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Pacific and Yukon Region 2005
Canadian Wildlife Service

Technical Report Series Number 401

Environment Canada | Environnement Canada
Canadian Wildlife Service | Service Canadien de la faune

Canada

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Technical Report Series No. 401
Pacific and Yukon Region 2005
Canadian Wildlife Service

This series may be cited as:

Smith, J.L. and K.H. Morgan, 2005.
An Assessment of Seabird Bycatch in Longline and Net Fisheries
in British Columbia.
Technical Report Series No. 401. Canadian Wildlife Service,
Pacific and Yukon Region, British Columbia

Issued under the Authority of the
Minister of Environment
Canadian Wildlife Service

Catalogue No. CW69-5/401E
ISBN 0-662-33923-1
ISSN 0831-6481

Copies may be obtained from:
Canadian Wildlife Service
Pacific and Yukon Region
5421 Robertson Road, RR#1
Delta, British Columbia
Canada, V4K 3N2

ABSTRACT

In 1999, Canada endorsed the United Nations International Plan of Action to reduce the incidental catch of seabirds in longline fisheries; at that time the extent of seabird bycatch in British Columbia (BC) was unknown. All signatories to the Plan were asked to evaluate the effect that their fisheries had on seabird populations. Understanding the extent of seabird bycatch is also important to Fisheries and Oceans Canada in order to manage their fisheries in accordance with the UN Code of Conduct of Responsible Fishers. The initial purpose of this review was to summarise existing seabird bycatch data in the longline fisheries in BC, in order to develop a National Plan of Action. Based on the desire to understand the level of bycatch in more than the longline fisheries, we expanded the review to also include net fisheries. We obtained data (from logbooks and observers) from the commercial halibut and rockfish longline fisheries, the seamount fishery between 1998 and 2002, and from an ongoing salvaged bird program. Also, we gathered data (logbook and observer) from salmon gill net and seine fisheries between 1995 and 2001. Six species of birds were reported caught on longlines in the halibut, rockfish and sablefish fisheries. Black-footed Albatrosses *(Phoebastria nigripes)* were the most common bycatch, but Northern Fulmar *(Fulmarus glacialis)*, Short-tailed Shearwater *(Puffinus tenuirostris)*, Herring *(Larus argentatus)*, California *(L. californicus)* and Glaucous-winged *(L. glaucescens)* gulls were also caught. The highest overall bycatch rates occurred in the seamount rockfish fishery (2-year average: 0.024 birds/1,000 hooks). Depending on the fishery, observer coverage in the longline fisheries we examined ranged between 0.2 and 100% of hooks fished. In the salmon net fisheries, we found bird mortality to be highly variable; bycatch rates ranged between 0.019 and 0.219 birds/hour fished. Common Murres *(Uria aalge)* and Rhinoceros Auklets *(Cerorhinca monocerata)* were the species most often reported caught; comprising more than 90% of the bycatch in the Area D Sockeye Gill Net Selective Fishery. Over the five years in which seabirds were identified to species, Common Murre and Rhinoceros Auklet accounted for almost 90% of all birds caught in the Area 21 Gill Net Test Fishery. Marbled Murrelets *(Brachyramphus marmoratus)* were reported caught in at least three fisheries. A high proportion of the bycaught birds were left unidentified and were not salvaged. We stress that the estimates of species-specific bycatch may be underestimated due to the high number of unidentified and non-salvaged birds. We also caution the reader that this is a preliminary assessment of the state of seabird bycatch in west coast fisheries; the data we describe were predominantly small sub-samples of the various fisheries examined, and the *ad hoc* sampling design precluded rigorous analyses. We encourage the continued development of

data collection programs to address seabird bycatch. Fisheries observers should either be fully trained to identify bycaught birds to species or preferably, they should be instructed to salvage all bycatch birds; and observer coverage should be expanded to represent the fishing effort both spatially and temporally for bycatch rates to be estimated. Overall, the current information suggests that bycatch is a concern and conservation efforts are required.

RÉSUMÉ

En 1999, le Canada a adhéré au Plan d'action international des Nations Unies visant à réduire les captures accidentelles d'oiseaux de mer par les palangriers. On ignorait à l'époque l'ampleur de ces captures en Colombie-Britannique, mais tous les signataires du plan devaient évaluer les effets de leurs pêches sur les populations d'oiseaux de mer. Pêches et Océans Canada juge aussi important de connaître l'ampleur des captures d'oiseaux de mer pour gérer les pêches conformément au Code de conduite pour une pêche responsable de l'ONU. Le but premier de cet examen était de faire une synthèse des données existantes sur les prises d'oiseaux de mer chez les palangriers de la Colombie-Britannique afin de dresser un plan d'action national. Désireux de connaître le niveau des prises accidentelles dans les autres types de pêches, nous avons élargi la portée de l'examen de façon à inclure les pêches au filet. Nous avons ainsi recueilli des données (dans les livres de bord et auprès des observateurs) sur les pêches commerciales du flétan et des sébastes à la palangre dans les eaux situées à proximité du mont sous-marin entre 1998 et 2002, de même qu'auprès d'un programme de récupération des oiseaux en cours. Nous avons aussi rassemblé les données (livres de bord et observateurs) sur les pêches des saumons au filet maillant et à la seine entre 1995 et 2001. On a signalé la capture de six espèces d'oiseaux dans les palangres dans le cadre des pêches du flétan, des sébastes et de la morue charbonnière. Ces prises consistaient le plus souvent en Albatros à pieds noirs *(Phoebastria nigripes)*, mais on a aussi capturé des Fulmars boréals *(Fulmarus glacialis)*, des Puffins à bec grêle *(Puffinus tenuirostris)*, de même que des Goélands argentés *(Larus argentatus)*, de Californie *(L. californicus)* et à ailes grises *(L. glaucescens)*. Les taux de prise globaux les plus élevés ont été observés dans la pêche des sébastes dans les eaux proches du mont sous-marin (moyenne sur 2 ans : 0,024 oiseaux / 1 000 hameçons). Selon la campagne, la couverture par les observateurs dans les pêches à la palangre variait entre 0,2 et 100 % des hameçons pêchés. Dans les pêches de saumons à la palangre, la mortalité des oiseaux est apparue fort variable, les taux de prise accidentelle variant entre 0,019 et 0,219 oiseau/heure de pêche. Dans la pêche sélective au filet maillant du saumon rouge dans la zone D, le Guillemot marmette *(Uria aalge)* et le Macareux rhinocéros *(Cerorhinca monocerata)* étaient les espèces les plus souvent capturées, et représentaient plus de 90 % des captures accidentelles. Pendant les cinq années au cours desquelles les oiseaux de mer ont été identifiés au niveau de l'espèce dans la pêche expérimentale au filet maillant dans la zone 21, ces deux espèces représentaient également plus de 90 % de tous les oiseaux capturés. On a signalé des prises de Guillemots marbrés *(Brachyramphus marmoratus)* dans

au moins trois pêches. Une forte proportion des oiseaux capturés accidentellement n'ont été ni identifiés ni récupérés. Nous soulignons que les prises accidentelles d'espèce précise pourraient être sous-estimées vu le grand nombre d'oiseaux non identifiés et non récupérés. Nous signalons également au lecteur qu'il s'agit ici d'une évaluation préliminaire de l'état des prises accidentelles d'oiseaux de mer dans les pêches de la côte ouest; les données que nous présentons provenaient en grande partie de petits sous-échantillons des différentes pêches étudiées, et le plan d'échantillonnage *ad hoc* empêchait toute analyse rigoureuse. Nous encourageons le développement continu de programmes de collecte de données sur les captures accidentelles d'oiseaux de mer. Les observateurs des pêches devraient par ailleurs recevoir la formation requise pour pouvoir identifier les espèces d'oiseaux capturés ou être tenus de récupérer tous les oiseaux; la couverture par les observateur devrait également être élargie de façon à représenter l'effort de pêche dans l'espace et dans le temps pour qu'on puisse estimer les taux de prises accidentelles. Dans l'ensemble, les données actuelles indiquent que les captures accidentelles sont préoccupantes et justifient la mise en place d'initiatives de conservation.

ACKNOWLEDGEMENTS

This study was funded by Fisheries and Oceans Canada (DFO) and the Canadian Wildlife Service (CWS) of Environment Canada. The report would not have been possible without the help of many people. We would especially like to acknowledge and thank B. Payne (DFO) for all of her efforts to bring this study together and for her invaluable support. We thank the members of the Pacific Seabird Bycatch Working Group for their commitment and interest to assess seabird bycatch in British Columbia. Fisheries data and information were provided by many DFO staff including: G. Curry, C. Eros, J. Fargo, L. Gordon, B. Hargreaves, L. HopWo, T. Johansson, M. Joyce, L. Lacko, D. Lawseth, E. Lochbaum, J. Mitchell, B. Patten, B. Payne, P. Ryall, W. Saito, B. Shaw, D. Trager and L. Yamanaka. T. Geernaert and M. Wade (International Pacific Halibut Commission [IPHC]) contributed fisheries data for the commercial halibut fishery. Pertinent fisheries and at-sea observer information was received from: H. McElderry, G. Clapp and S. Stebbins (Archipelago Marine Research Ltd. [AMR]); S. Davis and K. Rivera (National Marine Fisheries Service [NMFS]); and T. Sutcliffe (Prince Rupert Community Fisheries). We especially thank D. Pahti and J. Riley of AMR for storage and shipping of salvaged birds. I. Jones (Memorial University), D. Bertram (CWS), R. Elner (CWS), K. Fort (CWS) and M. Hipfner (CWS) reviewed and suggested improvements on earlier versions of the report and A. Burger (University of Victoria) provided helpful comments on the topic of assessing seabird bycatch. E. Melvin (Washington Sea Grant), J. Parrish, N. Hamel and K. Dietrich (University of Washington); and L. Mitchell (The Seabird Project) are thanked for contributing seabird bycatch and fisheries information from the United States. We also thank the various fisheries associations for their support with the investigation of seabird bycatch and B. Bennett (Malaspina College) for his helpful suggestions during the development of a fisheries observer seabird identification training curriculum. Finally, we thank all of the fisheries observers, dockside monitors and fishermen that collected or contributed seabird bycatch data.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Bycatch is one of the most prominent concerns facing fishery managers and harvesters in many of the world's fisheries. The incidental catch, or bycatch, of non-target fish species, marine mammals, seabirds, sea turtles, and sharks raises a complex set of scientific, economic, political and ethical issues (Hall *et al*. 2000). Additionally, the life history characteristics of seabirds (typical of other long-lived marine organisms), make populations particularly vulnerable to additional sources of mortality. In some species, such as the Common Murre *(Uria aalge)* a reduction in the annual adult survival rate of as little as 3% can cause a severe population decline and local extirpations (Nur and Sydeman 1999).

While the full extent of seabird bycatch globally is still not known, some commercial and industrial fishing activities (past and present) kill large numbers of seabirds. For example, from 1981 to 1984, US-based fisheries observers in the North Pacific Japanese salmon drift net fishery reported that between 75,000 and 250,000 birds (comprising 21 species) were killed annually. The deaths of thousands of seabirds and marine mammals eventually contributed to severe restrictions being placed on this fishery, including a United Nations resolution to halt drift gill nets in international waters in 1990 (King *et al*. 1979, Ogi 1984, DeGange and Day 1991, DeGange *et al*. 1993, Tasker *et al*. 2000). More than half of the 75,000 - 250,000 birds killed were Short-tailed Shearwaters *(Puffinus tenuirostris)*, but thousands of puffins *(Fratercula spp.)*, murres *(Uria spp.)* and auklets *(Aethia spp.)* also died (Atkins and Heneman 1987).

In the 1990s, the international community was alerted to the thousands of albatrosses killed in pelagic longline fisheries in the southern oceans. Birds attempting to take the bait off hooks being set for fish were pulled under the water and drowned (Brothers 1991). In Australia, an estimated 44,000 albatrosses were killed each year from 1981-1986 and perhaps 10,000 or more albatrosses are still killed annually in their domestic longline fisheries (Brothers *et al*. 1998). In the Alaskan groundfish demersal longline fishery between 1993 and 2001, an estimated 10,000 to 27,000 birds were killed each year, including albatrosses, Northern Fulmars *(Fulmarus glacialis)*, and shearwaters (NMFS 2001a). Demersal fisheries target fish that live on or near the seabed. The fisheries may be directed towards particular species or species groups, but generally, the catch is a mixture of species.

