (B.C.) with the exception of spiny dogfish (*Squalus suckleyi*). The first commercial fishery for spiny dogfish began in the 1870's to exploit the commercial market for oil. The major fishery for dogfish occurred from 1937 to 1949 as a consequence of the strong market for livers as a source of vitamin A. The fishery collapsed almost completely with the introduction of synthetic vitamin A in 1950. In addition, the bluntnose sixgill shark (*Hexanchus griseus*) has been the focus of at least three known directed fisheries in Canadian Pacific waters from the 1920s to the early 1990s with focus on harvest for leather and vitamin A. Similarly, the tope (Soupfin) shark (*Galeorhinus galeus*) was the target of a brief but extensive commercial fishery in the early 1940's, but by 1946 the fishery had diminished.

Historic Management and Monitoring

Prior to 1977 there was no active management in place for spiny dogfish or any shark species in Canadian waters. However, in 1977, Canada declared a 200-mi exclusive economic zone. This required that Canada actively assess and manage fisheries stocks, including spiny dogfish. From 1977 to present, spiny dogfish have been managed under Schedule II: Other species license (C) eligibility. There was no limit on the amount of spiny dogfish permitted to be harvested by those with a Schedule II privilege. Although there were approximately 2,500 commercial vessels eligible to participate in the spiny dogfish fishery as a part of each vessel based license, only 30-40 vessel participated in the directed dogfish fishery prior to 2006. Total allowable catch (TAC) limits were established in 1980 with 32% allocated to the groundfish trawl fleet and 68% to the hook and line fleet. The groundfish trawl fishery has been managed using individual transferable quotas since 1997 under their Category "T" licence.

In 1996, a mandatory dockside-monitoring program (DMP) was introduced within the hook and line spiny dogfish fishery. The DMP accounts for all landed catch. This was in addition to the requirement to keep accurate logbooks that record detailed information about each fishing event for every trip. In 1999, partial at-sea monitoring (10-15%) using a combination of on-board observers and electronic monitoring was introduced. The hook and line fisheries are not permitted to retain sharks other than spiny dogfish.

One hundred percent at-sea and dockside monitoring has been in place for the groundfish trawl fishery since 1997. This sector uses on-board observers. The groundfish trawl fishery is the only fishery in BC permitted to retain shark species that are incidentally caught. However the groundfish trawl fishery, as of 2010, implemented measures to prohibit fishing for, possession of or selling of SARA listed species including: Pacific basking Shark, tope Shark and bluntnose sixgill shark.

Commercial Groundfish Integration Program

The commercial groundfish fishery consists of seven fisheries, multiple licence categories, harvesting more than 20 different species. The complexity of different regulated single species fisheries combined with the lack of accurate reporting of catches and releases, by area and species (including sharks), led to significant conservation concerns. This practice of releasing fish at sea occurred because fleets were unable to restrict their harvest to their target species. Harvesters were, therefore required to release much of their incidental catches. Harvesters had no incentive to accurately report their catch.

In 2001, DFO initiated its Selective Fishing Policy with three objectives: enforcing selective fishing technology, avoiding incidental catches, and releasing any incidental catch alive and unharmed (DFO, 2001). In addition, in 2003 the Species at Risk Act (SARA) came into force and further afforded legal protection by the Government of Canada to any species listed under the Act, several shark species were under consideration for listing.

In 2003, DFO established five guiding principles to help meet these conservation objectives:

1. All groundfish catch (including sharks) must be accounted for;
2. Groundfish catches will be managed according to established groundfish management areas;
3. Harvesters will be held individually accountable for their catch;
4. New monitoring standards will be established and implemented to meet the above three objectives;
5. Species of concern will be closely examined, and actions such as reduction of TACs and other catch limits will be considered and implemented to be consistent with the precautionary approach for management.

In 2006 the Commercial Groundfish Integration Program (CGIP) was introduced as a pilot program (permanently implemented in 2010). This was an industry led initiative to address the guiding principles above. There are six critical components to the CGIP: the implementation of ITQs; the ability to retain other species; individual vessel accountability; quota transferability between fisheries; new, consistent management areas; and improved catch monitoring. This program has allowed the spiny dogfish fishery to be the first shark fishery in the world to receive Marine Stewardship Certification (September 2010). Since the implementation of this program, the number of active spiny dogfish harvesters has been reduced to 16-19 vessels.

Establishment of Individual Transferable Quotas for All Groundfish Fisheries

Holding harvesters accountable for all their catch would require the trading of quota for all species among all licence types. As such, the three fisheries not previously managed using Individual Transferable Quotas (ITQs), rockfish, lingcod, and spiny dogfish moved to this type of management technique in 2006.

Ability to Retain Other Species

As described above, harvesters were to be held accountable for all their catch under the CGIP. Previously, the conditions of licence would not permit the retention of incidental catches. Under the CGIPP, all conditions of licence were amended to allow for the retention of other groundfish species (not sharks other than spiny dogfish).

Individual Vessel Accountability

Vessels are required to acquire quota to cover the mortality for all catches, including those fish released at sea while fishing.

Quota Transferability between All Groundfish Fisheries

To enable vessels to account for all groundfish catch mortality, including fish released at sea, quotas need to be transferable between fisheries (different licence types). Reallocation of quotas between fisheries is only temporary (for the year), and limits have been placed on how much quota a vessel can acquire.

Consistent Management Areas

One of DFO's guiding principles included the establishment of groundfish management areas. Prior to the integration program, there were varying management areas for different fisheries and for different species. Common management areas allow DFO to manage stocks by area, which will improve stock assessment for groundfish species. Lastly, common management areas are especially critical when all species quotas are transferable between fisheries.

Catch Monitoring

While the previous dockside monitoring program (DMP) allowed for all landed catch to be verified, at-sea monitoring is also essential for incidental catch (ie: sharks). As such, in 2006 the new standard for commercial groundfish fisheries became 100% at-sea monitoring. This was in addition to the already existing 100% DMP requirement.

The new catch monitoring program requires all vessels fishing within the hook and line and trap fisheries to have at-sea monitoring either via onboard observers or EM. Harvesters are required to record all retained and released catch by piece and by location within their logbooks (including sharks). Ten percent of the camera footage is viewed to check the accuracy of the harvesters' logbook. The data collected at the DMP, which verifies only catch that is retained and landed, is also used to audit the logbook. If a logbook is found not to accurately represent actual catch seen on the video footage or the DMP, 100% of the camera footage is reviewed.

New Management Changes

Increased concern recently for shark by-catch as a result of SARA listings as well as international commitments to protect shark species has invoked additional changes to shark management in BC. In 2010 a 2-year pilot was introduced within the electronic monitoring program whereby harvesters receive feedback on their shark catch (as well as marine mammals and seabirds. The pilot will allow for 2 years of feedback to be provided to harvesters with respect to the accuracy of their shark reporting and

commencing in 2013 if the logbook catch for sharks is not within acceptable accuracy – 100% review of the video footage will be conducted at the cost of the harvester.

As of the 2010 commercial fishing season, encounter protocols were implemented for Pacific basking shark (SARA listed as Endangered) to ensure harvesters take every measure to avoid incidental capture, fishing gear is not set/hauled when the shark is 10 m from the vessel or visible from the water's surface and any incidentally caught shark is released in a manner that causes the least harm. Although currently only applicable to Pacific basking shark, these encounter protocols are anticipated to be included for all shark species (with the exception of the species permitted to be retained by the commercial groundfish trawl fishery).
In addition to the above condition, for the 2011 fishing season a new condition of licence prohibiting the fining of sharks (for those that are permitted to be retained). The condition will read: No person shall remove and retain the fins of any spiny dogfish (or other shark species for groundfish trawl) without retaining the remainder of the carcass for validation upon landing. The number of fins landed shall correspond to the number of carcasses landed. Although fining does not occur within B.C. it was felt that explicitly stating this within the conditions would support proactive management measures for sharks.

Prior to 2010, shark species within the recreational fishery were managed under the "other species" category, which allowed for each harvester to retain up to 20 sharks a day. In consultation with the Sport Fishing Advisory Board, changes were made the recreational fishery whereby the daily limit for all sharks was changed to 0 with the exception of salmon shark and spiny dogfish. Salmon shark was reduced to a daily limit of 1 and possession limit of 2 and spiny dogfish to 4 and 8, respectively.

Lastly, a laminated shark identification guide was developed in 2010 to aid in species identification for commercial and recreational fisheries in logbooks. The guide was distributed to all commercial groundfish harvesters and provided to many recreational harvesters.

Summary

Significant changes have occurred over the past decade to improve in the management and monitoring of shark species within B.C. There is no targeted commercial shark fishery in BC with the exception of the spiny dogfish fishery and the commercial groundfish trawl fishery is the only fishery permitted to retain other shark species as non-directed catch. The CGIP with its world-class monitoring and management measures allowed for the spiny dogfish fishery as well as other groundfish fisheries to receive marine stewardship council certification. Increased international scrutiny for sharks species and the introduction of the SARA has promoted additional changes to shark management in BC, as noted above. DFO continues to work collaboratively with stakeholders to ensure the adequate protection, management and monitoring of shark species in Pacific waters.

Conservation and Recovery of Sharks in Canadian Pacific Waters

Heather Brekke
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Species at Risk Act (SARA)

The *Species at Risk Act* (SARA) came into force in 2003. The purposes of the *Act* are "to prevent wildlife species from being extirpated or becoming extinct, and to provide for the recovery of a wildlife species that are extirpated, endangered or threatened as a result of human activity and to manage species of special concern to prevent them from becoming endangered or threatened". More information on SARA can be found at www.sararegistry.gc.ca. Under SARA, species can be listed under SARA in the following assessment levels: Extinct, Extirpated, Endangered, Threatened, Special Concern, Data Deficient, or Not at Risk.

The SARA listing process is initiated when the Committee on the Status for Endangered Wildlife in Canada (COSEWIC) releases a species status report and determines its status level. Once a species is assessed by COSEWIC as at risk, the Government of Canada must then make a listing decision: accept the species assessment and add the species to the list; decide not to add the species to the list; or refer the current assessment back to COSEWIC for further information or consideration.

While the COSEWIC species assessment initiates the process, science advice, management scenarios, and public consultation plays a key role in determining whether or not to list the species under SARA. If a species is listed as extirpated (extinct in Canada), endangered, or threatened, specific protection measures immediately come in to effect that prohibit harmful actions against the species. In addition, a recovery strategy and action plan must be completed. For species of special concern, a management plan must be completed.

Once a species is listed under SARA as extirpated, endangered, or threatened, it receives legal protection under the Act. In addition to the existing prohibitions under the *Fisheries Act*, under SARA it is illegal to kill, harm, harass, capture, take, possess, collect, buy, sell or trade any listed endangered or threatened animal or any part or derivative of an individual. These prohibitions apply unless a person is authorized, by a permit, licence or other similar document issued in accordance with SARA, to engage in an activity affecting the listed species or the residences of its individuals. Species listed as special concern are not included in these prohibitions.

There are currently 46 listed aquatic species at risk in BC. Endangered, threatened, and special concern marine species in Pacific region currently listed under SARA can be found at www.aquaticspeciesatrisk.ca.

SARA-listed shark species

This list of SARA-listed species includes three of the fourteen shark species found in Canadian Pacific waters. These include the basking shark (*Cetorhinus maximus*), listed as Endangered in February 2010; the bluntnose sixgill shark (*Hexanchus griseus*) and the tope shark (*Galeorhinus galeus*), both listed as Special Concern in March 2009. The

North Pacific spiny dogfish (*Squalus suckleyi*) was recently assessed by COSEWIC in November 2011. When COSEWIC sends this status report to the Government of Canada (September 2012), it will trigger the Government to determine whether or not to list this species under SARA. This listing process will commence sometime after Fall 2012, with the earliest the actual listing decision will be decided upon being 2014 or later. All species show vulnerability to fishing mortality, some level of decline in abundance and/or data limitations, and intrinsic productivity characteristics that warrant concern.

Basking Shark (Cetorhinus maximus)

The key factors limiting the recovery and survival of basking sharks are their long-life (~50 years), slow growth and maturation, and low fecundity, which lead to overall low productivity. Even in the absence of human-induced mortality, basking shark populations grow very slowly. The Pacific population of basking shark is threatened by various anthropogenic sources. Four classes of current threats have been identified in this Recovery Strategy, which are entanglement, collision with vessels, harassment from marine based activities, and prey availability. The decline of the Pacific population of basking shark is primarily due to human-caused mortality, which occurred between 40 and 70 years ago. Broad strategies and approaches to address the limitations and threats are presented in this recovery strategy.

