A Review of Data Sources and Catch Records for Pacific Saury (*Cololabis saira*) in Canada

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CONTENTS

INTRODUCTION 1
METHODS 2
Literature search 2
Survey databases 3
Research groups/teams 3
Individual accounts 3
RESULTS 4
Literature search 4
Survey databases 6
Groundfish database 6
Small pelagics database 7
Historical Whaling Database 7
Catch and Release Estimate Tool 7
Research groups/teams 7
Individual accounts 8
Seabirds 8
Pacific salmon 8
Groundfish 8
Other 9
Annotated Bibliography of DFO reports 9
CONCLUSIONS 16
ACKNOWLEDGEMENTS 16
REFERENCES 17

ABSTRACT

Wade, J., and Curtis, J.M.R. 2015. A review of data sources and catch records for Pacific Saury (*Cololabis saira*) in Canada. Can. Manuscr. Rep. Fish. Aquat. Sci. 3058: iv + 20 p.

Pacific Saury (*Cololabis saira*) is a short-lived pelagic fish that is widely distributed in the North Pacific Ocean and subject to important fisheries, particularly west of 175°E. Concern for the longterm sustainability of commercial fisheries in the western Pacific Ocean prompted the Scientific Working Group of the North Pacific Fisheries Commission to undertake a review of Pacific Saury ecology and catch records, and develop a multinational assessment of stock status to inform fishery management in international waters. This report compiles and summarizes Canadian biological data and information specific to Pacific Saury in or adjacent to British Columbia waters. No records were found pertaining to Canada's involvement in an international fishery or survey for the species. Although some reports document large catches of Pacific Saury, they are infrequently captured during research surveys or commercial fishing events. From 1997 to 2013, 224 kg of saury were captured by Canadian commercial fisheries.

RÉSUMÉ

Wade, J., et Curtis, J.M.R. 2015. Examen des sources de données et des registres des pêches sur le balaou japonais (*Cololabis saira*) au Canada. Can. Manuscr. sci. sci. halieut. de 3058: iv + 20 p.

Le balaou japonais (*Cololabis saira*) est un poisson pélagique dont la durée de vie est courte et qui est largement répandu dans le Pacifique Nord. Il est visé par des pêches importantes, particulièrement à l'ouest du 175^{e} méridien est. Préoccupé par la durabilité des pêches commerciales à long terme dans l'ouest de l'océan Pacifique, le Groupe de travail scientifique de la Commission des pêches du Pacifique Nord a entrepris un examen de l'écologie et des registres des pêches du balaou japonais et a élaboré une évaluation multinationale de l'état des stocks afin d'orienter la gestion des pêches dans les eaux internationales. Le présent rapport compile et résume les données biologiques et les renseignements canadiens portant sur les populations de balaou japonais présentes dans les eaux de la Colombie-Britannique ou les eaux adjacentes. Aucun registre n'a été trouvé sur la participation du Canada à une pêche internationale ou à un relevé de l'espèce. Bien que certains rapports fassent mention de prises importantes de balaou japonais, ces prises sont peu souvent consignées durant les relevés de recherche et les activités de pêche commerciale. De 1997 à 2013, 224 kg de balaou japonais ont été capturés dans le cadre des pêches commerciales canadiennes.

INTRODUCTION

Pacific Saury (*Cololabis saira*) is distributed throughout the entire North Pacific Ocean from coast to coast to the north of 25°N (Hubbs and Wisner, 1980). All life stages can be found from the inshore waters of Japan to 175°E in the western and central North Pacific Ocean (Watanabe & Lo, 1989). Pacific Saury (saury) was first discovered in coastal British Columbia by Gilbert in 1915 (Clemens & Wilby, 1964). This species can be found from southeastern Alaska to southern California (Novikov, 1974) although it is not known to be present in any great extent within Canadian waters (Baitaliuk et al., 2013).

In the southern warm water regions of the western Pacific Ocean, Pacific Saury are an abundant and commercially important species (McFarlane et al., 2009). From 1998 to 2008 squid accounted for 61.39% of catch in weight from the Japan/East Sea followed by Pacific herring (*Clupea pallasii pallasii*) 5.37% and Pacific Saury 3.41% (MOMAF 1997-2006 in McFarlane et al., 2009). Modern catch of Pacific Saury by all countries is between 400,000 and 600,000 tons (Baitaliuk et al., 2013).