Twenty of the world's 24 species of albatrosses are endangered and BirdLife International (2000) reported that the incidental take of birds during pelagic and demersal longline fishing is the primary threat to at least 16 species. All three North Pacific albatross species, Black-footed Albatross *(Phoebastria nigripes)*, Short-tailed Albatross *(P. albatrus)* and Laysan Albatross *(P.*

immutabilis), forage within BC waters. The Black-footed Albatross has recently been listed (upgraded) as Endangered by the World Conservation Union (IUCN), whereas both Laysan and Short-tailed Albatrosses are designated as Vulnerable. 2003 was the first year that the Laysan Albatross was listed by the IUCN. Mortality from longline fishing is cited as the primary threat to all three species (The 2003 IUCN Red List of Threatened Species *http://www.redlist.org/*).
Longline fishing is one of the most common fishing methods used worldwide (Brothers *et al*. 1999, Hall *et al*. 2000). International resolutions to evaluate and to reduce seabird bycatch in these fisheries began in 1996. At the First World Conservation Congress in Montreal, the IUCN adopted the resolution *Incidental Mortality of Seabirds in Longline Fisheries* and called upon all states to reduce seabird mortality to insignificant levels for affected species. Further resolutions were adopted by the United Nations (UN) to reduce seabird bycatch at the 23rd Session of the Food and Agricultural Organization (FAO) in March 1999. At that meeting, the Committee on Fisheries unanimously adopted an *International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries* (abbreviated to IPOA-Seabirds, FAO 1999). In the IPOA-Seabirds, the FAO requested that all member states undertake an assessment of the levels of seabird mortality in their longline fisheries and to develop a National Plan of Action (NPOA) (if found warranted by the levels of mortality observed). Member states were required to describe their progress on the NPOA as part of their reporting terms of the FAO Code of Conduct for Responsible Fisheries at the 24th session of the UN FAO in 2001.
In the United States, the Federal listing of the Short-tailed Albatross to the Endangered Species list elevated the seabird bycatch issue. A cooperative effort involving several Federal agencies produced a draft National Plan of Action in 2000. The next year, an Environmental Assessment to analyse the impacts of revisions to existing seabird avoidance measures was produced (NMFS 2001b) and later the same year, mandatory seabird avoidance measures were adopted as per the Biological Opinion for the Conservation of the Short-tailed Albatross. A National Plan of Action was released in 2001.
In Canada, two Federal agencies have regulatory authority with regards to the issue of bycatch - Environment Canada (EC) and Fisheries and Oceans Canada (Department of Fisheries and Oceans [DFO]). Environment Canada has a mandate for seabird conservation and the responsibility to enforce the statutes of the Migratory Bird Convention Act. The Canadian Wildlife Service (CWS), an agency within EC, establishes regional management priorities for seabirds and implements management directions. The DFO is the federal authority over all fishing activities, and is responsible for the enforcement of the Fisheries Act and the Oceans Act. The DFO is also responsible for implementing the United Nations Code of Conduct for

Responsible Fisheries; the Code was established to implement policies for the responsible conservation, management and development of fisheries resources (FAO 1995, [Article 6.2]). Also, the DFO is responsible for implementing a Pacific Region Selective Fisheries Policy and the Canadian Code of Conduct, an industry led initiative.

Progress towards a Canadian National Plan of Action began in 2000 when a workshop was co-hosted by EC and the DFO to discuss seabird bycatch in longline and gill net fisheries and provide direction for future action. An outcome of that workshop was the establishment in 2000 of a National Seabird Bycatch Working Group to proceed with the implementation of the IPOA-Seabirds. The National Working Group presented a draft assessment report at the 24th session of the FAO in Rome, February 2001.

Despite the overlap between longline and gill net fisheries and at least 55 species of seabirds, there have been virtually no studies to document bycatch rates or the effects of those fisheries on seabird populations in BC. Longline fishing is a concern for surface-feeding seabirds such as albatrosses, fulmars, shearwaters and gulls; whereas, gill nets are a concern for diving birds such as loons, grebes, cormorants and alcids.

In 2000 the Pacific Seabird Bycatch Working Group was formed; the creation of this working group was one of the recommendations made at a bycatch workshop hosted by EC in 1998 (K. Morgan, unpublished). The Pacific Seabird Bycatch Working Group's goals were to increase the understanding of seabird bycatch in longline and net fisheries, and to promote the use of mitigation measures to reduce seabird bycatch in BC.

1.1 Objective of Report

This report was initiated to compile and summarize existing data collected on seabird bycatch in longline and gill net fisheries in British Columbia. These fisheries were chosen by the Pacific Seabird Bycatch Working Group because concerns were raised by the DFO managers, CWS staff and marine ornithologists over uncertainties surrounding seabird bycatch. In addition, Canada endorsed the International Plan of Action (IPOA-Seabirds, FAO 1999) and more information was needed in order to prepare an assessment report for its National Plan of Action. The objectives of the project are to:

1. consolidate seabird bycatch data collected to-date;
2. summarize trends (fisheries and catch information, numbers of birds reported caught, bycatch rates);
3. determine if a baseline bycatch rate could be established for the fisheries examined;
4. provide recommendations for future monitoring and research; and,

5. provide suggestions for addressing impact on seabird species.

The initial report was prepared with data collected from the longline and net fisheries between December 2000 and March 2001. More data were added to the halibut, rockfish and Area 21 Gill Net Test Fishery sections in revisions of the report prepared in 2004 and 2005.

2. FISHERIES DESCRIPTIONS, OBSERVER COVERAGE AND DATA SOURCES

2.1 Demersal Longline Fisheries

In terms of effort and catch, the commercial halibut and rockfish fisheries are the two largest longline fisheries on the Pacific coast of Canada. Demersal longlining is a typical method of fishing in relatively shallow habitats in areas of cold, upwelled water where groundfish species like cod, halibut, sablefish and rockfish occur. Baited hooks are fished along an anchored groundline and left on the ocean floor for up to 24 hours.

2.1.1 Commercial Halibut Fishery

Longline vessels are licensed to catch Pacific halibut (*Hippoglossus stenolepsis*) in BC waters between 15 March and 15 November each year, in both nearshore and offshore waters. Halibut are caught coast-wide but fishing effort is highest in Queen Charlotte Sound, Hecate Strait and Dixon Entrance. Up until 2001, there were an estimated 234 active halibut licenses in BC (from a total of 326 licenses). Vessels range in size from 9 to 27 m. As many as 8 million hooks are hauled annually, landing between 5 and 6 tonnes of halibut. Hooks are generally spaced 2-3 m apart on a 2,700 m groundline; and most hooks are baited by hand, although some vessels have automatic baiting machines. The hooks are left for 5 to 24 hours at an average depth of 97 m (range 14 - 241 m). In 2002, seabird avoidance measures, such as streamer lines or towed buoys, became a mandatory condition of licensing in the commercial halibut fishery. The BC Halibut Advisory Board and the DFO worked with the authors of this report to create solutions to reduce bird bycatch without reducing their overall catch.

The management of the Pacific halibut fishery is based on an international agreement between Canada and the United States. In 1923, a Convention was signed that created the International Fisheries Commission, which later became the International Pacific Halibut Commission (IPHC). The IPHC conducts annual stock assessment surveys in Canada and the United States, investigates halibut ecology and life history, and, more recently, seabird bycatch. The IPHC stock assessment surveys, which are collected annually during the summer, provide catch information and biological data independent of the commercial fishery. The IPHC charters up to 15 commercial fishing vessels to conduct these surveys from the California - Oregon border to the Aleutian Islands, including Canadian waters. The IPHC charter boats set about 700,000

hooks annually using fixed hook, longline gear. Bird mortalities are recorded with location of capture and the carcasses are transferred to the appropriate agency. Seabird avoidance devices on IPHC charter boats became mandatory in 2000 and most vessels use one or two towed buoy bags or streamer lines (T. Geernaert, IPHC, pers. comm.).

2.1.1.1 Observer Coverage

In 1999, an at-sea observer program was initiated by the DFO to more accurately estimate total retained and discarded catch (L. Yamanaka, DFO, pers. comm.). The observer program (which included seabird bycatch monitoring) was funded by the DFO and the fishing industry. Because the observer program began late in the 1999 season, only a small percentage (< 2%) of hooks hauled, were observed. Observer coverage continued in 2000 but the program fell short of the target of observing 10% of all hooks. In 2001, observer coverage increased to approximately 10% of hooks hauled and by 2002, 18.6% of the hooks were observed.

2.1.1.2 Data Sources

Data for the halibut fishery were provided by both the DFO and the IPHC; the DFO provided data from the observed fishery and the IPHC provided data from logbooks. The IPHC also provided data specific to seabird bycatch from their portside interview program. In 1998/1999, the IPHC interviewed skippers/owners to assess seabird bycatch and to learn about Short-tailed Albatross sightings between Washington and Alaska. Vessel owners/skippers were asked if they had caught any seabirds, what species they caught, and if they had seen any Short-tailed Albatross. The interview and survey results reported by Gilroy *et al.* (2000) are used in this report.

2.1.2 Commercial Rockfish and Charter Seamount Fisheries

Longline vessels that are licensed to catch rockfish species (ZN license) fall into two categories: the commercial fishery and a charter fishery on the seamounts. Both fisheries set gear on or slightly above the sea floor (i.e. demersal longlining). The seamount fishery is managed using special permits or charters and vessels apply for the right to fish the seamounts. Vessels fishing the seamounts target rougheye rockfish *(Sebastes aleutians)* and set an estimated 180,000 to 350,000 hooks/year.

The commercial rockfish fishery targets yelloweye *(Sebastes ruberrimus)*, quillback *(S. maliger)*, redbanded *(S. babcocki)* and rougheye rockfish. Other species caught include dogfish *(Squalus acanthias)* and lingcod *(Ophiodon elongatus)* (H. McElderry, Archipelago Marine Research Ltd., unpublished). The commercial fishery sets 3 to 4 million hooks annually, with an average of 1,200 hooks/set. Most hooks are baited with squid or octopus or herring. The fishery takes place in inshore and offshore waters, from 1 April to 31 March and, with few exceptions, is

coast-wide. Vessels range in size from 10 to 20 m. In 2002, the use of seabird avoidance devices became a mandatory condition of licensing in the commercial rockfish fishery (L. Yamanaka, pers. comm.).

2.1.2.1 Observer Coverage

Up until 2000, the ZN licensed fisheries had limited observer coverage. In 2001, the DFO increased the coverage of the observer program with a target goal of observing 25% of all hooks fished.

2.1.2.2 Data Sources

Data for the commercial rockfish fishery and seamount charters were provided by the DFO. The rockfish data were analyzed for this report by calendar year (i.e., from January through December) instead of the fishing year (April through March).

2.1.3 Other Demersal Longline Fisheries

The DFO manages spiny dogfish and lingcod longline fisheries. The fisheries are open year round and in recent years the fisheries have not reached their total allowable catch. Each year, approximately 1,800 tonnes of dogfish are landed coast wide (R. Kadowaki, DFO, pers. comm.). In 1999, the dogfish fleet made roughly 250 fishing trips, setting 1 million hooks. At the time of this report, there were no observers in these fisheries.

2.2 Net Fisheries

Vessels licensed to catch salmon in BC harvest fish with gill nets and seine nets. Coastal gill net vessels are generally less than 15 metres in length and are operated by a crew of one or two. Gill nets are set below the surface and are typically constructed of a multi-strand mesh comprised of 30 or more filaments in each twine. In recent years, a newer type of mesh, known as Alaska Twist has been tested in some salmon gill net fisheries. This mesh is made from 6 or more filaments twisted together in each twine. Seine nets are set to encircle concentrations of fish, trapping them when the two ends are pulled together and the bottom of the net closed, or 'pursed'. Seine fishing vessels are generally greater then 20 metres long.

Increasingly, salmon gill net fisheries are under pressure to be more selective and reduce the bycatch of non-target salmon species, marine mammals and other taxa, including seabirds. The DFO regulates fishery time, location, target species, net configuration, and soak time (the length of time that the net fishes); the regulations are in place to control fleet catching capacity and to improve selectivity and the post-release survival of non-target fish.

The main salmon species targeted in the commercial gill net fishery are pink *(Oncorhynchus gorbuscha)*, sockeye *(0. nerka)*, and chum *(O. keta)* salmon. There are also some limited

opportunities for chinook *(O. tshawytscha)* and hatchery coho *(O. kisutch).* The reduction in the abundance of target species and increased closures, have caused a decline in the annual salmon fishing effort and landings. A series of commercial license retirement programs has also contributed to a drop in the number of vessels fishing for salmon.

The DFO statistical areas are combined into eight License Areas (Appendix V). Two License Areas pertain to seine fisheries (A and B), three of them (C, D and E) pertain to gill net fisheries and the remaining three (F, G and H) pertain to troll fisheries.

2.2.1 Observer Coverage

Most commercial salmon fisheries have extremely limited observer coverage; whereas test (stock assessment), experimental (gear testing) and selective (species selectivity) fisheries all collect seabird bycatch data; some have up to 100% coverage.

A seabird salvage program was initiated in 2000 by the DFO and CWS to retain dead birds from the gill net fisheries. Dead birds were retrieved by observers, collected by port managers and observer providers, and then shipped to the Institute of Ocean Sciences, Sidney, BC. A subset of the salvaged birds (primarily Common Murre and Rhinoceros Auklet *[Cerorhinca monocerata]*) were necropsied to determine gender and age class (adult, immature, young of the year), and to take detailed measurements.

2.2.2 Data Sources

We used fisheries and seabird bycatch data provided by the managers of the North and South Coast Divisions of the DFO (Area C and D). Most of our results came from the DFO Fishery Summary Reports but some (Area 21 Gill Net Test Fishery, Area 4 Coho Gill Net Test Fishery and the Area 4 Selective Seine Fishery) were compiled from raw data. Fisheries data came from one commercial, one selective, one seine, one trap, two experimental and three test fisheries (Table 1). These fisheries targeted salmon off the west coast of Vancouver Island, the mouth of the Skeena River, near Prince Rupert and near Port Hardy. Bycatch rates were reported as both birds/set and birds/net-hour fished.

Table 1. Salmon fisheries examined for seabird bycatch in British Columbia.