The recovery goal of the basking shark Recovery Strategy is to see positive growth in the Pacific population of basking shark. To support this, the strategy outlines key objectives to maintain the current abundance and distribution of basking sharks within Canadian Pacific waters, and to attain positive population growth as well as an increase in aggregations (two or more sharks). Adequate information does not exist to identify critical habitat at this time. Habitat requirements have not been investigated for basking sharks in Canadian Pacific waters, and no specific locations have been identified for reproduction, pupping or rearing. Thus, a schedule of studies has been included in this document, which outlines the research required to gather information that will contribute to the future identification of critical habitat. An action plan, due in 2016, will identify the key implementation requirements for the recovery of basking sharks, and it is anticipated critical habitat will be included in this document.

Bluntnose Sixgill Shark (*Hexanchus griseus*) and Tope Shark (*Galeorhinus galeus*)

As these two shark species were listed on the same date in 2009, and they have similar threats and associated potential management actions, a combined Management Plan for both species was completed. The bluntnose sixgill shark and tope shark are limited by bottom-up and top-down processes that affect their intrinsic rate of increase, prey availability, recruitment success, and mortality rates. The primary threats identified for these species are entanglement and bycatch. Other threats identified include pollution, habitat loss or degradation, climate and oceanographic change, and harassment. Historic threats included directed fisheries and entanglement/ bycatch. While these populations are migratory throughout the northeast Pacific, it is unknown whether threats occurring outside of Canadian Pacific waters have an impact on these populations.

The management goal for the bluntnose sixgill shark and tope shark is to maintain their abundance within Canadian Pacific waters at current or higher levels. Management objectives and resulting actions were identified in the management plan to support the management goal, and are loosely based around improving scientific knowledge, maintaining viable populations as well as species' distribution, and enhancing communication and outreach.

Recovery and Conservation Efforts

Actions identified in the Basking Shark Recovery Strategy as well as the bluntnose sixgill Shark and tope Shark Management Plan fall under the key areas of management initiatives, scientific research and monitoring, and communication and outreach. Much work has gone into recovery and conservation actions to date, including, but not limited to, the maintenance and promotion of the Basking Shark Sightings Network, presentations throughout the coast, development of communication materials (e.g. Sharks of British Columbia identification guide), tips for spotting basking sharks from the air as well as from boats, as well as educational materials for youth. Management initiatives include changes to commercial and recreational fisheries (e.g. basking shark avoidance measures added to conditions of licence in commercial fisheries, modifications to the BC Sport Fishing Regulations to introduce 'zero take' for SARA-listed species, and 'zero retention' (catch and release only) for all other shark species with the exception of salmon shark and North Pacific spiny dogfish. Codes of Conduct are being drafted for basking shark viewings as well as interactions in commercial fisheries. Further, aerial surveys have been conducted for basking sharks since 2008, opportunistic tagging and sampling programs have been implemented, and a trinational working group for basking sharks has been established. Further recovery and conservation efforts are scheduled for 2012 and beyond.

Thinking about the effects of shark conservation on BC fisheries

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Background

Although data-deficiency often hinders formal assessments, it is widely recognized that shark species around the world have historically been overfished. This has resulted in decreasing catches, and landed value, at a global scale for the last decade (Fig. 1). While this has obviously had an impact on shark fisheries, ecological functions have also been modified due to the removal of what are often the top predators in a given ecosystem. The recognition of the ecological, and subsequent economic, impacts of shark depletions are increasingly better recognized, and are beginning to result in more protection measures such as species listings under legal conservation frameworks and an increase in the coverage of shark protection areas around the world. It is clear, and in many cases legally mandated, that threatened species must be protected to retain ecological and economic benefits, but it must also be recognized that conservation will not come without some costs. These do not stem from an inherent opposition to conservation *per se*, but rather from the adaptation of an industry to new restrictions, such as those that conservation usually entails.

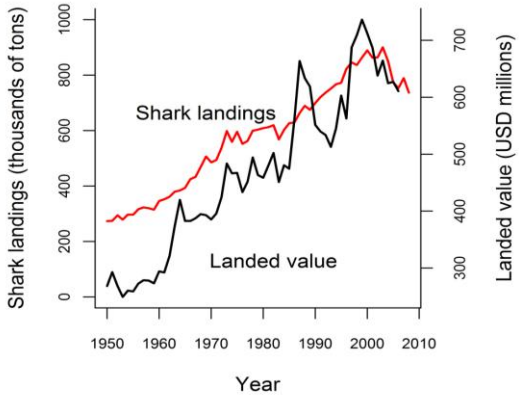

Figure 1. Global shark landings and landed value. Based on data from FAO 2011 and

In the case of fisheries these costs follow from the fact that, all things being equal, limitations on fishing catch (targeted or incidental) lead to reductions in fishing effort, which in turn usually (but not always) lead to reductions in catch and profits. The "all things being equal caveat" is an important one to keep in mind, as will be discussed below.

Method

We apply the thinking outlined above into a semi-conceptual case study in Canada, with the overarching question being: "Under current fishing conditions, what effect might sixgill shark bycatch limitations have on the BC halibut fishery?" We chose these two model species because sixgill is one of the most common SARA-listed bycatch species in the BC groundfish fishery, of which halibut is the most economically important. Sixgill abundance is unknown but was assumed to be 10% of halibut abundance, and current bycatch is some 10 tonnes/year. We used cost, price and economic impact data reported for the current BC fishery by DFO (values are in Canadian dollars, M=million).

We used a relatively simple Schaeffer production model to simulate species dynamics, where biomass (B) at time t is given by the carrying capacity (K), population growth rate (r), fishery effort (E) and catchability of each boat (q) as:

$$B_{t+1} = B_t + r \cdot B_t \cdot (1 - B_t/K) - (B_t \cdot q_t \cdot E_t)$$

The key assumptions in this form of the model are that *i*) both populations follow logistic (Schaeffer) growth, *ii*) biological and economic parameters (*e.g.*, price, unit cost, carrying capacity) are constants, and *iii*) fisheries catch is directly proportional to effort (*i.e.*, catchability is independent of biomass).

Results and Discussion

Under current fishing conditions, potential bycatch reductions would also have significant negative effects on overall revenue and profits from the halibut fishery (Fig. 2). Unlike fisheries without effective controls, the success of groundfish fisheries management in BC has led to significant economic benefits from halibut, both in terms of landed value ($30 M/year) and downstream economic impacts from wholesale ($130 M/year), wages ($60 M/year) and supported jobs (1,500/year). All of these benefits would be impacted from fishery closures resulting from mandated bycatch limits, *if fishing operations continue without any modifications*. So, although a reduction in allowable shark bycatch can cost millions in foregone halibut catch, these potential impacts can be mitigated or avoided altogether through very small reductions in the current non-directed catch rate per boat, particularly because catch of sixgill sharks in the halibut fishery is already relatively low.

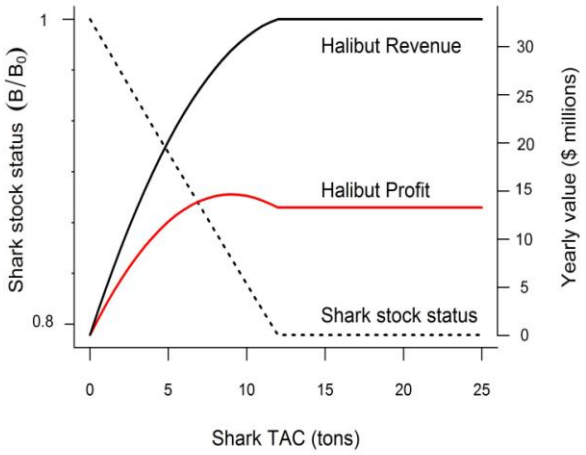

Figure 2. Shark allowable bycatch effect on shark stock status, and halibut fishery revenue and

Cost mitigation strategies can include gear or fishing operation modifications to avoid bycatch and post-release mortality. Also, directed research to improve regional abundance and distribution estimates and release-mortality rates may lead to new knowledge to revise and perhaps avoid restrictions coming from a precautionary approach to data-deficiency. Finally, as has been the case for many BC fisheries, market strategies such as seafood labeling and partnerships with government and ENGO groups can help mitigate costs associated with potential decreased landings. Ultimately, recognizing potential costs of conservation should not be used to resist it, but rather as an incentive to adapt and thrive under shifting guidelines.

Distribution, Bycatch and Management of Sharks in Alaska

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This presentation presented information on the species that occur in Alaska waters and their distribution, bycatch in the state and federal waters commercial fisheries, directed sport fish catch of salmon sharks and management in state and federal waters.

The presentation began by listing the 11 species that have valid records for Alaska waters. Of these 11 species, three are common while the other eight are rare with few records in the state. The three most common species that occur in Alaska waters are: salmon shark (*Lamna ditropis*), spiny dogfish (*Squalus suckleyi*) and the Pacific sleeper shark (*Somniosus pacificus*). The other species with valid records in Alaska waters are the basking shark (*Cetorhinus maximus*), sixgill shark (*Hexanchus griseus*), blue shark (*Prionace glauca*), Pacific angel shark (*Squatina californica*), soupfin shark (*Galeorhinus galeus*), brown catshark (*Apristurus brunneus*), white shark (*Carcharodon carcharias*) and the common thresher shark (*Alopias vulpinus*), which is a recent addition to the list as of July 15, 2011.

Table 1. Fishery-independent data used in federal shark assessment models.

Data

Data regarding sharks are obtained from the following sources:

Source	Data	Years
AKRO Catch Accounting System	Non-target catch	2003 - 2011
(AFSC) Improved Pseudo Blend	Non-target catch	1997 - 2002
(AFSC) Pseudo Blend	Non-target catch	1990 - 1998
ADF&G	Sport catch	1998 - 2010
NMFS Bottom Trawl Surveys – GOA	Biomass Index	1984 - 2011
NMFS Sablefish Longline Survey	Survey catch numbers and CPUE	1989 - 2011
IPHC Longline Survey	Survey catch numbers, CPUE and RPNs	1998 - 2010

Data from the Alaska Department of Fish and Game (ADF&G) on Alaska state waters bycatch of sharks in commercial fisheries from 1985 to 2010 was presented showing the composition of species, which is dominated by spiny dogfish, but also showed an increase in Pacific sleeper shark bycatch since 2003. Reasons behind that increase are unknown, but it was mentioned that increases in depredation of sablefish by whales has been reported in the state waters sablefish fishery. Between 1985 and 2002, the majority of bycatch was being reported from the Southeast Region (Figure 1).

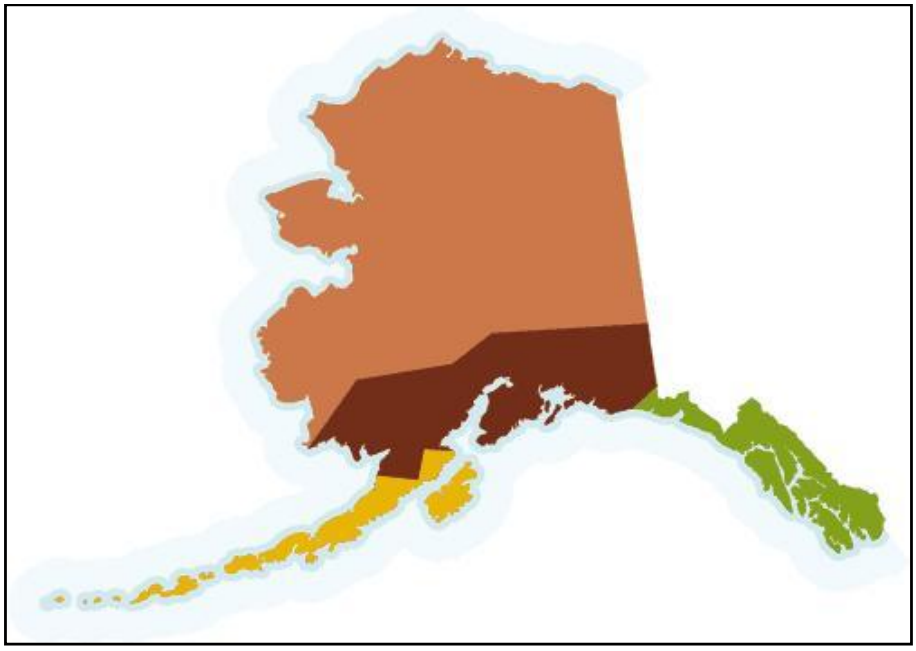

Figure 1. Map of the state of Alaska indicating Region by color: Southeast Region (I) is in green, Southcentral Region (II) is in dark brown, Arctic-Yukon-Kuskokwim Region (III) is in tan and Westward Region (IV) is in gold.