Because Pacific Saury was and remains an important commercial species in the western Pacific Ocean, there exists and an extensive amount of literature on the biology, distribution and life history of the species in that region. There is a much reduced body of literature available on the species within United States (US) waters and very little specific to the species in Canadian waters. The application of biological information derived from the western Pacific Ocean saury to that of eastern Pacific Ocean saury populations should be approached with caution as it has been documented that differences between these populations may be significant. For example, it is believed that important life history traits such as growth rates and instantaneous mortality rates vary both spatially and temporally with environmental conditions (Watanabe et al., 1997). More recently, Baitaliuk et al. (2013) reported that in the winter and spring intensive spawning is observed in the northeastern part of the Pacific Ocean, while open water spawning is observed in summer.

Concern for the longterm sustainability of important commercial fisheries in the western Pacific Ocean prompted the Scientific Working Group of the North Pacific Fisheries Commission to undertake a review of Pacific Saury ecology and catch records, and develop a multinational assessment of stock status to inform fishery management in international waters. This report aimed to compile and summarize Canadian biological data and information specific to Pacific Saury in or adjacent to British Columbia waters. Canada was requested specifically to provide a time series of fishery catch estimates.

METHODS

Our review of the biological, fisheries and other data pertinent to saury included a comprehensive literature search, queries of survey and fisheries databases, and interviews with regional experts.

Literature search

Primary databases searched included: Academic Search Premier; American Fisheries Society journals; BioOne; JSTOR; NRC Research Press; Science Direct and SpringerLink. Search terms included: Pacific Saury; *Cololabis saira*; Pacific Saury AND Eastern AND Pacific.

DFO library collections available online were searched, including: WAVES; Contractor Reports; Data Reports; Industry Reports; Manuscript Reports and; Technical Reports.

Reports searched included:

- Contractor reports (1-56)
- Data Reports
    - Fisheries and Marine Service Data Records (1-25)
    - Fisheries and Marine Service Data Reports (26-160)
    - Canadian Data Reports of Fisheries and Aquatic Sciences (161- 1238)
- Industry Reports
    - Project Reports/Canada. Dept. of Fisheries Industrial Development Service (1-26)
    - Project Report Series of the Industrial Development Branch (27-56)
    - Technical Report/Canada Fisheries and Marine Service Industrial Development Branch (57-88)
    - Technical Report Series of the Fishermen's Services Branch (89-91)
    - Fisheries and marine Service Industry Reports (92-110)
    - Canadian Industry Reports of Fisheries and Aquatic Sciences (111-289)
- Manuscript Reports-Fisheries
    - Manuscript Reports of the Biological Stations (1-639)
    - Manuscript Report Series (Oceanographic and Limnological) (1-229)
    - Manuscript Report Series (Biological) (640-900)
    - Manuscript Report Series (Fisheries Research Board of Canada) (901-1424)
    - Fisheries and Marine Service Manuscript Reports (1425-1550)
    - Canadian Manuscript Reports of Fisheries and Aquatic Sciences (1551-2995)
- Technical Reports-Fisheries
    - Technical Reports (Fisheries Research Board of Canada) (1-456)
    - Technical Reports (Canada Fisheries and Marine Service Research and Development Directorate) (457-714)
    - Fisheries and Marine Service Technical Reports (715-923)
    - Canadian Technical Reports of Fisheries and Aquatic Sciences (924-2993)

- Technical Reports- Hydrography and Ocean Sciences
    - Canadian Technical Reports of Hydrography and Ocean Sciences (1-274)

Search terms used in WAVES included: *Cololabis saira*; Pacific Saury; stomachs AND saury; stomachs AND groundfish; stomachs AND pelagics; stomachs AND *Clupea pallasii*; stomachs AND *Merluccius productus*; fur seal AND stomach; seabird; bird AND diet. All DFO reports pertaining to anything marine on the west coast of Canada were searched for the terms: saury; Pacific Saury and; *Cololabis saira*. In addition, one word in each title was searched to ensure the search function was working.

All Canadian Science Advisory Secretariat publications were searched for Gillespie; squid; Hargreaves; saury; *Cololabis saira*; hake; plankton; sablefish and; herring.

Survey databases

DFO has a number of different survey databases most of which are not linked together; additionally, individual research groups may have their own databases which are not included, for example, in the survey databases. An email was sent to all staff located at Fisheries and Oceans Canada's Pacific Biological Station and South Coast offices in Nanaimo asking them for their help in providing data on Pacific Saury within the scope of their own work. All leads were followed up, resulting in further contact with individuals as well as other research teams. Contact people for each of the small pelagics, recreational salmon fishery and whaling databases were asked to search for any records of *Pacific Saury*. The groundfish database was searched for both *Pacific Saury* and *Sauries* (no specified species). The catch data supplied were extracted from several databases with varying degrees of complexity and varying sources.