Fishery name	Dates
Area 21 Gill Net Test Fishery	Sep. - Oct., 1995 to 2001
Area 4 Coho Gill Net Test Fishery	Jul. 28 – Aug. 8, 2000
Johnstone Strait Gill Net Experimental Fishery	Jul. 25 – Aug. 23 1997
Area D Sockeye Gill Net Selective Fishery	Jul. 28 – Aug. 14, 2000
Barkley Sound Sockeye Gill Net Commercial Fishery	Jun. 19, Jun. 26, 2000
Area 4 Selective Seine Fishery	Jul. 29 – Aug. 8, 2000
Area 12 Chum Gill Net Test Fishery	Jul. 10, 2000
Area 4 Chum Gill Net Experimental Fishery	Aug. 12, 2000
Area C Free Float Salmon Trap Fishery	Jul. 25 – Aug. 7, 2000

2.2.2.1 Area 21 Gill Net Test Fishery

The Area 21 Gill Net Test Fishery was initiated in 1995 to evaluate the strength of the chum salmon return to the Nitinat Lake tributaries and hatchery, in order to assess whether a commercial opening would be approved. The fishery was also designed to study the distribution of steelhead *(Oncorhynchus mykiss)*, chum, chinook and coho in the Nitinat commercial fishing area (J. Mitchell, DFO, pers. comm.). Initially, the project was a collaborative effort between the DFO and the BC Ministry of Environment, Lands and Parks (MELP) (now the BC Ministry of Environment). During the first two years, MELP provided financial support for the project, but in 1997 they withdrew support because of concern over the bycatch of non-target species, particularly marine mammals. MELP rejoined the project in 1999 after the introduction of timing and area restrictions and gear adjustments. The project ended in 2001 because sufficient data had been gathered to adjust the commercial fishery to avoid bycatch of steelhead and coho (J. Mitchell, pers. comm.). The test fishery ran from late September until early October. There was 100% observer coverage and observers always collected seabird bycatch data. Beginning in 1997, observers received formal seabird identification training by Birdsmith Ecological Research. From 2000 to 2001, the test fishery participated in the CWS salvaged bird program. Up to eight vessels fished using two 200-fathom (365 m) nets either tied end-to-end or set independently (Table 2). Initially, traditional monofilament nets were used and soak times were not standardized. In 1998, drop weedlines and Alaska Twist mesh were introduced to reduce steelhead and coho bycatch and optimize chum catches. Drop weedlines consist of a 1-2 m net-free area, directly below the cork line, and acoustic pingers were added to reduce marine mammal bycatch (J. Mitchell, pers. comm.). In 1999, soak times were reduced to one hour to

increase the survival of coho bycatch. The DFO provided raw data and annual reports (J. Mitchell, unpublished) for bycatch analyses.

2.2.2.2 Area 4 Coho Salmon Gill Net Test Fishery

The Area 4 Coho Gill Net Test Fishery took place near the mouth of the Skeena River for 11 days in 2000. Nets were modified with drop weedlines and some multi-strand nets were replaced with Alaska Twist. Mesh size and fishing depth varied among vessels. Target soak time was one hour. This fishery participated in the CWS salvage seabird program.

Table 2. Summary of the Area 21 Gill Net Test Fishery.

Year	Number of vessels	Drop weedline (m)	Acoustic pingers	Number of nets	Target soak time (hours)
1995	8	not used	not used	2	no target set
1996	8	not used	not used	2	no target set
1997	8	not used	not used	2	2
1998	7	1.2 - 2.0	Used	2	2
1999	7	2.0	Used	2	1
2000	4	2.0	Used	2	1
2001	2	1.2 – 2.0	used (on some)	2	1

2.2.2.3 Johnstone Strait Gill Net Experimental Fishery

The Johnstone Strait Gill Net Experimental Fishery was initiated in 1996 by Area D harvesters because they wanted to increase the depth of their nets from 60 to 90 meshes, and to change gear from multi-strand to Alaska Twist. The DFO agreed to the request for one year provided there was a suitable monitoring and assessment program to establish the efficacy of the new gear. The timing of the net experiment coincided with the 1997 Fraser River sockeye migration in Area 12 and was outside the regular commercial fishery. The objective of the experimental fishery was to compare catch rates of Alaska Twist nets (90 meshes deep) with traditional multi-strand nets (60 meshes deep). Net length varied from 365 to 378 m (200 to 207 fathoms). Twelve test groups of two boats each fished one day/week for six weeks, and totaled 144 vessel trips (P. Ryall, DFO, unpublished). Most vessels fished with 14.8 cm (4-7/8 inch) mesh and both Alaska Twist and multi-strand were used equally. All vessels were required to make six sets/day, half at night and half during the day so that the minimum number of sets would be 864. Fisheries observers were instructed to collect seabird bycatch data; however, they did not

receive seabird identification training. We used Ryall (unpublished data) to assess the level of seabird bycatch.

2.2.2.4 Area D Sockeye Salmon Gill Net Selective Fishery

The Area D Sockeye Gill Net Selective Fishery was proposed by the "Area D Salmon Gill Net Association" to study the selectivity of the commercial sockeye fishery in Johnstone Strait. The fishery was held in Area D before the 2000 Johnstone Strait commercial sockeye fishery. The purpose was to identify ways to reduce the mortality of non-target species. Nine vessels were chartered for three weeks and assigned to one of three 48-hour fishing periods. The fishery ran from July 27-29, August 5-7 and August 12-14, 2000. Each vessel carried an observer and the test fishing was done in six locations. Soak times were limited to one hour. Three nets were tied end-to-end, and vessel operators were ordered to commence setting and hauling nets simultaneously. Skippers could choose their set locations and the objective was to pick areas that historically had high sockeye abundance. All vessels had an Alaskan Twist net onboard and all nets were identical for mesh size, number of meshes and length. Observers were required to collect set, catch and coho survival data, as well as help with the real time catch monitoring. Assessing the effect of time of day on catch results was a major component of this study so three time factors were chosen: sunrise ('morning'), randomly throughout the day ('day') and after sunset ('dark'). To ensure a valid comparison between the three time factors, vessel operators had to make at least six sets/day, randomly choosing times during the day, as well as either making one set after the 'dark' set, or one set prior to the 'morning' set. Vessels were required to make 18 morning sets; and fishing effort was supposed to be consistent between all vessels, within each group, with vessels setting and hauling at the same time. This fishery participated in the CWS salvaged bird program.

2.2.2.5 Barkley Sound Sockeye Salmon Gill Net Commercial Fishery

The Barkley Sound Sockeye Gill Net Commercial Fishery was the only commercial fishery examined. In the '80s and early '90s, this fishery had an active fleet of 300 to 400 vessels, each fishing two to three days/week, and 24 hours a day. The fishery was open from late June to early August to catch sockeye returning to the Somas River. However, since the late '90s, the sockeye returns have declined and fishing effort has been reduced to conserve stocks. In 2000, there were two one-day commercial openings, each lasting six hours. The first opening had 95 vessels and the second opening had 110 vessels. Fishing was regulated to daylight hours only and the fishing area was reduced in size from previous years. Beginning in the 1998 fishery, observers recorded the salmon catch. Some observers may have kept notes on bird bycatch, although it was not required formally by the DFO until 2000 (L. Gordon, DFO, pers. comm.).

Given that there were four to seven observers available for the entire fleet and they remained on the same vessel all day, observer coverage of the fleet was between 4 and 7% of all boats. Skippers were required to record all catch information, including seabird bycatch, in DFO logbooks; however, skippers had little incentive to report seabird bycatch (L. Gordon, pers. comm.). Soak times were regulated to one hour in order to increase the survival rate of salmon bycatch. Regulations allowed skippers to choose net type (Alaska Twist or traditional multi-strand), whether or not to use a drop weedline, and whether or not to fish with mesh sizes greater than the minimum. While observers recorded data for each individual set, skippers combined catch data in six-hour blocks. This meant that set times and durations were not available from skippers logbooks to calculate birds caught/net-hour. Data summaries were provided by the DFO.

2.2.2.6 Area 4 Selective Seine Fishery

This fishery targeted salmon entering the Skeena River for 10 days between July 29 to August 1 and August 3 to 8, 2000. Part way through the fishery the observers were directed by the DFO to complete seabird bycatch data forms. However, most of the observers had not received any training and, as a result, many observers did not collect seabird bycatch data. Raw data sheets were provided by the DFO for analysis.

2.2.2.7 Other Salmon Fisheries

Three other salmon fisheries participated in the seabird bycatch project in 2000. Observers in a one-day test fishery (the Area 12 Chum Gill Net Test Fishery) in Knight Inlet (in July) reported bycatch of one Common Murre and one Marbled Murrelet (*Brachyramphus marmoratus*). Observers in a one-day experimental fishery (the Area 4 Chum Gill Net Experimental Fishery, in August) reported two Common Murres as bycatch. And lastly, during a free-float trap fishery that ran from July 25 to August 7 on the Skeena River (Area C Free Float Salmon Trap Fishery), observers reported no birds caught from 58 sets. For all three of these fisheries, no other data were available.

2.3 Trawl Net Fisheries

The groundfish trawl fishery is the largest fishery by volume on the West coast of Canada with annual landings of approximately 140,000 tonnes and an estimated worth of $60-65 million (http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/groundfish/GFTrawl/history.htm).
The commercial fisheries (domestic trawl, Joint Venture hake and shrimp) are open year-round under an Individual Vessel Quota system. Since 1996, they have had 100% observer coverage. Trawl fisheries are a source of food for birds when fish bycatch and offal from fish processing is

discarded from the vessel (Garthe and Huppop 1994, Garthe and Damm 1997). Birds may either become entangled in the trawl net when it is being hauled back or hit by the third wire (transducer cable). In Alaska, it is suspected that trawl fisheries kill seabirds (S. Fitzgerald, National Oceanic and Atmospheric Administration – Fisheries Service, pers. comm.).

2.4 Sablefish Trap Fishery

The sablefish (or black cod, *Anoplopoma fimbria)* fishery is open year round. Most vessels use traps, but some (12 - 14) use longline gear; the majority of the fishing takes place in the southern Hecate Strait and Queen Charlotte Sound (H. McElderry, pers. comm.). The eastern half of the Hecate Strait, Queen Charlotte Sound and Statistical Areas 1-29 are closed for conservation goals. There is little or no observer coverage in the sablefish fishery. An experimental trap fishery is open between April and October on the seamounts and a lottery system assigns permits. Most of the fishing has occurred on the Bowie Seamount, but more recently has included the Cobb, Warwich, Union and Explorer seamounts (H. McElderry, pers. comm.). Video cameras or observers monitor this fishery, providing fishing locations and estimates of catch. Currently, there are minimal seabird bycatch data for either of the sablefish fisheries.

2.5 Troll Fisheries

Troll fisheries target salmon and other species. A selective sockeye troll fishery in 2000 (July 2 - August 10) compared hook types and release methods in order to reduce the mortality of coho bycatch (G. Curry, DFO, pers. comm.). Observers recorded all bycatch and reported zero birds killed. One gull species was hooked during a set, but was released alive. Troll fisheries may catch birds but the extent of bycatch (and mortality) is not documented.

2.6 First Nations and Recreational Fisheries

First Nations and sports fisheries were excluded from these analyses due to the absence of any reporting programs that could acquire seabird data. Because First Nations fisheries operate in many areas of the coast, some impact might be expected. Recreational fisheries use a variety of hook and line techniques and some anecdotal information exists concerning incidental catch of seabirds, including Marbled Murrelets and Common Murres. However, based on evidence from other jurisdictions (e.g. Washington state), the catch of seabirds is likely low.

3. OBSERVATIONS

3.1 Demersal Longline Fisheries

3.1.1 Commercial Halibut Fishery

3.1.1.1 IPHC Stock Assessment Surveys

During the IPHC halibut stock assessment surveys of 1998 and 1999, one Black-footed Albatross was reported caught in BC waters (Table 3).

Table 3. Summary of IPHC halibut stock assessment surveys in BC and all other IPHC areas, 1998-1999 (from Gilroy *et al*. 2000).

	1998		1999	
	BC	**Other IPHC areas**	**BC**	**Other IPHC areas**
Number of hooks hauled (1,000's)	80	610	100	700
Number of seabirds reported caught	1	26	0	6
Bycatch rate (birds/1,000 hooks)	0.0125	0.0426	0	0.0086

3.1.1.2 IPHC Skipper Interviews

The IPHC interviewed halibut skippers from Washington to the Aleutian Islands in 1998 and 1999 (Gilroy *et al*. 2000). The landed catch was similar between years but the number of reported hooks was much lower in 1998 (Table 4). The logbook matches (i.e., the relationship between offload records and skipper logbooks) from the interviews was poor in 1998 (only 58%), but it improved to 73% in 1999. Port samplers became aware of the importance of matching logbooks to offload records, and records were verified in 1999 (T. Geernaert, pers. comm.). BC skippers reported 24 and 23 birds caught from 4.6 and 8.3 million hooks hauled in 1998 and 1999, respectively (Tables 4 and 5). However, the IPHC noted that because of the discrepancies in logbook matches, the number of hooks hauled was most likely under-estimated in 1998. Gilroy *et al*. (2000) reported that 4.63 million hooks were hauled in BC waters in 1998; however the IPHC later increased the number to 8.03 million hooks (T. Geernaert, pers. comm.). The overall bycatch rates were 0.0030 and 0.0028 birds/1,000 hooks (BC), and 0.0039 and 0.0010 birds/1,000 hooks (all other IPHC areas) in 1998 and 1999, respectively (Table 5).

Table 4. Summary of the IPHC skipper interviews in BC for 1998-1999. Percentages are the percent of either the total catch or the number of logbook matches (from Gilroy *et al.* 2000).

	1998	%	1999	%
Landed catch of halibut (tonnes)	5,852.2		5,551.8	
Interviewed catch (tonnes)	4,703.6	80	4,315.9	78
Logbook matches of landed catch (tonnes)	3,363.6	58	4,064.5	73
Number of vessels interviewed	940		891	
Number of logbook matches	694	74	827	93
Number of hooks from interviews (1,000's)	4,630 *		8,300	

* Under-represented; the IPHC later estimated hooks hauled in 1998 was 8,028,315.

Table 5. Numbers of seabirds reported caught and bycatch rates (birds/1,000 hooks) based on IPHC skipper interviews in BC and all other IPHC areas, 1998-1999. The bycatch rate for 1998 was calculated using the higher IPHC estimate of the number of hooks hauled (see above).