Data were sparse for gear types, but it is likely that most shark bycatch in the state comes from groundfish fisheries, but certain fisheries have not, to date, been required to report bycatch discards at sea (e.g. state waters salmon fisheries). However, as the U.S. Federal government mandate to report all removals to the National Marine Fisheries Service for inclusion in fisheries modeling from which harvest limits are set begins to occur, the contribution of bycatch from different fisheries and gear types should become much clearer. This topic was touched upon again later in the presentation during the overview of Federal management.

The presentation then focused briefly on the state waters targeted sport fishery data for sharks from 1998 through 2010, which mainly occurs in Southeast- and Southcentral Regions. Data from the ADF&G Statewide Harvest Survey (SWHS, which is a mail survey sent to a proportion of sport fishing license holders each year) showed catches ranging between approximately 5,000 and 50,000, while harvest during that time period ranged from less than 100 to approximately 1,000 sharks. These data indicate a potential problem as the mortality rate of discarded sharks is unknown. Obviously, if the discard mortality rate is high, then many more sharks are being "removed" from state waters than is currently thought. The targeted sport fishery for salmon sharks was reviewed and data indicate that the majority of harvest occurs in Southcentral Region and much of the effort has typically occurred in Prince William Sound. Harvest has declined considerably since 2006, but it is unknown if this is due to localized depletion (as salmon sharks have shown high fidelity to areas in the Sound) or to changes in the

dispersal and movements of sharks. Another mitigating factor may be the rising price of fuel and the distance from ports to good fishing grounds for salmon sharks.

The bycatch of sharks in Federal waters was covered, which included both the Gulf of Alaska (GOA) and the Bering Sea Aleutian Islands (BSAI) areas (Figure 2).

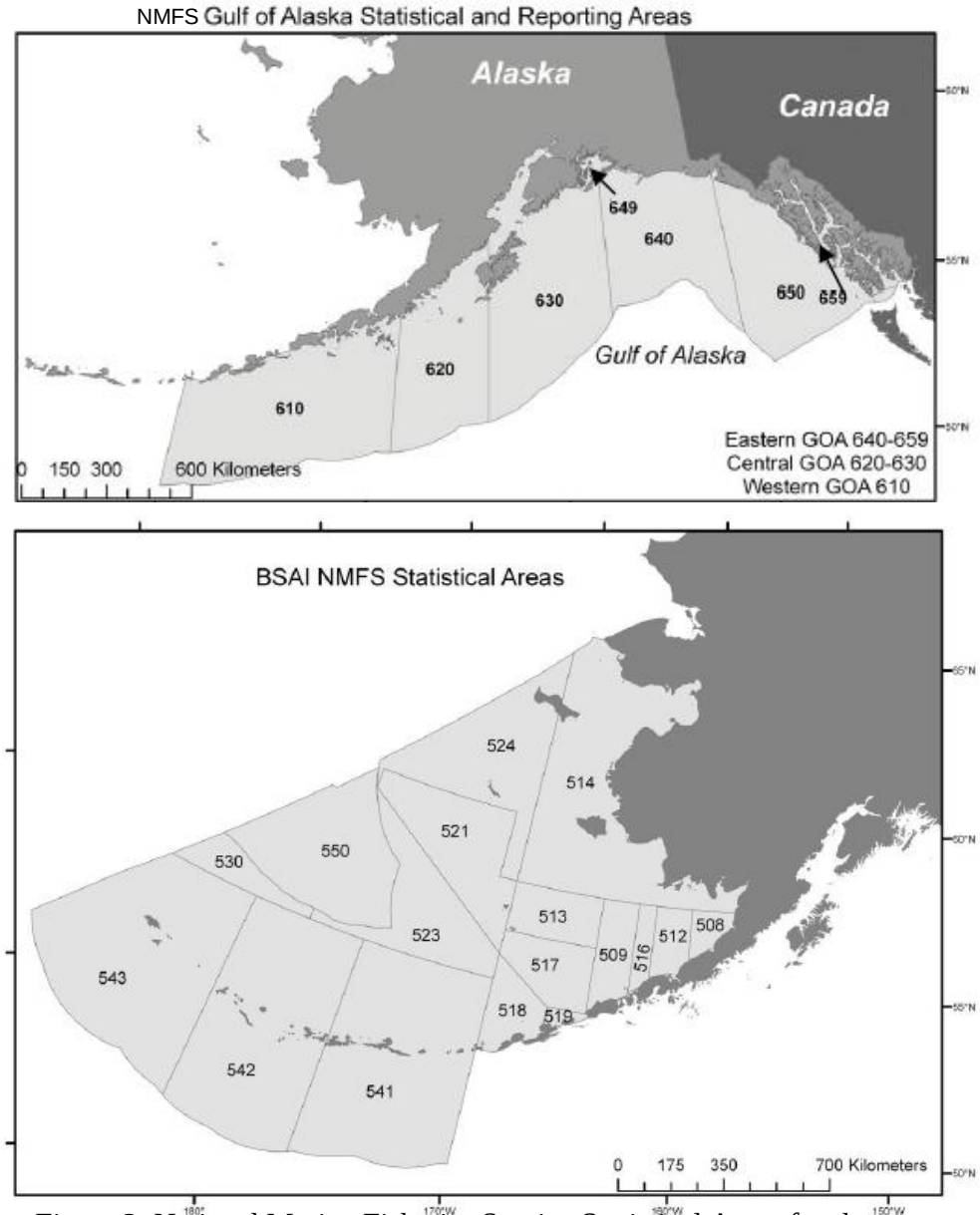

Figure 2. National Marine Fisheries Service Statistical Areas for the Gulf of Alaska and the Bering Sea Aleutian Islands.

Shark catch in federal waters commercial fisheries from 1987 through October of 2011 were presented. Spiny dogfish are the dominant species in the GOA catch. A recent

drop, since 2008, in the number of Pacific sleeper sharks was pointed out, but it is unknown whether this indicates a relative decrease in numbers due to the fishery-dependent nature of the data (e.g. could be result of fishing practices or combination of many variables, most of which are unknowns). Date were then presented to show which commercial fisheries in the GOA shark bycatch occurs in (Pollock, Pacific cod, flatfish, rockfish, halibut and sablefish) and the geographic distribution of observed catch in those commercial fisheries. The same information was presented for shark bycatch in commercial fisheries form the BSAI area. Pacific sleeper sharks are the dominant species in the shark bycatch in this area. In the BSAI however; a decline in Pacific sleeper shark catch has not only occurred in the fishery-dependent data, but in fishery-independent survey data as well. This indicates a relative decrease in the number of Pacific sleeper sharks, but it is unknown what this may mean at the population level as there is so little life history and population data on this species. This fact, along with discard mortality rates in state and federal waters were the two biggest concerns of the author of this presentation.

An overview of management at the state and federal levels was presented. Commercial fisheries for sharks are closed in state waters; however, fishermen may apply for a Commissioner's Permit to the Area Management Biologist. Bycatch levels are typically 20% of target species catch, either aggregate or by individual species or species complex depending on fishery, management Region, District or Area. It was indicated that the Prince William Sound State waters Walleye Pollock fishery is the only one in the presentation author's Region (Southcentral) that has a shark bycatch cap that would close that fishery if reached, but that cap has not been reached. The regulatory process for the state resides with the Alaska Board of Fisheries (BOF), while federal waters management resides with the North Pacific Fishery Management Council (NPFMC) – interactions between these two regulatory bodies occur as needed. Sharks have been part of the "Other Species Complex", which was an amalgamation group composed of squids, sculpins, sharks and octopus. This complex is now being separated and sharks are being grouped together with no other species. Stock assessments for sharks are produced through the North Pacific Fishery Management Council each year. In past years all total allowable catches (TACs) were added up for the other species complex, but now bycatch limits will be set for each group meaning that a shark TAC will now be in place (note: federal fisheries bycatch limits are typically set for individual species at 20% of allowable targeted catch). Data showing model results relative to the TAC, ABC (allowable biological catch) and OFL (overfishing limit) were presented for the shark complex for the GOA and BSAI. Data included in the assessment model are shown in Table 1. As with the state shark data, the discard rate of sharks in federal waters is enormous and cause for considerable concern considering that nothing is known about discard mortality rates in these species.

Federal management is based on a Tier system, which was presented in overview. Each level of the Tier system requires specific information be available for a species or stock to be assessed in the Tier. For example, sharks have been in Tier 6 for some time – this Tier (is the lowest one) requires reliable catch history information or the best available scientific information. Tier 5 would require reliable point estimate of biomass (B) and natural mortality rate (M). Shark catch history data is mostly unreliable with the exception of spiny dogfish in the GOA. In 2011, spiny dogfish in the GOA assessment

were moved to Tier 5, but other shark species remain in Tier 6. IN the BSAI, all sharks remain in Tier 6 as the catch history for all species is unreliable, and has the additional caveat/problem of having Pacific sleeper sharks driving the relative abundance. This issue is currently under discussion by groups within the NPFMC for future considerations and application of data. Lastly, future concerns were listed as:

- Mortality rates of discards
- Increasing management complexity
- Adapting to federal management changes (e.g., NS1 guidelines)
- Application of data to management
- Adherence to new Catch Accounting System (CAS). How to really account for all removals? e.g. Discards at sea by salmon fisherman are currently not required to be reported, fish caught and used for bait in fisheries, and on and on…
- Challenges surrounding ecosystem management (has relationship to NS1) and continuing resource development

Overall, shark bycatch levels are low and do not raise any major concerns in the federal waters assessments with the exception of discard mortality rates and Pacific sleeper sharks driving the catch history in the BSAI. It is worth noting that while there are currently no directed shark fisheries in federal waters, they are not closed to fishing as they are in state waters.

Shark Abundance and Distribution off the coast of California, Oregon, and Washington

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Although the public's perception of sharks often conjures up images of a large, fearsome, toothy predator, with its large dorsal fin cutting its way through the waters' surface, the reality is that sharks come in a variety of sizes and shapes. From the whale shark (*Rhincodon typus*), the world's largest fish, to the dwarf pygmy sharks (*Squaliolus* spp.), these enigmatic fishes occupy most marine, and some freshwater, habitats. In addition, the batoids and chimaeras, along with the sharks, form a distinctive group of fishes collectively referred to as the Chondrichthyans. There are more than 500 species of sharks, along with nearly 650 batoid and 50 chimaera species, bring the overall total to about 1200 species of sharks and shark-like fishes.

The diversity of sharks and their relatives has increased exponentially over the past decade with more than 200 new species having been described since 2000. This represents nearly 20% of all shark species that have been described which compares to about 200 species that had been described over the previous 30 years (1970-1999). Most of the new species discovered over the past decade have come from the Indo-Australian region, followed by the southern African and western North Pacific regions.

The continental United States Eastern North Pacific (ENP) Ocean region extends from approximately 47°N, 125°W to about 32°N, 117°W or from the Washington, U.S./Canada border southwards along the continental landmass of North America to the California, U.S./Mexico border. The area encompasses the California Current Large Marine Ecosystem. A major faunal shift from a boreal cold-temperate regime to a warm-temperate regime occurs in the southern reaches of this region; the major change from cold to warm temperate waters occurs at Point Conception, California.

Although not nearly as diverse as other geographic regions, the eastern North Pacific is well represented with 11 orders, 32 families, 46 or 47 genera, and 67 to 70 species being found within this region. Of the eight recognized shark orders, seven have representatives occurring in this area, with 20 families, 31-32 genera, and 41-44 species. The batoids have three orders, 10 families, 13 genera and 22 species represented, while the chimaera order has two families, two genera, and four species represented. Over the past decade at least five new Chondrichthyan species have been discovered as occurring in this region, with possibly several additional cryptic species also being present. This includes one genus (*Isistius*) and at least three species (Cookiecutter Shark *I. brasiliensis*, Bull Shark *Carcharhinus leucas* and Blacktip Shark *C. limbatus*) that may occur within this region, but their distribution is of uncertain status. All are known from the Eastern Central Pacific region and may occur within the ENP, but have not yet been confirmed. The skates (families Arhynchobatidae and Rajidae) are among the most specious group with at least 11 species represented, and perhaps 1 or 2 additional, unidentified deepsea species also occurring within this region. Also, at least one

additional chimaera, tentatively identified as *Hydrolagus* cf. *trolli*, has been observed by from very deepwater around seamounts off central and southern California.

Though the occurrence of sharks, skates, rays, and ratfishes along the western coast of the United States may be well documented, the movement of individuals throughout their range is poorly known. However, growing evidence suggests complex population dynamics are common among this group of fishes that have profound implications for research and conservation. A variety of behavioral, oceanographic, and ecological processes generate spatial, temporal, sexual, habitat, size-, and age-specific variation that influence the distribution and abundance of sharks and their relatives. Areas of ecological significance may shift broadly over an individual's lifetime or vary by sex. Patterns of spatial segregation coupled with the high mobility of many sharks, skates, and rays confound traditional approaches to regional management and conservation efforts because populations commonly straddle and move among national and state boundaries.

One example of spatial and sexual segregation occurs in the tope shark, *Galeorhinus galeus*. Landings data from the early 1940's revealed that females most commonly occur in the southern portion of the range, primarily off of central and southern California. Southern California also appears to serve as the primary nursery grounds for this species in the eastern Pacific. Northward along the California coast through British Columbia, males dominate the landings and few females are found north of Fort Bragg, California.

Salmon sharks (*Lamna ditropis*) and white sharks (*Carcharodon carcharias*) exhibit strong seasonal/temporal shifts in distribution and abundance. Adult female salmon sharks typically move southward from the Gulf of Alaska to give birth in the coastal waters off British Columbia, Washington, Oregon, California, and Baja California during the spring and early summer and move northward again, occupying nearshore and oceanic habitats. Adult white sharks make broad offshore movements into the central Pacific, mixing in shared feeding and mating grounds before returning to nearshore coastal environments in the late summer and early fall. In both species, individuals may return to the same locations, demonstrating fidelity to specific sites despite undertaking broad movements.

Considering the limited understanding of chondrichthyan distribution and abundance off the west coast of North America, it is expected that further patterns of complex population structure and movement patterns will continue to be identified among other species. Effective research and conservation efforts necessitate implementation on spatial and temporal scales that are ecologically relevant to the species of interest. In many cases, international collaborative efforts will be essential to achieve objectives for conservation and sustainable management.

Of the 68 chondrichthyan species that occur off the California, Oregon, and Washington coasts, the IUCN Red List Assessments are as follows: 16 have been assessed as Data Deficient, 27 Least Concern, 12 Near Threatened, 12 Vulnerable, and 1 Endangered. Most of the species (n = 25) that have been assessed as Near Threatened or higher are the sharks (n = 21) with most of those being the highly migratory species. The batoids have four species listed as being Near Threatened, whereas none of the chimaeras are considered to be categorized as Endangered or higher at this time.

Management of shark bycatch in Washington in the trawl and longline fishing industries

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Marine Nearshore Ecologist Washington Department of Fish and Wildlife

The marine waters of Washington State can be divided into three geographic units that are subject to distinctly different fishery management regimes. As with other coastal states the U.S. Exclusive Economic Zone (EEZ) extends 200 nautical miles out to see from the coast and is bounded to the north by the Canadian EEZ. Fisheries in this zone are regulated and monitored by the National Marine Fisheries Service and have been restricted in many areas to protect rockfish and Essential Fish Habitat. The State Waters of Washington, by comparison, extend only 3 NM from the coast and are managed cooperatively by the State Department of Fish and Wildlife and several coastal Tribal nations (Hoh, Makah, Quileute, and Quinault). Commercial trawling and longlining is not allowed in State Waters, with the exception of Tribal fisheries operating within their Usual and Accustom Areas. Puget Sound consists of all waters east of a line stretching from Bonilla Point, B.C. to Tatoosh Island at the western end of the Strait of Juan de Fuca, and north to the Canadian border. Fisheries within Puget Sound are also managed cooperatively by State and Tribal governments, though the Tribal Nations are far more numerous. In recent decades several conservation initiatives lead by these governments, as well as non-profit groups, have lead to progressively tighter fishing regulations in the Sound.

Several species of shark occur in Washington waters, the most common in both nearshore and offshore waters being the Pacific spiny dogfish *Squalus suckleyi* (previously *S. acanthias*, but see Ebert et al. [2010]). Fishermen and naturalists may also encounter bluntnose sixgill *Hexanchus griseus*, sevengill *Notorynchus cepedianus*, salmon *Lamna ditropis*, and soupfin sharks *Galeorhinus galeus* on a somewhat regular basis in nearshore waters. In offshore, primarily outer coast waters common thresher *Alopias vulpinus* (and other thresher species), shortfin mako *Isurus oxyrinchus*, and blue *Prionace glauca* sharks are more prevalent. Though rarely encountered by anyone but commercial fisherman, the benthic brown catshark *Apristurus brunneus* is widely distributed throughout Washington waters. Though substantially less common than other species, basking, white, Pacific sleeper, Pacific angel, and leopard sharks have also been recorded in Washington.

Historically, and until quite recently for the first species listed, there have been directed fisheries for *S. suckleyi*, *C. maximum*, and *A. vulpinus*. Initially fisheries for the first two species were focused on livers only and were phased out when synthetic Vitamin A began to be produced commercially in the 1950s. From the mid 1970s through today *S. suckleyi* has been fished for human consumption. The *A. vulpinus* fishery began in the mid 1980s and was terminated in less than a decade due to bycatch concerns associated with marine turtles and mammals. Threshers and makos are now fished as part of the High Migratory Species complex in offshore waters. In the past decade directed shark fisheries in Washington have been in sharp decline. The last commercial fish buyer in Puget Sound who would purchase *S. suckleyi* stopped doing so in 2010.

A number of trawl and longline fisheries operate in Washington waters, many of which capture sharks incidentally. The largest two of these are the limited entry sablefish-endorsed fixed gear groundfish fishery and the Pacific whiting/hake mid-water trawl fishery, both of which operate off the outer coast. Additionally, longlining for halibut and the Highly Migratory Species complex (albacore, mako, threshers) occurs off the outer coast and into the Strait of Juan de Fuca, and bottom trawling for pink shrimp occurs both along the southern outer coast near the Columbia River delta and in Puget Sound. Bottom trawling for flatfish also occurs along the outer coast. All of these fisheries are managed by the Pacific Fishery Management Council and monitored by the National Marine Fishery Service's West Coast Groundfish Observer Program (WCGOP). By and large, other trawl and longline fisheries inside Puget Sound have been successively phased out by legislative action and are currently limited to a few, small-scale, localized Tribal fisheries.

In addition to shark bycatch in trawl and longline fisheries it is important to note that numerous other fisheries (e.g., recreational hook-and-line for diverse species, commercial salmon purse seining/gillnetting/troll, the Dungeness crab pot fishery) have the potential for substantial incidental shark take. These additional fisheries are not considered further here and their impact on shark stocks remains largely unknown.

Vessels that participate in the high seas whiting/hake *Merluccius productus* fishery in Washington waters generally operate out of Westport, WA, Astoria, OR, or other ports in Oregon. WCGOP data for the fishery date back only to 2005 and indicate that the fishery has very little bycatch. By and large this is due to improved sonar technology and net deployment methods, as well as revised fishing seasons that allow fisherman to set almost exclusively on aggregation of their target species. In 2010 fishers landed 170,000 mt of whiting and only 432 mt of spiny dogfish. Other sharks, in aggregation with several other groundfish, constituted only 1.26 mt of catch.

Non-nearshore fixed gear sablefish-endorsed vessels have fished a seven-month season from April through October since 2002. Fixed gear includes longlines and pots and ~85% of annual harvest is taken using these methods (trawl accounts for the remainder). Landings from this fleet are monitored using fish tickets and at-sea observes, though observer coverage can be spotty. On a west coast-wide basis 164.7 mt of sablefish were landed by fixed gear in 2009. Shark bycatch consisted primarily of spiny dogfish (9.23 mt), blue sharks, (2.1 mt), and brown catsharks (0.05 mt).

Halibut longlining occurs along the outer coast and well into the Strait of Juan de Fuca. At-sea discard of bycatch is not recorded or reported and stock assessment efforts by the International Pacific Halibut Commission (IPHC) on record sablefish, cod, and rockfish bycatch. A 2003 IPHC study attempted to use logbooks to ascertain levels of shark bycatch and whale interactions. Sharks were noted in <10% of interviews and only spiny dogfish catch was common in Washington waters. The study concluded that logbooks were not a valid resource for quantifying shark bycatch or whale interaction.

Pink shrimp bottom trawling occurs on the outer Washington coast off the Columbia River and near Willapa Bay, as well as in isolated locations in Puget Sound. Trawl configuration, tow speed, fishing season, and the extent of the fishery all limit bycatch

predominantly to hake and flatfish. Spiny dogfish are occasionally taken, but at very low levels.

A conservative total annual estimate for reported shark bycatch in trawl and longline fisheries in Washington waters is 500 mt, >95% of which is spiny dogfish. At least 80% of spiny dogfish bycatch is in the whiting mid-water trawl fishery and bycatch quantity is equal to approximately half of current directed spiny dogfish harvest. blue, thresher, mako, sixgill, soupfin, and brown catsharks make up the remainder of reported bycatch. At-sea discard of additional shark bycatch from all fisheries likely constitutes several hundred additional metric tons each year. Additionally, several non-trawl, non-longline commercial (State and Tribal) and recreational fisheries operating in the state likely include substantial unreported shark bycatch. Current funding levels do not allow for more comprehensive survey and monitoring coverage of these fisheries.

Catch, Bycatch and Management of Sharks in California Fisheries

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NOAA Southwest Fisheries Science Center, Fisheries Resources Division

Shark landings in California have fluctuated greatly since the early 20th century. Several fisheries emerged that specifically targeted certain species of sharks only to subsequently wane due either to regulatory changes, over exploitation, or changes in market demand. Notable fisheries that resulted in significant catch include a soupfin shark fishery in the 1930s and 1940s when over 24 million lbs were landed, a harpoon fishery for basking sharks with estimated catch of greater than 2000 individuals between 1930-1950, and targeted fisheries for Pacific angel shark and thresher shark beginning in the late 1970s (CDFG 2001). These and other fisheries that either target or catch sharks incidentally off California have resulted in apparent local population declines highlighting the need for monitoring, research, and management of sharks.

The majority of sharks caught off California are taken in commercial groundfish and highly migratory species fisheries and by recreational anglers. Regulation of shark catch and bycatch falls under the jurisdiction of State, Federal and/or International Fishery Managers. Prior to 1982 when the Pacific Fishery Management Council (PFMC) instituted a federal management plan for groundfish (GFMP), sharks were managed solely by the State. Now, under the GFMP, several coastal and bottom sharks are managed federally including spiny dogfish, and soupfin and leopard sharks (PFMC 2011a). In 2004, the PFMC implemented a federal management plan for highly migratory species (HMS FMP) that covers management of thresher sharks (3 species), shortfin mako and blue sharks (PFMC 2011b). Additionally, the HMS FMP continued a prohibition on landing white sharks established previously by the California Department of Fish and Game (CDFG) and implemented prohibitions on the retention of basking and megamouth sharks. Several other species continue to be managed by CDFG including Pacific angel and smoothhound sharks. Regulations, including recreational fishery regulations, are imposed cooperatively through State and Federal processes. Management measures include harvest guidelines for species or species complexes, recreational bag limits, time and area restrictions, size limits and a number of monitoring programs including logbooks, observer programs and requirements for landing sharks with fins attached.

Species specific shark landings data are not available in California prior to 1977. While total commercial shark landings in California peaked in the 1930-1940s at an average of 3000 mt annually (CDFG 2010) and again in the late 1970s through mid 1980s, recent shark landings are comparatively low. In 2008 and 2010, total elasmobranch (sharks, skates and rays) landings to California ports were 404 and 321 mt, respectively (http://pacfin.psmfc.org/). Although commercial landings are low, both the amount of shark discarded and levels of recreational catch are not well known. There is no market for some species, like blue shark, so nearly all are discarded. Observer programs are now in place to monitor catch by species, size and sex and record discard disposition for several fisheries with the greatest protected species interactions, and logbooks are mandatory for most fisheries. Additionally, California has improved recreational fishery

data collection with enhanced sampling since 2004. Monitoring programs have been improved in recent years, but observer programs do not cover all fisheries with shark bycatch, and coverage of several fisheries is relatively low. Nevertheless, these data are valuable for fishery catch and effort analyses and shark population assessments.