	1998		1999	
Bycatch of:	**Birds**	**Bycatch rate**	**Birds**	**Bycatch rate**
Albatrosses (BC)	16	0.0020	16	0.0019
Albatrosses (all other IPHC areas)	11	0.0007	1	0.0001
Other seabirds (BC)	8	0.0010	7	0.0008
Other seabird (all other IPHC areas)	55	0.0033	12	0.0010
Total seabirds (BC)	24	0.0030	23	0.0028
Total seabirds (all other IPHC areas)	66	0.0039	13	0.0011

On an individual IPHC area basis, the interview results for BC were higher than the rates derived for most of Alaska. The bycatch rate was 0 birds/1,000 hooks in Area 2C (S.E. Alaska/Dixon Entrance to Cape Spencer) and 0.0020 birds/1,000 hooks in Areas 3A (Gulf of Alaska/Cape Spencer to Trinity Is.) and 3B (Alaska Peninsula/Trinity Is. to Unimak Pass). The results of the interviews also indicated that albatrosses were the most commonly reported bycatch; and that the highest rate of albatross bycatch occurred in BC (Gilroy et al 2000).

3.1.1.3 Logbook and Observer Summaries

On an annual basis, the total number of hooks hauled in the commercial halibut fishery in BC ranged from 6.4 to 8.3 million hooks (average 7.5 million), with landings between 4,628 and

5,539 tonnes (Table 6). Observer coverage increased substantially after 1999 and reached a high of 18.6% of hooks hauled in 2002. In the four years examined, observers witnessed nine birds caught. In 1999, two seabirds, a Herring Gull (*Larus argentatus*) and a Black-footed Albatross (BFAL) were caught. In 2000, one Black-footed Albatross was caught; in 2001, two Black-footed Albatrosses, one Glaucous-winged Gull *(Larus glaucescens)* and one Short-tailed Shearwater were captured; and in 2002, two seabirds were caught – a Black-footed Albatross and a Northern Fulmar. The overall bycatch rate for the fishery (based upon observed hooks) ranged between 0.0013 and 0.0154 birds/1,000 hooks (4-year average 0.0071 birds/1,000 hooks). A simple extrapolation (using the observed-hooks bycatch rate) predicts that between 10 and 128 birds (average 54/year) were caught in the commercial halibut fishery; of those we predict that between 5 and 64 were Black-footed Albatrosses (Table 6).

Table 6. Fishery, Black-footed Albatross and total seabird bycatch data (including birds released alive) for the commercial halibut longline fishery in BC. Extrapolated bycatch calculated by multiplying total hooks fished by the bycatch rate (birds/1,000 observed hooks).

	Calendar year				
Commercial halibut fishery	**1999**	**2000**	**2001**	**2002**	**4-yr. Avg.**
Landed catch (tonnes)	5,539	4,821	4,628	5,437	5,106
Total hooks fished (1,000's)	8,309	7,228	6,418	8,106	7,515
Number of observed hooks (1,000's)	130	184	630	1,505	612
Observer coverage (%)	1.6	2.5	9.8	18.6	8.1
Number of seabirds reported caught	2	1	4	2	2.3
Seabirds caught/1,000 observed hooks	0.0154	0.0054	0.0063	0.0013	0.0071
Extrapolated bycatch of BFAL	64	39	20	5	32.0
Extrapolated total seabird bycatch (incl. BFAL)	128	39	40	10	54.3

3.1.2 Commercial Rockfish and Charter Seamount Fisheries

Between 2.7 and 5.0 million hooks were hauled by the commercial rockfish fishery between 1999 -2002 (Table 7). Observer coverage ranged between 0.2 and 10.6% of total hooks; far below the DFO goal of 25% coverage. During the years we examined, observers reported 11 birds caught in the commercial rockfish fishery: ten Black-footed Albatrosses and one California Gull (*Larus californicus*). Bycatch rates ranged between 0 and 0.0316 birds/1,000 observed

Table 7. Fishery, Black-footed Albatross (BFAL) and total seabird bycatch data (including birds released alive) for the commercial rockfish and charter seamount fisheries in BC. Extrapolated bird bycatch calculated by multiplying total hooks fished by the bycatch rate (birds/1,000 observed hooks).

	Calendar year				
Commercial rockfish fishery	**1999**	**2000**	**2001**	**2002**	**4-yr. Avg.**
Total hooks fished (1,000's)	3,860	5,026	4,059	2,704	3,912
Number of observed hooks (1,000's)	8.17	37.36	70.30	285.12	100.24
Observer coverage (%)	0.2	0.7	1.7	10.6	2.6
Number of seabirds reported caught	0	1	1	9	2.8
Seabirds caught/1,000 observed hooks	0	0.0267	0.0142	0.0316	0.0181
(a1) Extrapolated bycatch of BFAL	0	135	0	85	55.0
(a2) Extrapolated total seabird bycatch (incl. BFAL)	0	135	58	85	69.5
Charter seamount rockfish fishery	**1999**	**2000**	**2001**	**2002**	**4-yr. Avg.**
Total hooks fished (1,000's)	307	160	0	0	234
Number of observed hooks (1,000's)	130	160	0	0	145
Observer coverage (%)	42.3	100			71.1
Number of seabirds reported caught	3	4	0	0	3.5
Seabirds caught/1,000 observed hooks	0.0231	0.0250	0	0	0.0241
(b1) Extrapolated bycatch of BFAL	7	4	-	-	5.5
(b2) Extrapolated total seabird bycatch (incl. BFAL)	7	4	-	-	5.5
Overall extrapolated bycatch of BFAL in both rockfish fisheries (a1 + b1)	7	139	0	85	57.8
Overall extrapolated total seabird bycatch (incl. BFAL) in both rockfish fisheries (a2 + b2)	7	139	58	85	72.3

hooks. In the charter seamount fishery (1999 and 2000 only; no fishery in 2001 or 2002), observers reported 7 bycaught birds; all were Black-footed Albatross. The birds were caught over Bowie, Union or Hodgkin's Seamounts. The average charter seamount fishery bycatch rate was 0.0241 birds/1,000 observed hooks; far higher than the rate calculated for the commercial halibut fishery, but not strikingly different from the average bycatch rate in the commercial rockfish fishery. An extrapolation (using the observed hooks bycatch rate) predicted for the

entire fishery that from zero to 135 birds were caught annually in the commercial rockfish fishery (average 69.5/year, 1999 through 2002). Most of the birds caught in that fishery were Black-footed Albatrosses. An additional 4 to 7 birds were predicted caught annually in the charter seamount fishery (Table 7). The overall total predicted annual bycatch from both rockfish fisheries ranged between 7 and 139 birds.

3.1.3 Predicted Total Seabird Bycatch from Longline Halibut and Rockfish Fisheries

By summing the extrapolated seabird bycatch numbers calculated for the commercial demersal longline halibut and rockfish fisheries we predict that between 95 and 178 seabirds (primarily Black-footed Albatrosses) were caught each year. Gulls were the next most common bycatch victims (Table 8).

Table 8. Extrapolated seabird bycatch from the halibut and rockfish fisheries examined. Values for species (other than BFAL) were derived by multiplying the overall predicted bycatch by the individual species proportions (of all salvaged birds, 1999 – 2002).

Extrapolated bycatch of:	Calendar year				4-yr. Avg.
	1999	2000	2001	2002	
Black-footed Albatross	71	178	20	90	89.8
Northern Fulmar and Short-tailed Shearwater	26	0	30	2	14.5
Herring, California and Glaucous-winged gulls	38	0	48	3	22.2
Total birds (all species)	135	178	98	95	126.7

3.2 Net Fisheries

3.2.1 Commercial Salmon Fisheries

3.2.1.1 Area 21 Gill Net Test Fishery

Over the seven years that this test gill net fishery ran off the west coast of Vancouver Island, a total of 392 birds were caught (Table 9). The annual number of birds caught varied considerably (from 25 to 119 birds); the average number of birds caught was 56. In any given year, no more than four species were caught but overall, nine species were reported caught during the study. However, because all of the birds in the first two years of the study were not identified (34 in 1995, 58 in 1996) the overall number of species may have been higher.

Table 9. Fishing effort and seabird bycatch data for the Area 21 Gill Net Test Fishery (1995-2001). Numbers in brackets [ ] under "Seabirds caught" are birds that were released alive.

Year	Total fishing days	Total sets	Total hours fished	Seabirds caught	Number of species
1995	16	855	1818	34	[n/a]
1996	19	1349	3043	58	[n/a]
1997	16	865	1504	62	4
1998	14	736	1336	52 [7]	5
1999	13	833	1306	42 [3]	4
2000	16	650	1014	119 [9]	4
2001	12	137	227	25 [2]	2
Total	106	5425	10248	392	9
Avg. (± St. Dev.)	15 (2.3)	775 (359)	1464 (856)	56 (31)	

Using the proportions of identified birds (1997 through 2001) we partitioned the 34 and 58 unidentified birds to species; these are shown in italics in Table 10. The bycatch of Common Murres far exceeded the bycatch of all other identified species. The majority of seabirds caught in this fishery died; over the 7-years of this study only 5.4% of the birds caught were released alive (Table 10). Bycatch rates ranged between 0.019 and 0.117 birds/net-hour (average 0.054 ± 0.042). The lowest observed bycatch rates were in 1995 and 1996; the highest was in 2000 (Table 11).

Table 10. Seabird species and numbers caught as bycatch in the Area 21 Gill Net Test Fishery, 1995-2001. Species totals and percentage are based only on identified birds.

Species	'95	'96	'97	'98	'99	'00	'01	Total	%
Pacific Loon	*0*	*0*	1	0	0	0	0	1	0.34
Pelagic Cormorant	*1*	*1*	0	2	3	1	0	6	2.03
Brandt's Cormorant	*0*	*0*	0	1	0	0	0	1	0.34
Sooty Shearwater	*1*	*0*	6	0	0	0	0	6	2.03
Common Murre	*30*	*53*	46	44	36	113	24	263	89.15
Rhinoceros Auklet	*1*	*2*	0	4	1	3	0	8	2.71
Marbled Murrelet	*1*	*1*	4	0	2	0	0	6	2.03
Pigeon Guillemot	*0*	*1*	0	0	0	2	1	3	1.02
Cassin's Auklet	*0*	*0*	0	1	0	0	0	1	0.34
Unidentified bird	(34)[1]	(58)[1]	5					97	
Total number of birds caught	34	58	62	52	42	119	25	392	
Number released alive				7	3	9	2	21	5.4

[1] Original data were listed as unidentified birds ('95 and '96); we partitioned the unidentified birds according to the species' proportions from salvaged birds ('97 – '01) – those values are shown in italics.

Table 11. Seabird bycatch rates for the Area 21 Gill Net Test Fishery, 1995-2001.

Year	Birds caught*	Seabirds/set	Seabirds/net-hour
1995	34	0.040	0.019
1996	58	0.043	0.019
1997	62	0.072	0.041
1998	52	0.071	0.039
1999	42	0.050	0.032
2000	119	0.183	0.117
2001	25	0.182	0.110
Average	56	0.092	0.054

* Includes seabirds released alive.

Most birds were caught in the top or middle one third of the net between 1999 and 2001 (Figure 1). More birds were entangled in the top third in 2000 and in the middle third in 1999 (chi-square 15.97; df =3; p=0.001).

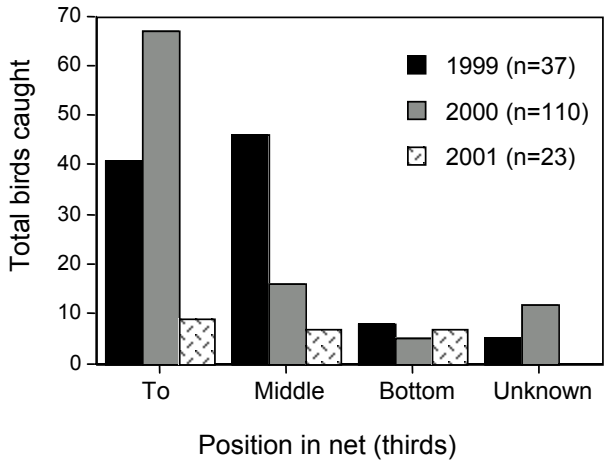

Figure 1. The total number of diving birds caught in gill nets according to depth from the 2 m deep weedline, Area 21 Gill Net Test Fishery, 1999-2001.

In 1999 and 2001, birds were caught relatively evenly throughout the entire day. In 2000, more birds were caught in the sets between 09:00 and 10:00 (Figure 2).

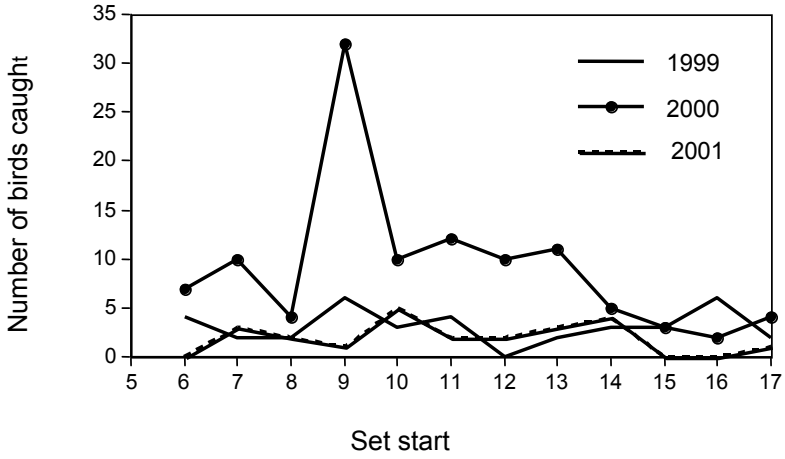

Figure 2. The number of seabirds caught as bycatch with respect to set time Area 21 Gill Net Test Fishery, 1999-2001.