The main HMS fisheries that land catch in California include harpoon, pelagic drift gillnet and shallow-set longline that all target swordfish, deep-set longline that targets tunas, and troll/pole-and-line that targets albacore. Of these, the longline and pelagic driftnet fisheries have the greatest shark catch. For these fisheries, blue sharks make up the greatest component of the shark catch and in some times and areas blue shark catch exceeds the target species catch. In many cases, the fisheries for HMS are constrained not by the status of the target species, rather by the catch of protected or vulnerable non-target species. An example is a large turtle conservation area off central and Northern California closed to drift gillnetting Aug. 15 - Nov. 15 each year to protect endangered leatherback sea turtles. Thus, scientists and managers are beginning to consider adaptive measures that account for the differential distribution and behaviors between target and non-target species in order to provide increased opportunities for fishers to optimize catch and minimize bycatch. More information on relative distributions of target and non-target species and their links to environmental and oceanographic features is needed.

The NOAA Southwest Fisheries Science Center (SWFSC) has been conducting research on pelagic sharks since the early 1990s. Analyses have shown these species to be highly vulnerable based on their life history characteristics, and susceptible to west coast based fisheries based on their horizontal and vertical overlap with fisheries. Studies include demographic analyses based on fishery catch data by size and sex, fishery-independent surveys, biological studies of age, growth and maturity, population genetics, feeding habits, and tagging studies to track migrations and habitat use patterns and post-release survival. Some of the findings for common thresher shark include identification of nursery habitat and stock range, and evidence of increasing population growth in California waters since the switch in the pelagic drift gillnet fishery from thresher to swordfish targeting in the mid 1980s. A thresher shark assessment will be completed with Mexican colleagues using the new information in 2012. Similarly, studies are now being summarized for shortfin mako and blue sharks to use in upcoming assessments conducted collaboratively by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific (ISC). SWFSC scientists have also launched a basking shark research program in collaboration with scientists from DFO Canada and CICESE Ensenada, Mexico.

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Distribution and management of shark species in Mexican Pacific waters (Gulf of California and the west coast of Baja) and the management of by-catch in the fishing industry

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Shark Production

Mexico is among the 10th most important shark producing countries in the world [1]. Between 2006 and 2010, Mexican total catches showed an increasing tendency from 23,204 t to 29,775 t, with an average of 26,000 t during the period. Eighty three percent (24,727 t) of the 2010 national catches were from Mexico's Pacific coast, where the most important producing states were Sinaloa (5,596 t), Baja California Sur (5,159 t), Baja California (3,926 t) and Sonora (1,483 t), that are located in northwestern (NW) Mexico, and associated with the Gulf of California and the Baja California Peninsula. The 16,163 t produced by these four states represented 54% of the national production, and 65% of the Mexican Pacific coast production [2].

Catch species composition

The shark species composition of Mexico's official catch statistics is not reported in the annual production reports, and the few statistics with species composition that exist are reported by groups of species and by common names, creating miss reporting and confusion. In order to solve this problem, several studies have analyzed the species composition at landing sites, mainly for artisanal fisheries [for example 3, 4, 5, 6, 7, and 8]. These studies found that fisheries in NW Mexico catch 40 species of sharks and 31 species of rays.

The west coast of the Baja California Peninsula (WCBC) is influenced by the California current producing a temperate and semi-temperate habitat, while the Gulf of California (GC) has more complex oceanographic processes, and is characterized with a high fish endemism, including semi-tropical and tropical species [9]. Because of these conditions, the fish fauna composition at these two regions has been described to belong to the San Diegan and Cortez biogeographic provinces [10]. The principal shark species caught at the San Diegan province portion of WCBC (north Bahía Magdalena) are: blue shark (*Prionace glauca*), mako shark (*Isurus oxyrinchus*), common thresher (*Alopias vulpinus*), tope shark (*Galeorhinus galeus*), salmon shark (*Lamna ditropis*), and Pacific angelshark (*Squatina californica*). South of Bahía Magdalena, where the Cortez province starts, other species of shark are also important, like the Pelagic thresher shark (*Alopias pelagicus*), Scalloped hammerhead (*Sphyrna lewini*), and Smooth hammerhead (*S. zygaena*). In the Gulf of California Silky shark (*Carcharhinus falciformis*), Blacktip shark (*C. limbatus*), Brown smooth-hound (*Mustelus henlei*), Pacific sharpnose shark (*Rhizoprionodon longurio*), Pelagic thresher (*Alopias pelagicus*), Bigeye thresher (*A. superciliosus*), Scalloped hammerhead (*S. lewini*), Smooth hammerhead (*S. zygaena*), Pacific angelshark (*Squatina californica*) are important species. Nevertheless, in recent years the blue shark (*P. glauca*) has become an important species, mainly caught at the mouth of the gulf. Bull shark (*C. leucas*) was an important species in the past, but rarely encountered today.

Fisheries

In Mexico, three types of fisheries that target sharks and rays are recognized [11]. The small size vessel fishery is carried out on <10.5 m long vessels, with a capacity of 1.5-2 t, fishing with either a longline with 300 tom 500 hooks or bottom gillnets with a mesh size = or > than 6 inches. The

middle size vessel fishery´s vessels are made of metal, wood or fibreglass from 10 to 27 m long, and a capacity of 14 to 75 t using longlines with up to 1000 hooks. In the past this fishery also used drift gillnets up to 2000 m long [12], but this fishery suffered a moratoria by the NOM-029-PESC-2006 since 2009 [11]. The large size vessel fishery is conducted by vessels >27 m long, that can fish with longline using up to 1,500 hooks. In the past former

Management

The legal framework for the management of fisheries in Mexico is based on the General Law for Sustainable Fishing and Aquaculture. This law established that the National Council of Fishing and Aquaculture (CONAPESCA for its acronyms in Spanish) is the official institution for the management of fisheries and aquaculture activities, and the National Institute of Fisheries and Aquaculture (INAPESCA) is the scientific and technical advisor to CONAPESCA. This general law ratified the permit and concessions system that was in use since former versions of the law, and the National Fisheries Chart, produced by INAPESCA, as the public advisory document to CONAPESCA, where files for each of the commercial fisheries include the technical bases for its regulations. Also, the law recognizes the issue of specific standards (or "Normas") for the regulation of specific fishing activities.

Sharks have been exploited historically in Mexico. The first records of shark fin exportation to China are from La Paz, Baja California Sur, near the end of the 19 century. Since the start of the fishery, sharks have been used whole, as the meat is source of a low price protein, fins are exported mainly to the international market, and skin is used for leather goods, liver and bones are also used in some regions of the country. In order to regulate the fishery, in the 1970´s shark specific permits started to be issued. Since then several management actions have been taken.

At the beginning of the 1990´s signs of overexploitation started to show in the Gulf of Mexico and INAPESCA recommended a moratorium of permits in 1993. In recent years, Mexico listed the great white Shark (*Carcharodon carcharias*), basking shark (*Cetorhinus maximus*) and the whale shark (*Rhincodon typus*) as threatened species in its list of species at risk published by the Secretary of Environment and Natural Resources (SEMARNAT). And after signing the initiative for the International Plan of Action for Sharks, Mexico published its Shark´s National Plan of Action in 2004.

In 2007, standards for the fishery were published as the NOM-029-PESC-2006, which was a step forward for the implementation of regulations to reach sustainable shark fisheries in the country. In the NOM-029 three shark fisheries were recognized, specifying the type of fishing gear allowed for each fishery and for different regions in the country. Non fishing areas were established (mainly in association with sea turtles nesting beaches and marine mammal colonies), and the call for setting up a closed season was made. The NOM also established a logbook system in order to have better information of the shark species composition in the catches. No finning was allowed and the use of the complete shark became mandatory. Likewise, these standards are mandatory to other fisheries that catch sharks and rays incidentally. The NOM also prohibited the catch, or if caught incidentally, the retention of whole or any part of the body, of the whale shark (*Rhincodon typus*), basking shark (*Cetorhinus maximus*), white shark (*Carcharodon carcharias*), large-tooth sawfish (*Pristis perotteti*), smalltooth sawfish (*P. pectinata*), large-tooth sawfish (*P. microdon*), manta ray (*Manta birostris*), spinetail devilray (*Mobula japanica*), Munk´s devilray (*Mobula munkiana*), lesser devilray (*M. hypostomata*), and the Chilean devilray (*M. tarapacana*)..

Final Remarks

Shark and ray fishing in NW Mexico is based on several species, which are completely utilized as sources of low price protein. Even though several regulations have been developed for this fishery, including the banning of finning, there are still several caveats in the regulations, such as no minimum size have been established for any of the species. Despite the development of regulations, Mexico still has a very weak enforcement system, mainly due to the lack of staff, sufficient budget, but also because many of the shark landing locations are in remote areas, producing poor communications and presence of enforcement authorities. This enforcement system created is based on the fishers economic gain, implying that any future regulation development should consider social and economic factors in order to be more robust, suggesting also that a new culture for the management of these resources has to be developed.

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Inferences on Ecosystem Impacts of Shark Bycatch Removals: Search For a Generalized Approach From Bering Sea Sleeper Shark Fishery

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This presentation focuses on bycatch and uses the sleeper shark, *Somniosus pacificus*, bycatch in the Bering Sea as an example. In any study of bycatch it is important to carefully consider the multiple different factors involved and to define the context as carefully as possible. For example, will bycatch refer to retained and/or discarded animals, the percent of survival, or the likelihood of survival issues? It is important to consider why the study is being done. For example, considerations of ecosystem level questions arise in this era of ecosystem based management (EBM) and questions such as: the complexity and connectedness of the ecosystem arise. Implications of the gear type on the ecosystem, from trawl or longline, e.g., can be important. The impacts of by catch removals/mortality may also influence prey expansions or quasi-extinctions of prey, possibly leading to new ecosystem linkages.

Reasons to collect these data may vary from documentation of the trajectory to extinction, to stock assessments to estimate MSY – biomass or MSY-fishing mortality of the target stock or, in the case of the example here, reconstruction of the population structure at the beginning of the fishery on the target and thus, prior to significant bycatch removals.

In all of these possible objectives the issue of data quality and quantity are major limiting considerations. Bluntly: *all data are not created equally*. The sad fact is that a super-abundance of data cannot come even close to compensating for poorly or inadequately collected data. Ideally, life history data such as fecundity and age are collected, but in the sleeper shark example, e.g., neither is collected, which forces multiple approximations, often with impossible to determine impacts for the analysis to be carried out.

The pollock fishery in the sub-arctic Bering Sea is the most productive in the world. It occurs primarily on the continental shelf at depths less than 200m, with seasonal ice cover. Mid-water trawl gear is used and observer data collections provide 100% coverage for vessels over 125 ft. Thus an abundance of bycatch data is collected. The observer data collection operates as follows: fractions of the haul are sampled and weights of the sharks estimated. For this particular shark, this is exceptionally difficult du to its somewhat amorphous shape. Note that the Atlantic coast has a species analog, the Greenland shark, *Somniosus microcephalas*, also bycatch, but in the north Atlantic cod, and other fisheries. The decline in the observed bycatch from trawl and longline fisheries is dramatic over the 2003-2010 period, dropping from a mean of about 350mt to 50 mt, annually.

Possible interpretations

1. gear change;
2. fishing effort changes (spatial or temporal);
3. sharks moved away;
4. serial mortality over decades before now depleted number of females available to sustain historic bycatch levels.

Numbers 1, 2, 3 are eliminated from our knowledge. Number 4 is our target as most probable. *It is odd that we now look at the sustainability of bycatch as an indicator to assess the health of the bycatch stock.* Note that all bycatch in this fishery are pre-reproductive neonate / juvenile sharks. Characteristics of the data collection in the sleeper shark example include:

1. weights of sharks are guessed without a standard for comparison;
2. spatial patterns are observable for bycatch;
3. depth of gear is also available.

Weight data lead to inverse allometric, solved for length (L) as a function of weight (W):

$$L(W) = a\,W^{b}$$

Unfortunately, length is very poorly correlated with age information due to failure to accurately estimate age from hard parts of the body of sleeper sharks. The method of reconstruction of the original population depends on defining a bycatch matrix **B** as part of the inverse Leslie-like matrix model:

$$N_{t-1} = \mathbf{M}\,\mathbf{B}\,N_{t}$$

Due to the age data limited nature of the shark, matrix B contains stage specific information rather than age specific information. This allows projection back in time to estimate the stage specific nature of the population at the beginning of the removal of large components of population as by catch. Iteration stops when only minor matrix changes occur in each step. With an estimated initial population structure, and an estimate of the current population structure both available, it is possible to assess impacts of the estimated bycatch harvest.