3.2.1.2 Area 4 Coho Salmon Gill Net Test Fishery

During this 11-day fishery, 1,834 sets were observed and eight birds were reported caught. Observers identified three birds to species (two correctly, one incorrectly), four birds to family (n = 4) and gave one a colloquial name. The two birds salvaged from this fishery were a Marbled Murrelet (incorrectly identified as a Cassin's Auklet *[Ptychoramphus aleuticus]*) and a Rhinoceros Auklet. Overall, we know that three Rhinoceros Auklets, two Marbled Murrelets, and three unidentified birds were killed. The number of birds caught during observed sets ranged from 0 to 0.01 birds/set (average 0.004). Most of the seabirds were caught in the top one third of the net (n = 5; 63%). The total number of sets fished, the total fishing hours, and the number of vessels, were not available; therefore, we could not project the overall bycatch of seabirds.

3.2.1.3 Johnstone Strait Gill Net Experimental Fishery

Fisheries observers reported 152 birds caught in 1997; none of the birds were identified to species. The Alaska Twist (AT90) nets caught fewer birds than the multi-strand (MS60) net (38% versus 62%); and the AT90 nets caught more sockeye, coho and pink salmon than multi-strand nets (t-test, $p<0.001$, P. Ryall, unpublished data). Most of the birds that were caught were from one statistical area (12-11, n=105); the remaining birds were from two other areas (12-12, n=43 and 12-13, n=4). The extent of the observer effort was insufficient to allow us to predict the overall number of birds killed in this fishery.

3.2.1.4 Area D Sockeye Salmon Gill Net Selective Fishery

During nine days of fishing, a total of 417 sets were made representing 416 hours of fishing. Overall, 91 birds were caught with 88 killed and 3 released alive; most of the dead birds were salvaged (94%). At least four species were caught; the majority of them were Rhinoceros Auklets (Table 12). Most of the auklets were caught during the first test period in one set (n = 67; 75%). During the other two test periods, nine and 14 birds were caught. The overall bycatch rate for this fishery was 0.219 birds/net-hour

Table 12. Seabird bycatch from the Area D Sockeye Gill Net Selective Fishery Jul/Aug 2000.

Species	Number of seabirds caught	Percent of total bycatch
Common Loon	1	1.1
Pigeon Guillemot	1	1.1
Common Murre	5	5.5
Unknown	5	5.5
Rhinoceros Auklet	79	86.8
Total	91	100

As per the study criteria, most sets were made during the 'day' (n = 299; 72%). Of the remaining sets, more were made during the 'dark' period (n = 71; 17%) than during the 'morning' (n = 47; 11%). Most birds were caught during the 'morning' in test period 1 (Figure 3); no birds were caught during the 'dark' period. The overall bycatch rate for this selective fishery was 0.13 ± 0.23 birds/net-hour; the highest rate in any net fishery examined. Bycatch rates varied with time of day; the highest bycatch rate occurred in the morning (3.8 birds/net-hour). However, this exaggerated rate was the result of the previously noted single set that caught 67 birds. Typical bycatch rates in this fishery were 0.025 - 0.028 birds/hour. Most of the bycatch was from sets started in the early morning (Figure 4); most birds were caught during sets that started at 04:00 hours.

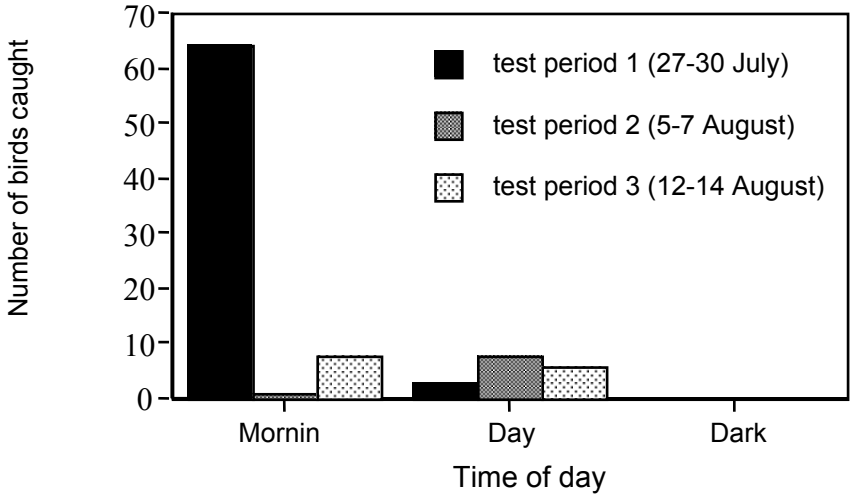

Figure 3. The timing of bird bycatch during the Area D Sockeye Gill Net Selective Fishery, July - August 2000.

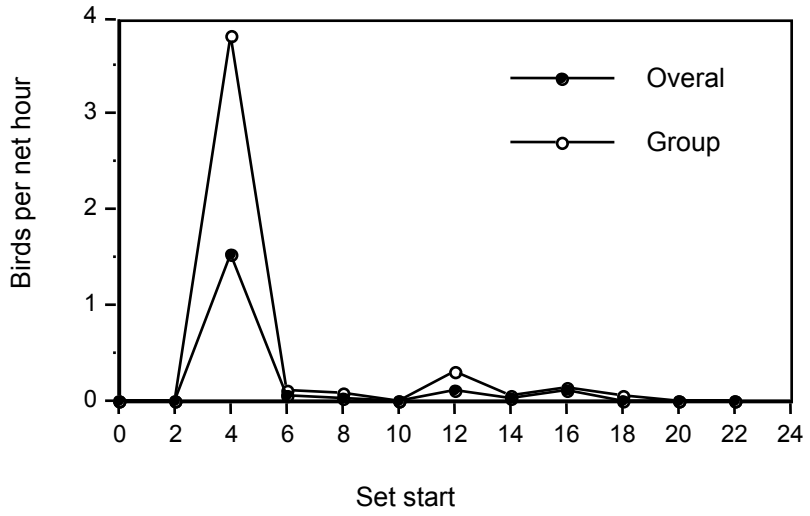

Figure 4. The number of birds caught based on set start time in the Area D Sockeye Gill Net Selective Fishery, July - August 2000.

3.2.1.5 Barkley Sound Sockeye Salmon Gill Net Commercial Fishery

In two one-day openings, 126 sets were observed from a possible 256 licensed vessels. Observers reported no bird bycatch and no other fishery data were available (Table 13).

Table 13. Fishery data for the 2000 Barkley Sound Sockeye Gill Net Commercial Fishery.

Opening date	Total number of sets	Sets observed	Hours observed	Average set time (hrs)	Seabirds caught
19 June	[n/a]	77	58.7	0.76	0
26 June	[n/a]	49	44.1	0.92	0

3.2.1.6 Area 4 Selective Seine Fishery

Fisheries observers recorded data for 135 sets in four sub-areas in Area 4. No birds were reported caught. Observers recorded the abundance of birds (mostly gulls and alcids) behind the vessel during setting; they noted 200 birds from 0 - 10 m, 290 birds from 10- 50 m and 819 birds greater than 50 m. Observers in this fishery were the only ones who recorded bird abundance behind vessels fishing in BC waters.

3.2.2 All BC Salmon Gill Net Fisheries - Summary

Over the past decade there has been a dramatic decline in the size of the salmon gill net fleet. Compared to 1996, the fleet has been reduced by approximately 40%; there are far fewer openings and the openings are much shorter. However, on an annual basis, for the entire BC

coast there hasn't been a significant reduction in overall fishing effort, and the fleet still possesses substantial catching power (Nelson and Turris 2004). Based on the total hours fished (all BC commercial salmon gill nets, 2001 through 2004), the average annual fishing effort was 167,206 (± 7,369) set-hours. Using the bycatch data from the Area 21 Gill Net Test (1995 – 2001), the Johnstone Strait Gill Net Experimental (1997), and the Area D Sockeye Gill Net Selective (2000) fisheries, we derived an average annual bycatch rate of 0.0723 (±0.0652) seabirds caught/hour of fishing. Utilizing the average (and range of) fishing effort and the range (average ± St. Dev.) of bycatch rates, we extrapolated to the entire gill net fleet. This resulted in a predicted annual bycatch of 12,085 seabirds (range 1,129 - 24,002 -Table 14). Although generally fewer than 5% of the birds caught are released alive, we remind the reader that not all of the predicted bycaught birds would die. Assuming that the proportions of birds identified and the predicted total number of seabirds caught, are representative of 'normal' commercial fishing, it is clear that Common Murre and Rhinoceros Auklets are the two seabird species that are most heavily impacted by gill net fishing in BC. Although an order of magnitude lower than the bycatch of Rhinoceros Auklets, our analysis predicts up to 552 Marbled Murrelets could become entangled each year.

By far, most of the Common Murres that were salvaged (from Areas 4, 12, 21 and D, between 9 July and 8 October 2000, and 28 September and 8 October 2001), were immature birds, and more males were killed than females (Table 15). In contrast, there were far more adult Rhinoceros Auklets killed than immature birds; these birds came from Areas C, D and 21, between 26 July and 2 October 2000. There was a strong bias towards more male Rhinoceros Auklets becoming entangled than females. Some of gender and age biases were likely related to the location and the date of the individual fisheries.

Table 14. Observed number of seabirds caught by species and extrapolated annual bycatch (average, minimum and maximum) for the entire gill net fishery fleet. Seabird bycatch numbers and percentages derived from all of the fisheries examined, 1995 - 2001.

Species	Number of birds caught	Percentage of bycatch (identified to species)	Extrapolated annual bycatch - average (min. and max.)
Common Murre	271	69.3	8,367 (782 - 16,636)
Rhinoceros Auklet	91	23.3	2,812 (263 - 5,585)
Marbled Murrelet	9	2.3	278 (26 - 552)
Sooty Shearwater	6	1.5	185 (17- 367)
Pelagic Cormorant	6	1.5	185 (17 - 367)
Pigeon Guillemot	4	1.0	123 (12 - 245)
Common Loon	1	0.3	31 (3 - 62)
Pacific Loon	1	0.3	31 (3 - 62)
Brandt's Cormorant	1	0.3	31 (3 - 62)
Cassin's Auklet	1	0.3	31 (3 - 62)
Total	391	100	12,085 (1,129 - 24,002)

Table 15. Percentages (of species totals) of Common Murres (n = 123) and Rhinoceros Auklets (n = 82) salvaged as bycatch, by gender and age class. Immature birds include young of the year, juveniles and sub-adults.

	Adult			Immature		
	Male	Female	Total	Male	Female	Total
Common Murre	16%	12%	28%	39%	33%	72%
Rhinoceros Auklet	60%	24%	84%	7%	9%	16%

4. DISCUSSION

4.1 Demersal Longline Fisheries

Here, we compare the estimated bycatch rates in BC to other demersal fisheries and discuss the various seabirds we found to be affected by the longline fisheries. The available seabird bycatch data in the halibut, rockfish and charter seamount rockfish longline fisheries provide an estimate of seabird bycatch rates. However, in some cases, the data we reported were from observer programs that covered less than three percent of the total number of hooks fished. Observer programs are critical in order to evaluate seabird bycatch. Coverage in the longline fisheries increased substantially in 2001 and 2002 from previous levels but overall it was less then half of the target level of 25%. Wiese and Smith (unpublished) found that observer coverage was not evenly distributed across management units and varied widely across months. In a study to assess the effects of bycatch in longline fisheries on Black-footed Albatross, they found that observer coverage reached as high as 50% in the rockfish fishery during the summer months in one management unit but was zero in other units. Since both bird populations and the fishing industry display large amounts of temporal-spatial variability throughout the year (F. Wiese and J. Smith, unpublished data), observer programs need to be designed so that they can capture this variability in order to evaluate the impacts of bycatch. We cannot compare the BC and Alaska commercial halibut fisheries because there is no observer program in the Alaska fishery. In fact, there are very few data from the north Pacific where seabird bycatch rates from demersal longline fisheries can be compared. However, an exception to this occurred in 1999; this represented a period when bycatch rates calculated using the IPHC skipper interviews, overlapped with observations noted by participants in the BC commercial halibut observer program. The observed bycatch rate from the 1999 BC halibut fishery (0.0154 birds/1,000 hooks [Table 6]) was more than five times the rate determined by the IPHC skipper interviews (0.0030 birds/1,000 hooks [Table 5]). Overall, for all IPHC areas (other than BC), the 1999 skipper interviews indicated a seabird bycatch rate of 0.0011 birds/1,000 hooks (Table 5) – less than one tenth of the rate calculated from the logbook and observer summaries for BC. However, IPHC staff cautioned about the accuracy of the interview results; questioning whether US skippers felt “as free” to answer the interview questions as their BC counterparts. US skippers have been under increased scrutiny because of the listing of the Short-tailed Albatross as Endangered in the US, and fishery regulations already exist to protect them (T. Geernaert, pers. comm.).

The BC commercial rockfish fishery reported no seabirds caught in the first year of the at-sea observer program (1999); but one, one and nine birds were reported caught in the second, third and fourth years of the program, respectively. The observed bycatch translates to a range of 0.0142 to 0.0316 seabirds caught/1,000 hooks fished (average 0.0181 birds/1,000 hooks). Although the data for the charter seamount rockfish fishery were from two years only, the seabird bycatch rates for this fishery was similar to the commercial rockfish fishery (0.0231 to 0.0250 birds/1,000 hooks).

In Alaska, the groundfish longline fisheries (non-halibut) reported an average seabird bycatch rate of 0.089 birds/1,000 hooks, which translated to between 10,000 and 27,000 birds/year (NMFS 2001b). That estimate is from six years of observer data, covering sets from more than 2,000 vessels. In British Columbia, most groundfish species, except halibut, are caught with trawl and not longline gear. Observers in the various BC trawl fisheries have not reported seabird bycatch (H. McElderry, unpublished data), although occasionally birds are caught (Appendix VI). There is also a small longline sablefish fishery but, with limited observer or remote video coverage, estimates for seabird bycatch are not available.

Seabird bycatch rates are generally higher for southern hemisphere pelagic longline fisheries than demersal fisheries (0.03 - 5.03 birds/1,000 hooks versus 0.19 - 0.67 birds/1,000 hooks); this is partly due to the large concentration of birds in the fishing grounds of the southern ocean (Alexander *et al*. 1997). The seabird bycatch rates from the demersal longline fisheries in Canada are far lower than the rates from the pelagic longline fisheries within the Australian Fishing Zone (up to 0.58 birds/1,000 hooks, Brothers *et al.* 1998).

Where possible, deriving species-specific bycatch rates would be very informative because of the inter-specific differences in seabird ecology, feeding modes, distribution, etc. and because gear and fishing activities might require modifications depending on the species of birds predicted to be impacted. Additionally, an understanding of the distribution and abundance of seabirds is necessary for forecasting how certain fisheries might impact specific populations. The following briefly describes the three North Pacific albatross species – the group of seabirds most frequently impacted by longlines.

Historically, the Short-tailed Albatross was common along the BC coast but is now an uncommon visitor in the spring and summer (Campbell *et al*. 1990). Since 1991, there have been more than 20 confirmed sightings of the Short-tailed Albatross over the continental shelf, along the shelfbreak or over seamounts within BC waters (K. Morgan, unpublished data). That includes a juvenile bird that had been captured at sea near the Aleutians, fitted with a satellite transmitter and eventually tracked to within 5km of the north end of Vancouver Island in mid-

November, 2003 (R. Suryan, Oregon State University, pers. comm.). Although it has not been reported as bycatch in any BC longline fishery, the Short-tailed Albatross is a global conservation concern because there are only an estimated 1,923 individuals in the world (G. Balogh, US Fish and Wildlife Service, pers. comm.). The Short-tailed Albatross is listed as Vulnerable by the World Conservation Union; Endangered in the United States and Threatened in Canada. The US listing of this species of albatross spurred the development of seabird bycatch reduction measures. Subsequently, new regulations were introduced to limit the allowable bycatch rate in the Alaskan groundfish fishery (NMFS 2001b).

In the northeast Pacific, the Black-footed Albatross is the albatross species at greatest risk of accidental capture in longline fisheries (Melvin *et al*. 2001, NMFS 2001b); largely because of their spatio-temporal overlap with the fisheries. The Black-footed Albatross is the most common albatross in the offshore waters of BC (Morgan *et al*. 1991); it occurs in areas of high productivity, such as offshore seamounts and along the continental shelfbreak (Campbell *et al*. 1990, Burger *et al*. 1997). As with other species of albatrosses, the Black-footed Albatross delays breeding until age six or seven and produces one chick/year, sometimes skipping a year (Whittow 1993). Banding records show that this species can live up to 43 years, and may breed throughout their entire adult life (Fernandez 1997). The size of the Black-footed Albatross breeding population in the eastern Pacific has declined and current estimates are ca. 109,000 pair (Kyoichi and Harua 1997). The World Conservation Union listed the Black-footed Albatross as Endangered based on projected declines of more than 20% in the next three generations (56 years) due to mortality in longline fisheries in the North Pacific (BirdLife International 2000). In February 2005, COSEWIC listed the Black-footed Albatross as a high priority candidate for assessment in Canada.

The third and most abundant of the Pacific albatrosses, the Laysan Albatross, has not been reported as bycatch in BC; however, it is the most frequently caught albatross species in the Alaskan groundfish fisheries (Melvin *et al*. 2001). The World Conservation Union recently listed (for the first time) the Laysan Albatross as Vulnerable, on the basis of a projected decline of more than 30% over the next three generations (84 years). The reason for the decline has been attributed to the effects of longline fishing in the North Pacific.

The Black-footed Albatross was the most common seabird species reported as bycatch in the BC longline fisheries examined here. Using simple extrapolations, we predicted that between 20 and 178 albatrosses are killed annually; numbers similar to those derived by Wiese and Smith (unpublished). They estimated between 58 and 223 albatrosses could be caught each year in BC, with the highest bycatch in the summer along the shelfbreak. We caution the reader that

our extrapolations were based on a small sample size and uneven (spatially and temporally) observer coverage. However, regardless of the exact number of Black-footed Albatross killed in BC's demersal longline fisheries, the species is definitely a global and a local conservation concern.

The introduction of certain mitigation measures (e.g., night-setting) can reduce the bycatch of one species or group (e.g. albatrosses) but can coincidentally increase the bycatch of other species (e.g. Northern Fulmars) that forage at night (Melvin *et al.* 2001). It is not known to what extent fulmars, shearwaters, gulls or other species are killed in the BC commercial longline fisheries. In the Alaskan groundfish fisheries, Northern Fulmars comprised between 70 and 87% of the total seabird bycatch in the two years examined (1999 and 2000, Melvin *et al*. 2001). Assessing seabird bycatch is similar to assessing bycatch of other non-target organisms. However, we must also consider the extreme inter-year variation in the number of birds present. Without information on the number of birds attacking baited hooks, it is impossible to assess the effectiveness of mitigation measures or compare inter-annual changes in bycatch rates. Bird numbers are influenced by many environmental and biological factors and can change dramatically from year to year (Melvin *et al*. 2001). To manage for the reduction of seabird bycatch, spatio-temporal patterns of seabird abundances and timing of fisheries need to be considered together. In British Columbia, the following areas and seasons are considered to be of potential bycatch concern (based on known seabird and commercial fishing locations): from mid-March to mid-June - Queen Charlotte Sound, Goose Island Bank, Scott Islands, and Cape St. James; from mid-June to mid-September - West coast Vancouver Island. Any longline fishing that would take place over an offshore seamount between April and September would also potentially be of concern, with regards to seabird bycatch.

On a vessel-by-vessel basis, seabird bycatch in demersal longline fisheries is usually a rare event. The fishing industry may perceive that the mortality of seabirds is insignificant and not worthy of concern (Melvin *et al*. 2001). However, when the total seabird mortality from all active vessels and over all years of fishing and in all areas is considered, the potential population impact cannot be discounted.

4.2 Net Fisheries

Currently, there are insufficient data to accurately model the level of seabird mortality in net fisheries in British Columbia. There were few openings that provided enough information to estimate a seabird bycatch rate; and most of the bycatch data came from the Area 21 Gill Net Test Fishery. Test fisheries, such as the Area 21 Gill Net Test Fishery, generally provide high

quality data; but, should these data be used to predict bycatch rates in the commercial fisheries? Possibly not, for the following reasons:

- in test or selective fisheries, fewer vessels are present than in typical commercial openings - the overall reduced vessel activity may either scare away fewer birds or conversely, fewer vessels attract fewer scavenging birds (which normally act as feeding-flock initiators); and
- the gear deployed is often drastically altered in test fisheries.

Additionally, the data we analysed were derived from a small portion of the BC waters where salmon are fished commercially and for a restricted period of time. Therefore, we stress that our data does not reflect the spatial/temporal variability in commercial fishing effort; nor does it reflect the inter- and intra-seasonal variation in seabird distribution and abundance. Notwithstanding these limitations, we conducted simple extrapolations using the bycatch rates from the test, experimental and selective fisheries, and from the recent, averaged annual coast-wide fishing effort, to generate 'ballpark estimates' of the range of seabirds entangled in gill nets in BC.

Our analyses predict that between 1,129 and 24,002 seabirds could become entangled in gill nets in BC each year. The Common Murre is the species most heavily impacted by gill nets, with a predicted average annual bycatch of 8,367 birds (range 782 – 16,636). Common Murres are impacted as well elsewhere, in gill net fisheries in both the Pacific and the Atlantic (e.g. Wolf *et al*. 1995, Melvin and Parrish 2001). Murres are colonial breeders along the Pacific coast and are a considered to be conservation concern because some populations are believed to be declining (M. Hipfner, CWS, pers. comm.). Melvin *et al*. (1997) summarized (by age-class and gender) the numbers of Common Murres and Rhinoceros Auklets killed in two Puget Sound (WA) fisheries. The fisheries they examined were a Chum fishery that took place between 25 October and 11 November 1995; and a Sockeye fishery that occurred between 28 July and 29 August 1996. Combining the results from the two fisheries showed that overall, Common Murre was the most numerous bird species captured; and, more than twice as many breeders (= adults) were caught as young of the year and pre-breeders (= immature birds). In comparison, we found that of the salvaged birds we examined, immature Common Murres were far more numerous than adults. In both Puget Sound and in BC, the ratio of bycaught male to female murres was approximately 1.2 to 1.0.

The next most frequently captured bird in BC (as well as in Puget Sound) was the Rhinoceros Auklet with a predicted annual bycatch in BC of 2,812 (range 263 – 5,585). The Rhinoceros Auklet is a common breeder in BC and populations are believed to be stable (Campbell *et al*.

1990). Several large colonies exist near active fishing grounds (e.g. Langara, Lucy and Pine Islands [BC] and Protection Island [WA]). As an illustration of the increased risk of bycatch when fishing takes place during the breeding season near a colony, we found one instance where 59 Rhinoceros Auklets were killed in a single set (near Pine Island, Area D). In the Puget Sound fisheries summarized by Melvin *et al.* (1997), more immature Rhinoceros Auklets were killed than adults, and there were almost twice as many males as females (ratio 1.8 males to 1 female). In marked contrast to the Puget Sound results, we found that there were more than 5-times as many adults Rhinoceros Auklets killed than immature birds. The ratio of male to female Rhinoceros Auklets examined in this study was approximately 2 to 1.

In the fisheries we examined, one commercial and two test fisheries reported catching Marbled Murrelets; this species is listed as Threatened by COSEWIC and as Vulnerable by the World Conservation Union (BirdLife International 2000). The COSEWIC listing was based on two threats; the main one being the loss of nesting habitat, and the second was the potential impact of bycatch in commercial fisheries. The Marbled Murrelet Recovery Team (Kaiser *et al*. 1994) and the Conservation Assessment of the Marbled Murrelet in BC (Burger 2002) both identified gill net fisheries as a conservation threat to the BC population of Marbled Murrelets.

Until the 1980s, the sockeye fishery in Barkley Sound was large with 300 to 400 vessels fishing 24 hours a day, from June through August. Carter and Sealy (1984) estimated that a minimum 175 – 250 Marbled Murrelets (primarily adults) were killed by nets in Barkley Sound in 1980. That mortality estimate represented approximately 6% of the breeding population or slightly less than 8% of the potential fall population. Using simulation models Beissinger and Nur (1997) and Boulanger *et al*. (1999) showed that adult survival is the most sensitive demographic parameter affecting populations of Marbled Murrelets, as well as other seabird species (Nur and Sydeman 1999). Beissinger (unpublished) modeled the impacts of gill net mortality on the population viability of Marbled Murrelets; and, using available estimates of fecundity and adult survival, he found that even modest levels of gill net mortality were likely to impact murrelet populations. The data were too few to conclude what the specific impact of gill net fisheries might have been on Marbled Murrelet populations in BC, but if the Barkley Sound sockeye fishery had continued at the pre-1980's intensity, the long-term impacts on Marbled Murrelets would have likely been devastating (Carter *et al.* 1995). Fortunately (for the murrelets and other seabirds), this fishery underwent major changes, including a reduction in the number of vessels, daylight fishing only and single-day openings in July and August. Elsewhere, the mortality of Marbled Murrelets in salmon gill nets was estimated at 3,300 birds per year in Alaska (Piatt and Naslund 1995).

Burger (2002) suggested that there are between 54,700 and 77,700 (median 66,000) Marbled Murrelets in BC; that number includes murrelets of all ages. Using Sealy's (1975) estimate of adults representing 85% of the murrelet population (based upon birds collected near Langara Island during the nesting season), and the estimated range of the Marbled Murrelet population, suggests that there may be between 46,495 and 66,045 (median 56,100) adult murrelets in the province. That translates to between 23,248 and 33,023 (median 28,050) pairs. The predicted proportion (of possible breeding pairs) initiating a breeding attempt ranges from 55 to 95% (Burger 2002); although Bradley (2002) determined that at least 62.5% of potential breeders in the Desolation Sound area attempted nesting. From this we suggest that there are between 12,786 and 31,371 Marbled Murrelet nesting attempts annually in BC. Manley and Nelson (unpublished data, in Burger 2002) estimated murrelet nesting success at 0.35 fledglings/nest; whereas, Bradley (2002) calculated a rate of 0.46 fledglings per nest. From these two fledging rates and the range of nesting attempts, we calculate that for all of BC, between 4,475 and 14,431 (mean 8,063) Marbled Murrelets fledge annually. Our bycatch extrapolations predicted that from 26 to 552 (mean 278) murrelets may become entangled annually in BC gill nets; representing between 0.18 and 12.34% (mean 3.45%) of the annual production. Burger (2002) stated that the risks of mortality to: "*...Marbled Murrelets from gill nets are low....there are too few data to be complacent. The high mortality recorded in Barkley Sound …. and the strong impacts of bycatch in population simulation models...are reminders that murrelets are highly vulnerable to this fishery…., but it is not known whether bycatch is a serious problem in BC"*. At the time of writing this report, there is a joint project underway (between CWS and the DFO) to more accurately determine the extent and impact of Marbled Murrelet mortality in commercial salmon fisheries.

In the past, commercial salmon fishing near Langara Island may have contributed to the decline in Ancient Murrelets *(Synthliboramphus antiquus)* (Bertram 1995) although they were not reported captured in any of the fisheries we examined. In the 1950s and 1960s, anecdotal reports suggest that 'hundreds' of Ancient Murrelets were caught in gill nets during the breeding season (Bertram 1995). In the 1970s, gill nets near the same island killed unknown numbers of Ancient Murrelets and Rhinoceros Auklets (Vermeer and Sealy 1984). Although commercial fishing effort is currently low in the Queen Charlotte Islands, if it increases again both Ancient Murrelets and local breeding populations of Rhinoceros Auklets could be at risk. The Ancient Murrelet is declining throughout its range (Gaston and Jones 1998) and is listed as a species of Special Concern by COSEWIC. Introduced mammals on nesting islands and bycatch in fisheries are cited by COSEWIC as the main threats to the Ancient Murrelet.