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Activities of the ISC SHARK Working Group

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The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) is an intergovernmental organization established in 1995 to provide scientific information on the status of highly migratory fish stocks and their fisheries in the North Pacific Ocean. The members of the ISC are Canada, China, Chinese Taipei, Japan, Korea, Mexico and USA, and non-voting members include the Food and Agriculture Organization of the United Nations (FAO), Inter-American Tropical Tuna Commission (IATTC), the North Pacific Marine Science Organization (PICES), and Secretariat of the Pacific Community (SPC). The Committee is organized of four species working groups including bluefin tuna, billfishes, sharks, and albacore, and a statistics working group. Each species working group is responsible for conducting collaborative population assessments of the species under its purview, to coordinate international and national programs of research addressing those species, and to report to the ISC Plenary on the trends in population abundance, developments in fisheries, and conservation needs. The assessments and conservation advice are used for fisheries management by the two international regional fishery management organizations in the North Pacific: IATTC and the Western and Central Pacific Fisheries Commission (WCPFC).

The Shark Working Group (SHARKWG) is the newest ISC working group established in 2010 to replace the Bycatch Working Group. The mandate of the SHARKWG is to conduct population assessments and other scientific studies as required on pelagic sharks caught in highly migratory species fisheries in the North Pacific. The focus of the SHARKWG is on monitoring blue, shortfin mako, bigeye thresher, pelagic thresher, silky, oceanic whitetip, and hammerhead sharks, either by leading population assessment efforts, or by working collaboratively on population assessments with RFMOs or other scientific organizations as needed. Initial efforts of the SHARKWG are focused on conducting population assessments of blue and shortfin mako sharks in the North Pacific.

The SHARKWG has held two meetings since its inception and is currently working on a blue shark assessment to be completed in late 2012. A shortfin mako assessment is scheduled to be completed in 2013. In December 2011, the ISC SHARKWG also sponsored a Shark Age and Growth Workshop to address uncertainties and develop collaborative studies on shark age and growth. To date, significant progress has been made on compiling and estimating blue and shortfin mako shark catch from fishery data, reviewing life history information for blue and shortfin mako sharks, making initial decisions regarding modeling for the upcoming blue shark assessment, and establishing cooperative studies on population genetics, tagging, and age and growth.

For more information see http://isc.ac.affrc.go.jp/.

Development of Codes of Conduct for marine user interactions with sharks

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There is increasing concern over the incidental capture of sharks in hook and line and net fisheries (including aquaculture predator nets). Recently Canada listed 3 species of shark under the Species at Risk Act (SARA) in waters off its Pacific coast. The bluntnose sixgill Shark (*Hexanchus griseus*) and tope shark (*Galeorhinus galeus*) were both listed as species of "Special Concern" under the *Species at Risk Act* (SARA) in March 2009. The basking shark (*Cetorhinus maximus*) was listed as "Endangered" under the *Species at Risk Act* (SARA) in 2010. Life history features such as longevity, late age at maturity and low fecundity indicate sharks are unable to recover quickly after population reduction. The management goal for the bluntnose sixgill shark and tope shark is to maintain their abundance within Canadian Pacific waters at current or higher levels. Primary threats identified for these species were entanglement and bycatch, and a primary management action was to develop Codes of Conduct to reduce mortality by both aquaculture entanglement and bycatch of bluntnose sixgill shark and tope shark in all commercial and recreational fisheries. This Code of Conduct can be used by all user groups for bluntnose sixgill shark, tope shark, as well as other shark species which are captured unintentionally in recreational or commercial fisheries and are subject to catch restrictions or for which limited knowledge is available for their management and conservation. A separate Code of Conduct has been developed for basking shark. The main threats identified for this species are entanglement and bycatch, collision with vessels, and harassment from marine based activities. A resulting management action was to develop and implement a Codes of Conduct (guidelines for marine users to minimize negative interactions and collisions, i.e., proper boating practices for commercial fisheries, recreational fisheries, and ecotourism to reduce mortality). This Code of Conduct can be used by all user groups to reduce harm and increase the chances of survival of captured basking sharks. A separate Code of Conduct has been developed for bluntnose sixgill shark, tope shark, and other shark species which are captured unintentionally in recreational or commercial fisheries and are subject to catch restrictions or for which limited knowledge is available for their management and conservation. These Codes of Conduct are the first step in developing mitigation measures and handling practices to minimize mortality of sharks.

The global context for Canadian chondrichthyan fisheries management

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The last two decades has seen a rapid rise in awareness of numerous problems in the management and sustainability of global fisheries. While there may be considerable debate on the exact global number of stocks that are over, fully or under-exploited, it is clear that a large proportion are being fished outside safe biological limits. The response has been a series of policy imperatives such as the move toward a precautionary approach, toward responsible fishing and an ecosystem approach to fishery management. There is increasing recognition that fisheries managers not only have a responsibility to manage for the profitability and social well-being of local communities and the current generation of stakeholders, but also now have to consider the longer-term consequences of management for biodiversity and the interests of future citizens. Overfishing and the impact of inadequate fisheries management are increasingly recognized as one of the most serious threats to marine biodiversity and indeed to global biodiversity. The 2010 Conference of the Parties of the Convention of Biological Diversity (CBD)adopted a Strategic Plan for Biodiversity for 2011-2020, consisting of five strategic goals, including Strategic Goal B: to *reduce the direct pressures on biodiversity and promote sustainable use.* Under which is Target 6: *By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.*

Specifically, the rising awareness of overexploitation of sharks and their relatives (Class: Chondrichthyes or "chondrichthyans") and increasing understanding of the intrinsic sensitivity of their slow life histories (compared to the main target species of many fisheries) led to the formation of the International Union for Conservation of Nature (IUCN) Species Survival Commission Shark Specialist Group (SSG) in 1991. The SSG is one of the largest IUCN Specialist Groups with 171 volunteer members organized in 12 regional groups that broadly correspond to the FAO major fishing areas[2]. The SSG operates with Co-Chairs, a Deputy Chair, Vice Chair Specialists (Science, International treaties, Communication, Taxonomy, Trade and TRAFFIC) and three Area

[2] http://iucnssg.org/index.php/Regional_Pages

Coordinators, who make up part of the "Executive Committee" and Regional Vice-Chairs are in place for each of the 12 SSG regions.

The SSG mission is *to secure the conservation, management and recovery of the world's sharks, rays and chimaeras through the mobilization of global technical expertise*. In 2000 the SSG initiated the Global Shark Red List Assessment with the main aims: (1) to establish and provide baseline information on the global Red List status of all chondrichthyan species currently described and their conservation requirements, and (2) to inform the effective conservation and management of these species at national, regional and international levels and to raise awareness of the threats to chondrichthyans on a global scale, with the intention of halting the ongoing population declines around the world. Around 1083 of the >1175 known species of shark, ray, skate and chimaera were evaluated according to the IUCN Red List Categories and Criteria through a series of 13 geographic and thematic workshops, involving 302 national, regional and international experts from 64 countries. The findings were reported as an influential series of regional and thematic reports[3].

Here we present the variation in IUCN Red List and Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status for Canadian chondrichthyans following a description of the fundamental similarity between the two assessment systems and three differences between the criteria and the resultant listings. The COSEWIC criteria are modeled on IUCN Red List criteria. This is not surprising because the IUCN Red List criteria have been in development since the late 1960s and have now been applied to more than 55,000 species. The main difference is that Red List criteria provide a status at the global *SPECIES* level that contrasts with COSEWIC by providing a national or subnational (Pacific or Atlantic) status assessment for part of the geographic range of more widely distributed species. This is the most important point, because IUCN Threatened species may not be threatened in Canadian waters, and *vice versa*; hence the IUCN and COSEWIC status may differ. This then brings us to the second important difference, which is that COSEWIC criteria incorporate the modifying effect of any potential rescue effect from beyond the Canadian part of the species geographic range. Third, the COSEWIC decline criteria and thresholds are broadly the same as IUCNs and depend on whether species are actively managed (A1 criterion) or not (A2-4). However, COSEWIC has only two categories: Endangered (70% decline if not managed, 50% otherwise) and Threatened (50% decline and 30% if, whereas IUCN has an additional category of Critically Endangered for steeper declines (90% if unmanaged, 80% if managed). Last, COSEWIC allows modification of status based on intrinsic vulnerability: late age at maturity, large body size, and non-overlapping generations (e.g. Pacific salmon).

Canadian waters, or Exclusive economic Zone (EEZ), extend 200 miles offshore and harbors over 5% of the world's chondrichthyan species, with at least 63 of more than1100+ known species of sharks, rays and chimaeras. This Class comprises two superorders: Holocephali and Elasmobranchii. In Canada the superorder Holocephali is represented by six species, from three genera in two families. The superorder

[3] http://www.iucnssg.org/index.php/reports_and_publications

Elasmobranchii comprises two subdivisions: the Selachii (modern sharks) and Batoidea (rays), which in Canada are represented by 29 and 28 species, respectively. None of the 63 chondrichthyans are endemic to the Canadian EEZ. An additional 13 chondrichthyan species are either found in adjacent U.S. waters (off Washington and/or Alaska) but have yet to be recorded there (e.g. frilled shark *Chlamydoselachus anguineus*) or may require taxonomic revision (*Bathyraja kincaidii* and *Bathyraja (Rhinoraja) interrupta*).

The IUCN lists 27 of the 63 chondrichthyans found in Canadian waters as either Threatened (Endangered = 3 species, Vulnerable = 12) or Near Threatened (n = 12). Twenty-five species are of Least Concern, 10 are Data Deficient and one species – the Pacific spotted spiny dogfish (*Squalus suckleyi*) - is Not Evaluated. Nationally, only 12 species (and some of their constituent populations have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Of these 12 evaluated species, 8 have populations that are listed as being Endangered, Threatened or Special Concern. Only three species were found to be Not At Risk (*Bathyraja kincaidii* [=*interrupta*], *Raja rhina*, *Raja binoculata*).

Approximately 25 out of the 63 Canadian chondrichthyan species are found in or adjacent to the Pacific coast of Canada and five species are Vulnerable globally according to IUCN Red List Assessment, including: thresher shark (*Alopias vulpinus*; COSEWIC status: Not Evaluated), basking shark (*Cetorhinus maximus;* COSEWIC: Endangered), white (*Carcharodon carcharias;* COSEWIC: Data Deficient), shortfin mako (*Isurus oxyrinchus*; COSEWIC: Not Evaluated in the Pacific but Threatened in Atlantic) and soupfin / tope shark (*Galeorhinus galeus;* COSEWIC: Special Concern). Four species have Near Threatened globally according to IUCN Red List Assessments: sixgill shark (*Hexanchus griseus;* COSEWIC: Special Concern), Pacific angel shark (*Squatina pacificus*; COSEWIC: Not Evaluated), blue shark (*Prionace glauca*; COSEWIC: Data Deficient) and big skate (*Raja binoculata*; COSEWIC: Not at Risk). A further ten Pacific Canadian species are of Least Concern and four are Data Deficient (*Notorynchus cepedianus, Somniosus pacificus, Apristurus brunneus, Bathyraja abyssicola* and *Raja inornata).*

There are pressing issues regarding research and conservation of chondrichthyans, including those found of the Pacific coast of Canada. First, greater understanding of taxonomy and basic natural history, particularly age and growth is still essential. This need is underscored by the recent discovery that the Pacific species known as spiny dogfish and long thought to be *Squalus acanthias* is actually a separate species, *Squalus suckleyi*, within the *S. acanthias* complex (Ebert et al., 2010). Indeed, numerous large-bodied chondrichthyans are now known to comprise of cryptic species complexes, that are not fully resolved (White & Last, 2012). Improvements in catch data collection are required as Canada develops sustainable fishing limits (FAO, 2010). A key question for the future is how the Canadian government will respond to increasing public concern over shark fin soup consumption by the Asian community and related assumptions about shark finning. Whereas, recent city bans and proposed federal legislation aimed at banning imports may not address threats to Canadian chondrichthyans and/or may not significantly reduce global demand, the associated outcry underscores the need for the Canadian government to adopt more stringent national and international

chondrichthyan management policies. Third, Canada, particularly as host to the secretariat of the CBD is committed to delivering Aichi Target 6. Toward this aim, there is clear opportunity to recognize and highlight the success of the Pacific integrated groundfish management system as one of the rare examples of a sustainable chondrichthyan fishery: that of the Pacific spotted spiny dogfish. In addition, Canada should improve the conservation status of chondrichthyans through the following national and international actions:

- close the targeted fishery for Endangered (COSEWIC) Atlantic porbeagle sharks, and end opposition to an Atlantic-wide prohibition on take of porbeagles under the International Commission for Conservation of Atlantic Tunas (ICCAT),
- work with the U.S. and EU to promote ICCAT catch limits for Vulnerable shortfin mako sharks,
- work to ensure the adoption of best scientific advice for the IUCN Threatened thorny skate (*Amblyraja radiata*) at the Northwest Atlantic Fisheries Organization (NAFO),
- promote a prohibition on take of IUCN Vulnerable oceanic whitetip shark (*Carcharhinus longimanus)* and a ban on setting purse seines on Vulnerable whale sharks at the Western and Central Pacific Fisheries Commission,
- ban all at-sea shark fin removal in line with the IUCN global policy on shark finning,
- promote this "fins-naturally-attached" approach at Regional Fishery Management Organizations (RFMOs),
- base Atlantic spiny dogfish quotas on science and the precautionary approach, not landings history, and work with the U.S. toward a bi-lateral management agreement for the species;
- end opposition to EU efforts to list spiny dogfish under Appendix II of the Convention on International Trade in Endangered Species (CITES),
- develop and offer a proposal to list a threatened Canadian chondrichthyan species under CITES,
- invite conservation representatives to serve on government delegations to RFMO meetings (as is done for fishing industry representatives)
- sign and engage in implementation of the Convention on Migratory Species (CMS) Memorandum of Understanding for Migratory Sharks.