Some gill net vessel owners in BC modify their multi-strand or Alaska Twist nets with a drop weedline to reduce the bycatch of steelhead and other fish species. Three fisheries that reported bird bycatch used drop weedlines: the Area 21 Gill Net Test Fishery, the Area 4 Coho Gill Net Test Fishery, and some vessels in the Barkley Sound Sockeye Gill Net Commercial Fishery. The fishing industry has speculated that drop weedlines could secondarily reduce seabird bycatch. However, nets modified with a drop weedline may in fact actually increase seabird bycatch because the net-free area gives the appearance that there is nothing hanging below the surface. Therefore, birds dive normally and become entangled in the unmodified net hanging further down. The efficacy of drop weedlines as a bird deterrent measure should be tested in the gill net fishery.

Data from this and other studies show that most diving birds are caught in the top or middle third of a net (Melvin *et al.* 1999). In Washington, Melvin *et al*. (1999) worked with the fishing industry to modify monofilament gill nets; the upper 20 to 50 meshes were constructed of white seine twine, which became known as “high visibility panels”. They found that seabird bycatch rates declined with the use of the modified nets and there was no reduction in the target catch. Melvin *et al*. (1999) believed that since most birds were entangled in the upper five metres of unmodified nets, the highly visibility panels alerted birds to a net below the cork line and caused them to avoid it. Their study recommended that high visibility panels should be tried provided that fishers refine the prototypes. They also suggested using acoustic pingers because they reduced seabird bycatch. Unfortunately, nets with pingers attracted more seals than nets without them. If the DFO considered adopting management measures (to reduced seabird bycatch) based on results from Washington State, it is important to remember that gill nets used in the Puget Sound are longer and deeper than most salmon gill nets used in British Columbia (i.e. 549 m long and 200 meshes deep [18.3 m] in WA *versus* 365 m long and 60-90 meshes deep [6.8 - 11.2 m deep] in BC). Without standardised bycatch units in all net fisheries (for example, birds/unit net area/hour fished) it is impossible to compare rates accurately.

Recommendations to reduce seabird bycatch in gill net fisheries often include time and area restrictions. In BC, data were available to examine the effects of timing in the 1999 and 2000 Area 21 Gill Net Test Fishery and the 2000 Area D Sockeye Gill Net Selective Fishery. During the Area D Fishery in early August, nets set at dawn caught the most birds. In the Area 21 fishery, most birds were caught in the morning. In Washington, Common Murres were caught with equal frequency at dawn or dusk, and Rhinoceros Auklets were caught most frequently at dawn (Melvin *et al*. 1999). Timing of openings is most important during the breeding season because many nocturnal seabirds travel to and from the colony at dawn and dusk.

As with the longline fisheries, bycatch rates need to be species-specific. Gear and fishing activities may need to be modified according to differences in bird biology, distribution and abundance. In Washington, Common Murres, Rhinoceros Auklets and occasionally shearwaters have been reported caught in monofilament gill nets (T. Wahl, unpublished data). Sooty Shearwaters *(Puffinus griseus)*, which can dive to depths of at least 60 m (Weimerskirch and Sagar 1996), were reported caught in the Area 21 Gill Net Test Fishery in 1997 (J. Mitchell, pers. comm.). Oceanographic conditions influence local shearwater numbers and thus, the likelihood of shearwaters becoming caught in nets. The seabird bycatch rates in Area 21 varied widely over the seven years; while nine species of birds were killed during this time, not all birds were caught each year. To assess the full impact of a fishery on seabird populations, especially those species that are not caught every year, multi-year studies in multiple locations under a variety of oceanographic/climatic conditions, that take into account variations in abundance and distribution patterns are required.

For seabird populations that have already been impacted by the loss of nesting habitat, introduced predators, oceanographic changes and toxicity from oil spills, mortality in gill nets may be an additional cause of population declines (DeGange *et al*. 1993, Nur and Sydeman 1999). In the late summer and early fall when birds move from their breeding colonies and undergo their post-breeding moult they become flightless. These birds aggregate and forage in prey-rich areas such as the Johnstone Strait, Juan de Fuca Strait and the mouth of Fraser River and therefore they are vulnerable to fisheries in these places.

5. RECOMMENDATIONS

5.1 Demersal Longline Fisheries

5.1.1 Recommended Seabird Avoidance Measures – Vessel Operators

The following avoidance measures were designed to apply to operators of all applicable vessels using hook-and-line gear as part of the Pacific halibut (L license) Individual Vessel Quota management program (0-200 nm offshore).

- Use hooks that when baited sink as soon as they are put in the water. This can be accomplished by the use of weighted groundlines, thawed bait, or additional weight.
- Avoid bait types that retain air in their swim bladders; if necessary, puncture bladder.
- Boats not processing fish during setting are to refrain from discharging residual bait or offal from the stern of the vessel while setting gear.

- Boats processing fish during setting are to use directed discharge (through chutes, pipes, or similar devices). Offal must be discharged in such a manner that is does not attract seabirds near the baited hooks, to the extent practical.
- Discharging during hauling is to be done in a manner that does not attract birds to the baited hooks.
- Make every reasonable effort to ensure that birds brought aboard alive are released alive and that, where possible, hooks are removed without jeopardizing the life of the bird.

5.1.2 Recommendations to Fisheries Managers

5.1.2.1 Minimum Measures Recommendations

These are the minimum actions that were recommended to meet the objectives of the Pacific Seabird Bycatch Working Group:

- Introduce mandatory 100% observer coverage for all ZN rockfish license holders awarded permits to fish above offshore seamounts.
- Increase observer coverage to achieve 25 % of hooks fished in halibut (L license) and rockfish (ZN license) demersal longline fisheries.
- Follow-up and enforce the completion of the DFO vessel logbooks in the L and ZN license fisheries. All logbooks must have complete information on fishing location, number of hooks set, number of hooks lost, gear code and discarded species.
- Facilitate an inexpensive and simple program to retain salvaged birds for delivery to the CWS.
- If an extensive salvage program is not feasible, train all observers that work on demersal longline vessels for a minimum of four hours how to identify seabirds and how to collect all seabird bycatch data.
- Have observers record all seabirds caught or hooked, including those that escape or are released (apparently) unharmed.
- Equip all certified at-sea observers with an information package that fully describes the seabird bycatch data collection protocol, the species known to be caught by hooks, and what to do when a live or dead bird is brought on board.
- Encourage observers, skippers and vessel owners to record and report banded birds to the Canadian Wildlife Service.
- Hold discussions with the IPHC to transfer stock assessment surveys and logbook data to the DFO in digital format.

5.1.2.2 Best Measures Recommendations

In addition to the Minimum Measures:

- Establish a sampling program to monitor the effectiveness of mitigation measures to reduce seabird bycatch.
- Train all fisheries observers, for a minimum of one day, on seabird identification and safe handling and release of live and uninjured birds.
- Encourage longline fishers to develop techniques to reduce seabird bycatch, and/or improve upon the methods already developed.
- Deliver an education program for license holders and fishing vessel crews that demonstrates the proper use and deployment of streamer lines, as well as the reasons for seabird conservation.
- Ensure that all observers collect information on the attack rate and numbers of birds present behind the vessel during setting and hauling of gear.

5.2 Net Fisheries

5.2.1 Recommended to Fisheries Managers

5.2.1.1 Minimum Measures Recommendations

- Ensure that all license holders in commercial net fisheries are sent information regarding the concerns of seabird bycatch in net fisheries.
- Encourage salmon net license holders to create innovative techniques to reduce bycatch without an unacceptable reduction in the target catch or increase of other non-target organisms.
- Facilitate an inexpensive and simple program to retain salvaged birds for delivery to the CWS.
- If an extensive salvage program is not feasible, train all observers that work on salmon net license vessels for a minimum of four hours how to identify seabirds and how to collect seabird bycatch data.
- Establish a minimum of 10% observer coverage in net fisheries.
- Investigate collecting seabird bycatch data from the First Nations fisheries.
- Continue the salvage seabird program.

5.2.1.2 Best Measures Recommendations

In addition to the minimum measures:

- Encourage skippers of commercial vessels without fisheries observers to collect seabird bycatch data and to retain dead birds for the salvaged bird program.
- Train all fisheries observers for a minimum of one day on seabird identification and safe handling and release of live and uninjured birds.
- Ensure that all fisheries observers record the position in the net that birds are caught.
- Ensure that all fisheries observers record the abundance and behaviour of birds that approach the gear.

5.2.1.3 Recommended Studies

- Conduct a study to test effectiveness of Alaska Twist (AS90) to reduce bird bycatch.
- Conduct a study to test the effect of using a 1 to 2 metre drop weedline on seabird bycatch.
- Examine the effectiveness of time and area closures for mitigating mortality of seabirds, with an emphasis on closures near seabird colonies from April to September.

6. CONCLUSIONS

The objectives of this report were to assess the extent of seabird bycatch in the longline and net fisheries in BC; to provide recommendations for future work; and to provide suggestions for addressing the impacts of seabird bycatch. Averaged seabird bycatch rates were used to extrapolate up to the entire fishing fleets in order to provide a crude estimate of fisheries impacts on seabird populations. The demersal longline fisheries in BC had by far the greatest impact on the Black-footed Albatross; this is a concern because the species has been heavily impacted by longline fisheries elsewhere in the North Pacific. In the salmon gill net fisheries, Common Murre and Rhinoceros Auklet were the most heavily impacted species. Marbled Murrelets were also reported caught in several of the fisheries. The vulnerability of these three species (as well as other diving species of seabirds) to net fisheries is also a cause for concern. We recommend that a comprehensive study to asses the impacts of bycatch of these species in net fisheries in BC needs to be conducted. Although we were unable to fully assess the impacts of non-target bycatch in these fisheries in BC, it is clear from these preliminary estimates that seabird bycatch off the west coast of Canada is a conservation concern. Not only were relatively abundant species with (presumed) stable populations killed as bycatch; we documented that nationally and globally threatened species of seabirds are also being impacted by the fisheries examined.

In order for species-specific bycatch rates to be accurately determined, observer coverage needs to be expanded in order to more closely reflect the spatio-temporal variation in fishing effort as well as the variability in the distribution and abundance of the seabird species being impacted. Fisheries observers should either be provided with the directions to salvage dead seabirds and with the materials required to safely store birds for delivery to the CWS, or be fully trained to accurately identify bycaught birds.

We also recommend that fisheries managers and the fishing industries need to work together in order to find ways to reduce seabird mortalities, especially in gill net fisheries. In concordance with those efforts, there also needs to be expanded education/communication programs designed to inform managers and fishers of the seabird bycatch conservation issues; and of the need for improved cooperation in reporting bycatch information.

Only through the above actions will we not only be able to accurately assess the levels and impacts of seabird bycatch; but we will also be far more capable of devising and implementing workable solutions to keeping seabirds safe while sustaining industrial fisheries in Canadian west coast waters.

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8. APPENDICES

Appendix I: Pacific Seabird Bycatch Working Group (2000/2001)

Fisheries and Oceans Canada:

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Trawl Coordinator: Barry Ackerman

Hook and Line Coordinator: Terry Bedard

Regional Salmon Manager: Greg Savard

Area 21 Chum Fishery: Jim Mitchell

Johnstone Strait Gill Net Study: Paul Ryall

Area 4 Coho Gill Net fishery: Todd Johansson

Area D Selective gill Net Fishery: Gordon Curry

Area 23 Barkley Sound Sockeye Fishery: Laurie Gordon, Bruce Patten

Area 4 Selective Seine fishery: Todd Johansson

Area G Selective troll sockeye fishery: Gordon Curry

International Pacific Halibut Commission (IPHC): Tracee Geernaert

Appendix II: Fishing and observer effort in rockfish fisheries, 1998-2000.

	1998	1999	2000
Longline - fishing trips	641	573	732
Handline - fishing trips	703	629	574
Seamount - fishing trips	6	13	7
Troll fishing – trips	18	15	11
Unknown – fishing trips	281	43	5
Other – fishing trips	0	35	34
Total fishing trips	**1,649**	**1,308**	**1,363**
ZN fishing trips observed (longline only)		2	1
ZN fishing trips observed (handline only)		1	1
ZN fishing trips observed (longline + handline)		2	2
Seamount fishing trips observed (longline only)		5	6
Total fishing trips observed	**0**	**10**	**10**
Longline – fishing sets	3,380	3,179	3,851
Handline – fishing sets	3,482	3,240	2,723
Seamount longline – fishing sets	100	172	77
Troll – fishing sets	94	75	96
Unknown – fishing sets	8	0	13
Total fishing sets	**7,064**	**6,666**	**6,760**
Longline – sets observed		37	74
Handline - sets observed		52	56
Seamount - sets observed		86	87
Total sets observed	**0**	**175**	**217**
Longline – hooks fished	4,127,721	3,859,783	493,807
Handline – hooks fished	180,365	27,960	18,585
Seamount – hooks fished	115,600	307,165	159,916
Troll – hooks fished	1,073	791	648
Unknown – hooks fished	25,600	0	0
Total hooks fished	**4,450,359**	**4,195,699**	**5,122,956**
Longline – hooks observed		8,171	16,168
Handline – hooks observed		162	461
Seamount – hooks observed		129,801	159,916
Total hooks observed	**0**	**138,134**	**200,620**

Appendix III: Fleet characteristics for halibut and rockfish fisheries.