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WWF Perspective on the conservation of Canadian shark species

Tonya Wimmer
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WWF-Canada is working to conserve biodiversity, restore ecosystem health and ensure that resource use is sustainable throughout Canada's oceans.

The decline in shark populations globally and nationally is a concern to WWF and so our key focus has been to address the major conservation concerns facing sharks in Canadian waters as well as work with network partners to address the primary global driver of the trade in shark products.

The unintentional capture of sharks, primarily as bycatch or through entanglements, is the main threat facing sharks in Canadian waters. The other issue hindering the protection of sharks is that for most species, there is a lack of understanding of their abundance, population structure, distribution and source and levels of threats. To address these issues, we have implemented a number of initiatives, including:

Working with partners to better understand our current knowledge of shark populations in Pacific, Atlantic and Arctic waters, the threats they face and identify information gaps and priorities for research, management and on-the-water actions. This was the goal of the Atlantic Shark Forum in March 2011 and of the Pacific Shark Workshop. The Atlantic Shark Forum identified four overarching priorities to address conservation concerns for Atlantic shark species. These are: Need a better understanding of shark avoidance and release practices already being used by industry in Atlantic Canada and how this information can be shared amongst sectors; Need to advance research on and the implementation of appropriate mitigation measures; Require more and better information on stock status of shark populations and need to make available training and education about shark conservation issues.

- Conducting research on elasmobranch bycatch and identifying bycatch hotpots in Atlantic Canada in collaboration with Dalhousie University
- Gather traditional knowledge of fishermen in Atlantic Canada regarding shark distribution, habitat use and bycatch hotspots.
- Examining Canada's efforts on shark conservation to date by examining the National Plan of Action for Sharks (NPOA), how well they've met this and other international commitments and identifying recommendations to improve policies, management and the NPOA.
- Working with industry to investigate possible measures to mitigate shark bycatch in key fisheries. This included conducting a pilot project on the use of rare earth metals to reduce shark bycatch in the commercial pelagic longline fishery for swordfish and tunas in Atlantic Canada.

- Working with recreational shark fishermen to develop best handling practices to maximize the post-release survival of released sharks.
- Developing materials to improve data collection on sharks caught in commercial and recreational fisheries. In Atlantic Canada, this includes developing an identification guide for use by observers and fishermen to ensure accurate and consistent information is collected from all fisheries interacting with sharks, skates, rays and chimeras.
- Working with researchers from Dalhousie University to provide information to partners and the general public on sharks and initiatives to study or protect them in Atlantic Canada through the Sharks of the Atlantic Research and Conservation Center: www.atlanticsharks.org.
- Engaging in and strengthening the MSC process to ensure fisheries seeking certification that interact with sharks are not having a negative impact on populations and the ecosystem.
- Working with key retail partners to ensure seafood products sold are from sustainable sources.
- Working through international fora to ensure that international trade in sharks and other specimens does not threaten the survival of any species.

Industry Perspective on the longline fishery for the North Pacific Spiny Dogfish (Squalus Suckleyi) and bycatch in British Columbia

Mike Renwick
Executive Director, BC Dogfish Hook & Line Industry Association

Background

The purpose(s) of the Association, founded in 2002, is to promote, develop and safeguard the interests of its members by promoting a sustainable hook and line dogfish fishery for B.C. coastal waters; developing and promoting responsible and selective fishing methods for the harvesting of dogfish; and maximizing the socio-economic benefits of the fishery to its members and to the Canadian public**.**

Membership is open and inclusive of both active dogfish fishermen and processors. There is a commercial fishery for spiny dogfish in BC today. Since this fishery's re-emergence as an organized fishery over the last 10 years or so, catch levels have averaged around 3,000 m.t , only 30-40% of the Total Allowable Catch on the main outside migratory stock.

Spiny Dogfish Fishery participation in the Commercial Groundfish Fishery

The dogfish fishery sector has been part of the Commercial Industry Caucus founded in 2002/03 that developed an 'all groundfish sector' suite of solutions, by consensus, that were required to meet DFO's goal to consolidate management of all groundfish fisheries under a single IFMP and meet 5 key objectives, including development of a system to monitor and attain full accountability of all catch.

Dogfish Stocks and MSC Certification

Based on stock status surveys and reviews on spiny dogfish conducted by independent fishery biologists over the last 20 years, and more recent commercial and scientific groundfish stock surveys, it appears that stocks of both outside and inside spiny dogfish (Gulf of Georgia) are stable and commercial directed fishing pressure is relatively low (approx. 20 medium size longline vessels in recent years).

In 2006, the Association reacted to mounting market pressures in markets for its products in Western Europe to seek sustainable certification, and conducted a pre-assessment of the 2 spiny dogfish stocks in BC waters. The assessment pinpointed that an updated stock assessment would be required to validate stock health. A joint US/Canada stock assessment was initiated in 2008 but was abandoned due to lack of funding. A joint DFO/private contractor stock assessment funded by this Association was initiated in 2009. The yield recommendations were not adopted by DFO, due to the inability of a DFO/industry committee to agree on some aspects of the modeling and recommendations.

Our Association entered the north pacific spiny dogfish fishery into a full MSC assessment in 2008 based on the belief that a full stock assessment would be completed for the review. Such was not to be. As a result, the MSC certifier used the Risk Based

Framework to assess the stock health component. The fishery was accepted by MSC and certification was granted in September, 2011, almost 4 years later.

Bycatch in the BC Spiny Dogfish Fishery

Bycatch of non-target quota species (non-directed catch) in the dogfish fishery is low due to dogfish gear, fishing grounds and selective fishing practices employed by dogfish fishermen. Total bycatch of quota species has averaged approx. 5.4% of the dogfish catch over the last 5 years by landed weight. These species include halibut, sablefish, lingcod and 11 rockfish species. All sectors provide annual access by negotiation annually to their target quota species to enable each other sector a permissible level of non-directed catch to which they are free to market.

Bycatch of non-target '*species of interest'* includes 5 skate species, 1 ray species, 9 shark species (not including dogfish), 5 bird species and 1 mammal species (seals). Fishermen are required to account for 'catch' of these species in their logbooks, on a piece count basis, whether they are landed or released. Archipelago Marine Research (AMR) conducted a summary of log book entries across all hook, line and trap groundfish vessels during the first 8 months of the 2011-12 fishing year for these species of interest. The dogfish sector log book data showed 5.7% of the occurrences across these 21 species relative to all hook, line and trap gear types.

At-Sea Handling Practices of Species of Interest (including other sharks)

All groundfish fishermen take care to return unmarketable non-quota species and certain species of concern whether caught by hook, line, trap or trawl. Specific to hook and line fisheries, fishermen attempt to first release an unwanted live fish by de-hooking or by cutting the purlon line. In some cases, when a fish is mouth hooked, an incision may be made to release the hook. Depending on the species, survival can be quite high, especially with undersized dogfish which appear to be very resilient. Some dogfish show signs of previous rough practices where scars show complete healing from previous encounters with fishermen.

Full Utilization of the Landed Catch of Spiny Dogfish

For the last decade, all of the dogfish landed is fully utilized. The marketable food products (backs, belly flaps, fins and tails) represent about 50% of the whole fish weight. The balance is considered fresh fish byproducts and converted by other manufacturing processes into dried shark cartilage, fresh hydrolyzed organic liquid fertilizer and a small quantity of livers are distilled for oil for a variety of uses.

Commercial Fishery Challenges

There has been an ongoing lack of funding by both DFO and commercial dogfish fishery stakeholders to carry out stock assessments on a regular basis (the last comprehensive dogfish stock assessment carried out by DFO was in 1988). Continuing low prices for dogfish products has hampered the industry's ability to invest or partner in scientific surveys, and the possible reduction or elimination of Government funding to support co-funding of fishery surveys, is a very ominous and potentially destructive situation facing all commercial fishery sectors coupled with negative impacts on coastal communities, employment, and First Nations.

The high costs of MSC sustainable certification for the dogfish sector require higher prices in the market place and higher prices to allow economic viability to the stakeholders here in BC. The market acceptance of MSC certified BC dogfish products and the ability of attaining higher prices is just getting underway in Western Europe and a positive outcome needs to come sooner, rather than later.

To meet some of the MSC conditions of certification, DFO committed to conducting a full stock assessment of the BC spiny dogfish stocks within the next 4 years. Departmental funding has not yet been guaranteed and federal budget cuts and ongoing economic weakness are concerning.

One item of recent concern to our stakeholders is the apparent differences in views on dogfish sustainability held by such organizations as COSEWIC, SARA, IUCN, CITES and various outspoken conservation NGO's. It seems that part of the reason for the inconsistent views and 'ratings' of dogfish fisheries is that there is no common set of criteria that are being measured.

Commercial Fishery Opportunities

Integrated fishing carried out in the BC Groundfish fishery has become just that. Individual fishermen now have the ability to land all species caught that are included in the IFMP, as well as some *species of interest* (e.g. some skate species), where these species are believed to be from healthy stocks and awaiting stock assessments. Full accountability of all catch and the rigors of the logbook, dockside and electronic monitoring program allow real-time management of these stocks, ensuring the catch is within TAC's at all times.

The future of integrated fishing will hopefully see fishermen truly being able to tailor individual fishing trips according to market demands, and while fishing to responsible and full accountability mechanisms, be able to maximize the economics of their fishing operations and value of the fish they are able to land and market.

This especially applies to dogfish, a species in BC that is highly abundant and the most common bycatch species among many of the groundfish directed fisheries. It literally takes up a lot of space on longline and trawl gear and continues to be discarded due to low market value relative to other target species. If the MSC certification is successful in improving the value of BC dogfish, we hope that all sectors will include their dogfish bycatch in their fishing plans.

Our sector worked hard with other groundfish sectors, DFO and the conservation community to co-develop this landmark program, and this cooperative and fruitful relationship among all stakeholders has enabled the BC dogfish fishery to attain MSC certification. We will continue to work cooperatively for the common goal of coast wide fishery sustainability in BC and Canada.

Improved data on catch and discards will be advanced under increased mandatory reporting of the catch and discards of dogfish and other shark species by the salmon, tuna and recreational sectors, for example.

Increased education and diligent use of identification charts/photographs as well as reporting of shark bycatch by both fishermen and observers/video reviewers of electronically monitored catch events.

A firm and public commitment by the Government of Canada is required to confirm an appropriate and consistent year-to-year funding of fishery science, including stock assessment funding, which ensures ongoing robust fisheries in the Pacific Region while ensuring sustainable and economically viable fishery stakeholders.

Priorities

Discussion Summary: Break out session - by sector

During the first working group breakout sessions, participants were organized according to their areas of knowledge and expertise or sectors (science, policy/management and industry). Participants within each session discussed the issues affecting their sectors and developed a set of priorities that would be most effective in advancing the management and conservation of sharks and other Elasmobranchs in Pacific Canadian waters. During the second breakout working group sessions participants were rearranged to achieve mixed-representation and discussed the category specific recommendations from the previous sector sessions, and developed a set of cross-cutting priorities for all sectors. These priorities (by sector and cross-cutting) are presented below. They are not necessarily presented in order of importance, but taken together should inform and guide responsible government agencies and stakeholders in developing science, management and conservation actions.