Target Species	Pacific Halibut	Rockfish
License	L	ZN
Boat type	Catcher boat	Catcher boat
Refrigeration	Ice	Ice
Trip length (days)	1 to 10	1 to 8
Vessel size (m)	15 to 40	15 to 20
Season	March 15 to November 15	April 1 to March 31
Hooks/year	7 to 8 million	3 to 4 million
Hook Type	Circle	Circle and J
Hook spacing (m)	2 to 3	
Soak time (h)	3 to 21	
Bait	Squid, octopus, salmon	Squid, herring
Primary area fished	WCVI, QCS, DE[1]	Coast wide

[1] WCVI = West Coast Vancouver Is., QCS = Queen Charlotte Sound, DE = Dixon Entrance

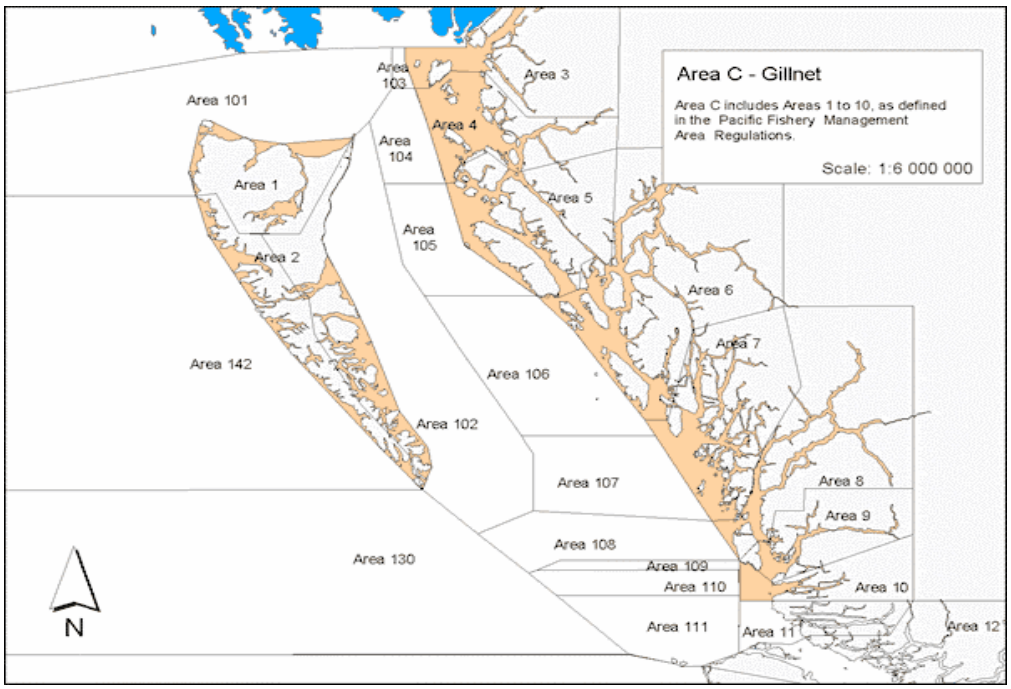
Appendix IV: Fisheries and seabird bycatch data - salmon gill net and seine fisheries.

Fishery	Number of sets	Hours fished	Birds caught	Birds caught per net-hour
Area 21 GNTF [1]	5,425	10,248	392	0.054
Area 4 Coho GNTF	1,834	-	8	-
J. Strait GNEF [2]	864	2,711	152	0.056
Area D Sockeye GNSF [3]	417	416	91	0.219
Barkley Sound Sockeye GNCF [4]	126	1,230	0	0
Area 4 SSF [5]	135	-	0	0
Area 12 Chum GNTF	-	-	2	-
Area 4 Chum GNEF	-	-	2	-
Area C FFTF [6]	58	-	0	0

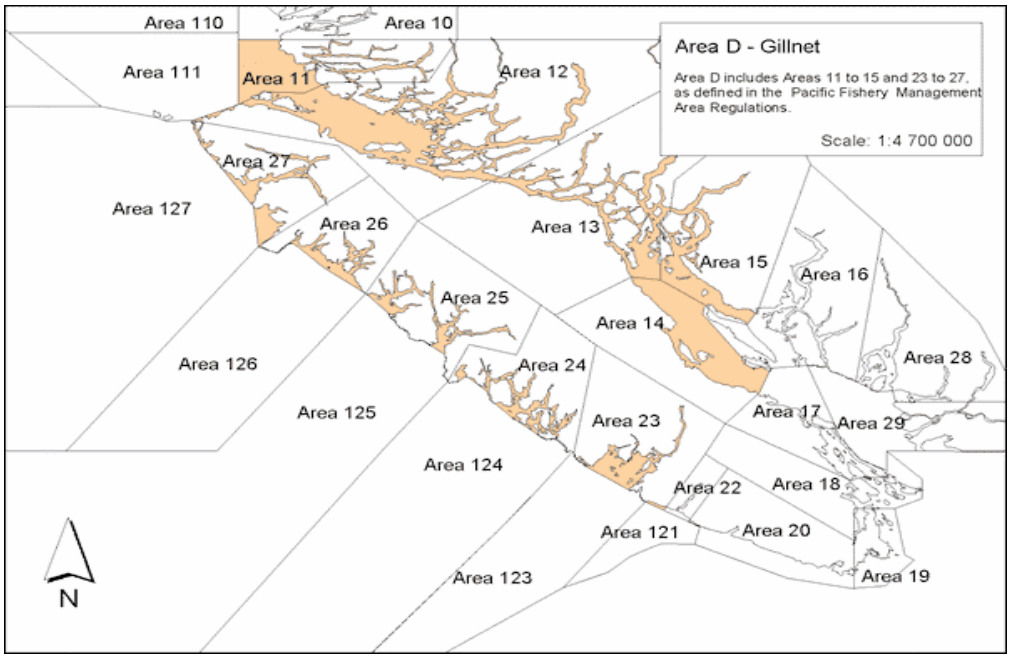
[1] GNTF = Gill Net Test Fishery
[2] GNEF = Gill Net Experimental Fishery
[3] GNSF = Gill Net Selective Fishery
[4] GNCF = Gill Net Commercial Fishery
[5] SSF = Selective Seine Fishery
[6] FFTF = Free Float Trap Fishery
- indicates no information provided

Appendix V: Salmon gill net license areas in BC

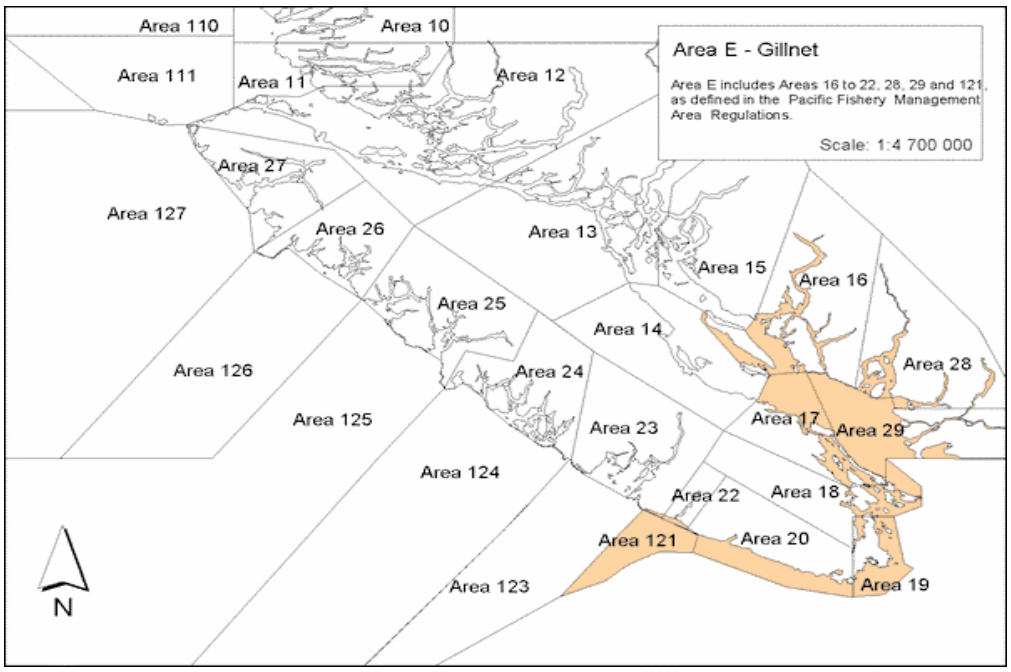
Salmon area C - areas 1 to 10, sub area 101-7



Salmon area D - areas 11 to 15 and 23 to 27



Salmon area E - areas 16 to 22, 28, 29 and 121



Appendix VI: Salvaged bird program

Starting in 2000, salmon fisheries cooperated in a joint DFO/CWS program to salvage dead seabirds caught during 2000 fisheries (Area D Sockeye Gill Net Selective Fishery, Area C Commercial Gill Net Fishery, Area 4 Coho Gill Net Test Fishery, Area 21 Gill Net Test Fishery and Area 12 Chum Gill Net Test Fishery). The fisheries were located on the south west coast of Vancouver Island, north coast of Vancouver Island/Queen Charlotte Sound, Johnstone Strait, and north coast /Prince Rupert. Birds were labeled, bagged, placed on ice and later given to either the observer service provider or directly to a DFO employee. No birds were salvaged from the longline fisheries in 2000. In total, 192 birds were salvaged; alcids made up 99% of the salvaged birds. Most of the salvaged birds were Common Murres and Rhinoceros Auklets.

Species composition of birds salvaged from five salmon gill net fisheries in BC in 2000.

Species	Total	Percent of total birds
Common Loon	1	0.5
Pelagic Cormorant	1	0.5
Common Murre	106	55.2
Pigeon Guillemot	2	1.0
Marbled Murrelet	2	1.0
Rhinoceros Auklet	80	41.7
Total	192	100

In 2002, an Archipelago Marine Research employee in Port Hardy began shipping all salvaged seabirds to CWS. To date 25 birds have been recovered; 23 of which were caught on longlines. More than half (52%) of the birds salvaged were Black-footed Albatross. Gulls accounted for 40% of the birds; and a single Northern Fulmar and one Short-tailed Shearwater were also recovered.

Species composition of birds salvaged from longline and trawl fisheries in BC

Fishery	Species	Number	Date Collected (mm/yy)
Longline Halibut	Black-footed Albatross	1	05/02
	Northern Fulmar	1	11/02
	Black-footed Albatross	2	06/03
	Black-footed Albatross	2	10/03
	Herring Gull	3	10/03
	California Gull	1	10/03
Longline Rockfish	Black-footed Albatross	2	06/02
	Black-footed Albatross	1	07/02
	Black-footed Albatross	1	08/02
	Gull sp.	1	02/03
	Black-footed Albatross	1	05/03
	Glaucous-winged Gull	1	12/03

Fishery	Species	Number	Date Collected (mm/yy)
	Glaucous-winged Gull	1	01/04
Longline Sablefish	Black-footed Albatross	1	06/03
	Black-footed Albatross	2	08/03
	Gull sp.	3	12/03
Midwater Trawl	Short-tailed Shearwater	1	07/02
Total Black-footed Albatross		13	
Total Gulls		10	
Total Northern Fulmar & Short-tailed Shearwater		2	
Total Birds		25	

Appendix VII: Seabird avoidance requirements for BC, by size of vessel and fishing area.

All vessels using hook-and-line gear must deploy based on size and fishing location, the following seabird avoidance measures:

	Vessel type		
Location	**< 30 ft LOA**	**30 - 55 ft LOA**	**> 55 ft LOA**
Inside waters	One device	Single streamer + one other device	Single streamer + one other device
Outside waters	One device	Single streamer + one other device	Paired streamer

Explanations:

- Vessels less than 30 feet, plus vessels up to 55 ft without masts, poles or rigging are exempt from deploying streamer lines but must deploy one or more avoidance measure.
- All boats greater than 55 ft must deploy streamer lines, no exceptions.
- Inside waters are defined as those inside the 200 m contour except the waters of Queen Charlotte Sound/north coast Vancouver Island (Triangle Is. east to Cape Sutil, north to Goose Group and west to Goose Is. Bank).
- Outside waters are defined as those waters greater than 200 m deep, as well as waters over the continental shelf adjacent to Queen Charlotte Sound/north coast Vancouver Island (Triangle Is. east to Cape Sutil, north to Goose Group and west to Goose Is. Bank).

- Other device: streamer line, towed buoy, or bird buoy bag (a buoy bag line must be 10-40 m in length).

Appendix VIII: Performance standard for seabird scaring lines (from Melvin *et al.* 2001)

The success of a particular mitigation measure rests on its ability to protect birds without an unacceptable reduction in the target catch or an increase in the capture of other non-target species. The following performance standards were developed by Melvin *et al*. (1999).

Single streamer: Deployed such that the streamers are in the air for a minimum of 40 m aft of the stern, and within 2 m of the point where the groundline enters the water.

Minimum length: 91.5 m

Streamer spacing: Every 5 m until performance standard achieved.

Streamer material: Should be made of brightly coloured, UV-resistant, plastic tubing or 9mm (3/8 inch) polyester line (or equivalent material). In the absence of wind, the individual streamers hang from the mainline to 0.25 m of the surface of the water.

Paired streamers: Deploy a minimum of two streamer lines while setting gear. If both streamers cannot be deployed prior to the first hook, then set one streamer with first hook and have second one flying before 90 seconds has elapsed.

Line material: Discretionary.

Terminal end: Discretionary.

Breakaways: Highly recommended, but discretionary.

Exceptions: When wind in excess of 30 knots (Beaufort 7 or near gale) performance standard can be adjusted to a single streamer from the windward side of the vessel.

- in winds exceeding 45 knots (Beaufort 9, storm force), the safety of the crew supersedes the use of seabird avoidance measures.
- although the following are not considered acceptable avoidance measures, vessels while fishing may also elect to use lining tubes and/or to set at night; however, such modification do not exempt vessels from being obligated to use accepted avoidance devices.