Top Priorities for Science

1. Improved stock status information:

    - Analysis of existing catch, survey and biological data to refine knowledge of spatial and temporal distribution, and identify key areas for mating, pupping and rearing of Elasmobranchs in Pacific Canadian waters.
    - Increased collection of biological samples to estimate key life history parameters.
    - Improved identification and reporting of bycatch from currently monitored (groundfish) and unmonitored (recreational, salmon and herring, tuna) fisheries.
    - Identification of transboundary populations.
    - Development of a prioritized list of species for directed research based on interactions with current fisheries.
    - Determination of discard mortality rates for all elasmobranch species by gear type and incorporate into bycatch mortality estimates.
    - Development of stock assessments for priority species including reference points and risk analyses.

2. Develop and evaluate options for mitigating elasmobranch bycatch and bycatch mortality:

    - Improve information base on spatial and temporal distribution of elasmobranchs and interactions with current fisheries.
    - Identify and test options to prevent interactions with current fisheries.

- Determine post release mortality for all elasmobranch species encountered by fisheries.
- Develop best handling and release practices for elasmobranch bycatch.

3. Increase collection of fishery-independent data:
    - Evaluate existing survey data (IPHC surveys, DFO surveys, US groundfish surveys) for elasmobranch bycatch information.
    - Initiate fishery-independent surveys for elasmobranchs where information is needed.

Top Priorities for Policy/Management

1. Develop regionally based shark (elasmobranch) management plan (action plan).
2. Following determination of stock status, establish precautionary catch limits if needed.
3. Improve training for observers, particularly species identification and collection of biological samples.
4. Promote development and enforce best practices for handling and release of elasmobranch bycatch.
5. Improve and enforce regulations governing shark bycatch in all fisheries.
6. Integrate fishers knowledge into management recommendations.
7. Improve awareness of shark conservation and management through development of an education/awareness program.

Top Priorities for Industry (On the Water Practice)

1. Improved science to ensure stock status of elasmobranchs has been determined using best available data.
2. Improved monitoring and enforcement of elasmobranch bycatch in all fisheries (currently only groundfish trawl and hook and line fisheries are adequately monitored).
3. Implement the use of Identification Keys, and develop data collection guides for fishers. This information could be very useful but must be accepted by science.
4. Promote best practices for handling and release of elasmobranch bycatch.

5. Work closely with science and management to develop options for mitigating elasmobranch bycatch i.e. initiate cooperative pilot programs.
6. Educate public re: industry role developing and promoting sustainable elasmobranch fisheries (dogfish, skate).
7. Actively promote international cooperation, as many elasmobranch stocks are transboundary, and there are catch and bycatch issues in other jurisdictions that could impact on British Columbian stocks.

Discussion Summary: Break out session cross-cutting priorities

To determine the stock status and improve conservation and management of elasmobranchs in BC waters:

1. Improved understanding of stock status of Pacific Canadian elasmobranchs through:
    - Improved catch, bycatch and biological data collection in all fisheries.
    - Analysis of existing and new catch, survey and biological data to refine knowledge of spatial and temporal distribution, and key life history stages.
    - Assessment of bycatch and post release mortality in all fisheries.
    - Prioritize species for directed research based on interactions with current fisheries and identify transboundary populations.
    - Develop stock assessments for priority species including reference points and risk analyses.

2. Minimize mortality and implement appropriate mitigation practices though:
    - Identification of where interactions with fisheries occur by increased monitoring, bycatch analyses, fisher knowledge.
    - Identifying, testing and implementing options to prevent interactions.
    - Conducting post release mortality studies in cooperation with industry.
    - Developing and implementing best handling and release protocols for bycatch.
    - Disseminating knowledge on elasmobranch avoidance, best handling practices and mitigation options to fishers through workshops, educational materials etc.

3. Increased education/awareness through:
    - Improved cooperation and coordination between sectors, including open communication among all stakeholders.
    - Training on identification and sampling of Pacific Canadian elasmobranchs and development of best handling practices.
    - Public education on issues and initiatives being undertaken with respect to conservation and management of elasmobranchs (particularly in Pacific

Canadian waters) through an interactive website, workshops, and dissemination of other educational materials.

4. Development of a regionally based elasmobranch management plan (action plan) which identifies issues, research priorities including needs/gaps, potential solutions, timeframes and costs.

Discussion and Next Steps

It is fair to say that sharks and other Elasmobranchs have taken on a deserved importance in the minds of the public based upon their image as a noble, powerful animal, and in the minds of scientists and managers based upon their role in the ecosystem. However declines in elasmobranch populations have been documented in many regions of the world. In the last two decades the management and therefore the conservation of elasmobranchs has not been successful in many instances, and more focused attention needs to be directed at these species. The Pacific Shark Workshop brought together a diverse group of scientists and stakeholders from government, academia, industry and NGOs to share knowledge and collaborate in identifying issues and to begin to develop solutions to advance conservation and management of sharks in Pacific Canadian waters. During the workshop it became clear that recent initiatives have been directed at research, management and conservation of sharks and other Elasmobranchs, however, as the above results show, there is still much to be done. It is hoped that the priorities and activities developed by breakout group participants (science, policy/management and industry), and the cross-cutting priorities identified by all participants will help to guide policy makers and funding agencies in the future.

Next steps in the process started at this workshop, as identified by the participants, should be:

1. Take all materials presented and discussion outcomes and publish the proceedings of the workshop with a well defined set of priorities. The proceedings should be widely distributed. Participants noted that not all stakeholder groups attended the workshop and wide distribution of this report should generate future interest. The participants emphasized the need for future collaborative workshops.

2. Develop regionally based shark (elasmobranch) management plan (action plan) which identifies issues, research priorities including needs/gaps, potential solutions, timeframes and costs

3. Development of an interactive Pacific elasmobranch website (similar to that being developed on the Atlantic coast). [Following the workshop, WWF and TRAFFIC in collaboration with IUCN have initiated development of this website].

4. Closer collaboration with all sectors; government, industry, academia, NGOs. Initially this could be pilot programs on bycatch mitigation or post release mortality studies.

5. Encourage all participants to find and access new funding opportunities (i.e. strategic grant possibilities) to further elasmobranch research, management and education/outreach programs.

6. Establish a bi-annual meeting or workshop to allow presentation of current research, management, conservation, and industry initiatives focused on elasmobranch biology, ecology and management along the west coast of North

America. This meeting, workshop or symposia could be held in conjunction with other meetings (i.e. AFS section meetings; west coast Groundfish meeting etc).

7. Many elasmobranch species, and therefore conservation/management issues, are transboundary, therefore collaborative stock status programs should be initiated with US and Mexican counterparts.

The Pacific Shark Workshop was a successful first step in developing an ongoing collaborative process for improving elasmobranch management and conservation in Canada's Pacific waters. The identified priorities should help to direct future elasmobranch research and management.

The following appendix is the original Priority lists distributed as part of the meeting package during the workshop as a starting point for discussion.

Appendix A: Original Draft Priority list

Draft Priority lists for Shark Conservation

Priorities highlighted below are in regards to shark species in Pacific Canadian waters. These tables are meant as a suggested starting point to help seed and focus discussion for the forum. We expect disagreement on many of the suggested topics and/or values, so please don't be shy about suggesting changes or edits, and please be prepared to add any and all topics deemed appropriate. We are aiming for a final list for each sub-heading of no more than 10 items by the end of the forum.

Use this system for scoring:

Relative Importance:

- Low = would address a notable issue, but unlikely to have broad effects on shark conservation
- Medium = would resolve a significant issue or roadblock to implementing effective conservation measures and ensuring recovery of shark populations
- High = would have a dramatic effect on the accuracy and implementation of effective conservation measures and ensuring recovery of shark populations

Time needed to address:

- Short = 1-5 years
- Medium = 5-10 years
- Long = >10 years

Cost to answer:

- Low = may be possible with existing funding
- Medium = significant additional resources necessary to address
- High = major funding initiatives and/or restructuring of existing funding necessary
- Unknown

SCIENCE

Priorities	Relative Importance	Time needed to address	Cost to answer
1) Determine the spatial and temporal distribution of sharks in Pacific Canadian waters			
2) Determine the spatial and temporal distribution of shark bycatch (commercial, recreational) hotspots in Pacific Canadian waters			
3) Implement fisheries-independent shark surveys to enhance shark population assessments and trends			
4) Increase scientific data collection for shark species			
5) Evaluate current options for mitigating shark bycatch in all fisheries, such as handling and release practices, gear modification etc.			
6) Collaborate with industry to determine possible methods of gear modifications to reduce shark bycatch			
7) Conduct and assess post release mortality studies for determining catch and release mortality of incidentally caught sharks			
8) Modify/develop stock assessment tools/methodologies for data limited bycatch shark species			

POLICY/MANAGEMENT

Priorities	Relative Importance	Time needed to address	Cost to answer
1) Support a re-commitment to an updated National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks) with clear actions, priorities, timeframes and responsible agencies involved			
2) Promote developing a regional/Pacific Canadian shark action plan to address conservation concerns for commercial and non-commercial species			
3) Improve regulations governing shark bycatch to account for total discard mortality in fisheries known to have bycatch of sharks			
4)Improve training for observers on the identification of shark species ,and collection of biological information from incidentally caught sharks in all fisheries			
5) Establish precautionary catch limits for bycatch of non-commercial shark species			
6) Develop and enforce best practices for handling and release of sharks			
7) Evaluate/assess current ability to monitor (e.g. observer coverage) and enforce regulations established for conservation and management of shark species			
8) Promote program to assess and develop options for the mitigation of threats for incidentally caught sharks such as handling and release practices, gear modification etc.			

PRACTICE

Priorities	Relative Importance	Time needed to address	Cost to answer
1) Gather industry knowledge to determine possible methods of bycatch reduction of sharks			
2) implement the use of identification keys, data gathering methods and user-friendly data charts that incorporate necessary information (if needed)			
3) Increase observer coverage in unmonitored fisheries known to have bycatch of sharks			
4) Promote and enforce reporting of species-specific shark catch in unmonitored fisheries			
5) Establish best practices for handling and release to ensure sharks are released alive			
6) Establish pilot projects to reduce/mitigate the bycatch of sharks in fisheries			
7) Identify and implement area closures of areas known to have high bycatch for at risk species (basking, tope and sixgill sharks)			

Appendix B: Pacific Shark Workshop Participants

Name	Affiliation
Dan Edwards	BC Dogfish Hook & Line Industry Association
John Koolman	BC Dogfish Hook & Line Industry Association
Mike Renwick	BC Dogfish Hook & Line Industry Association
Bruce Turris	Canadian Groundfish Research & Conservation Society
John Lenic	Canadian Pacific Sardine Association
Mitch Ponak	Canadian Pacific Sardine Association
Jackie King	Canadian Pacific Shark Research Lab, Pacific Biological Station
Sean Brillant	Canadian Wildlife Foundation
Scott Wallace	David Suzuki Foundation
Brian Mose	Deep Sea Trawlers Association
Ken Goldman	Department of Fisheries and Game Alaska
Tamee Karim	Department of Fisheries and Ocean
Paul Cottrell	Department of Fisheries and Oceans
Romney McPhie	Department of Fisheries and Ocean
Sandy McFarlane	Department of Fisheries and Ocean emeritus
Heather Brekke	Department of Fisheries and Ocean
Oscar Sosa-Nishizaki	Fisheries Ecology Laboratory,Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE)
Lucy Harrison	IUCN Shark Specialist Group
Nick Dulvy	IUCN Shark Specialist Group, SFU
Dave Ebert	Moss Landing Marine Laboratories
Suzanne Kohin	National Oceanic and Atmospheric Administration (NOAA)
Wade Smith	Oregon State University
Jennifer Yakimishyn	Pacific Rim National Park Reserve
Danielle Knip	Simon Fraser University
Lindsay Davidson	Simon Fraser University
Loren McClenachan	Simon Fraser University
Sabrina Garcia	Simon Fraser University
Andres Cisneros	University of British Columbia
Danielle Edwards	University of British Columbia
Vince Gallucci	University of Washington
Dayv Lowry	Washington Department of Fisheries
Bettina Saier	WWF Canada-Halifax
Tonya Wimmer	WWF Canada-Halifax
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