Research groups/teams

There are several groups at DFO who conduct, or did conduct, scientific research without direct application to specific stock assessments. The first group led by Dr. Dick Beamishincluded Dr. Ruston Sweeting and Ms. Chrys Neville. The second group led byDr. Marc Trudel was the High Seas Salmon Research group. Both groups were asked to check their databases for records of Pacific Saury.

Individual accounts

Anecdotal information has also been included in this report as it became clear that few data collected by DFO are available on this species in Canadian or adjacent waters. It was also important to provide an opportunity to capture accounts of incidental occurrences with the species which would not have been captured in any database. Equally important is knowing when the species was not encountered. Many of the experts questioned have considerable numbers of years in the field making it valuable to include whether or not they have encountered Pacific Saury. These anecdotes may help inform future research into the species.

RESULTS

Literature search

A search of the primary literature resulted in a large number of papers on Pacific Saury in non-Canadian waters. The majority were from studies conducted in the western Pacific Ocean and the remainder from those captured in United States waters. Because the goal of this project was to determine what information and data are available specific to Canada this literature has not been included in this report.

The WAVES search did produce some interesting results although again, the documents were not specific to the species in Canadian waters. There were 7 translation documents (Ayushin et al., 1967; Sololovskii, 1971; Kizevetter et al., 1975; Novikov, 1972, 74, 75; Miklukhina, 1973) from the Fisheries and Marine Service Translation Series and Fisheries Research Board of Canada Translation Series which provide considerable information on Pacific Saury in the western Pacific Ocean with some information on those in the California Current. These documents are mentioned because they were significant enough to be translated by the Canadian Government from Russian to English and may be difficult to find in the future. All of the translated documents were TINRO publications and focused mainly on the biology, ecology and populations structure of Pacific Saury.

There were three other documents from the WAVES search which provided general information on the species found primarily in US waters. The first document was an Oregon State University Bulletin reviewing stocks, harvesting techniques and processing methods of Pacific Saury (Inoue & Hughes, 1971). The other two documents were US Fish and Wildlife Service Reports (Hughes, 1970; Ahlstrom & Casey, 1956). Hughes (1970) provides an annotated reference on Pacific Saury, which although now outdated, was extensive for the time. The second report (Ahlstrom & Casey, 1956) provides a summary of the distribution and abundance of the species on the eastern Pacific coast between 1950 and 1955. It does not appear that there are any data within Canadian waters.

DFO data, technical and manuscript reports proved to be the greatest resource for Pacific Saury information, albeit limited. Several thousand reports were first screened based on location of study, then hundreds of those were searched for the key words. Because it was believed that the species would only be mentioned as ancillary to the main subject, it was not possible to screen out any documents of a particular species or gear type. For instance Pacific Saury is mentioned in a flying squid (*Ommastrephes bartrami*) report (Jamieson & Heritage, 1988) as well as a sablefish (*Anoplopoma fimbria*) study (Kennedy & Pletcher, 1968). Of the hundreds of documents searched, only 21 mentioned Pacific Saury. These are summarized in an annotated bibliography provided in the references section.

In general it can be said that very little information or data have been compiled on Pacific Saury specific to Canada and that reference to Pacific Saury in DFO reports is incidental to the study of other species. A table has been created to illustrate the types of information available in these reports (Table 1). The oldest DFO documents mentioning Pacific Saury were published in 1959

(Pike et al., 1959; Ricker, 1959); the most recent were published in 2009 (Olsen et al., 2009; Thompson & Therriault, 2009). Of these 21 documents, one (Panina, 1966) was a translation document from a Pacific Research Fisheries Centre (TINRO) publication and referred to Pacific Saury in the western Pacific Ocean. Of the remaining 20 documents, the subject matter is as follows: Pacific herring (N=3), marine mammals (N=6), squid (N=3), Pacific salmon (N=2), groundfish (N=2), sablefish (N=1), database (N=1), commercial fishery summary (N=1), Bowie Seamount (N=1).

The majority of reports referred to Pacific Saury in the context of stomach contents of other species (12/21 documents) while only 9 of 21 documents referred to the species itself, outside of this context (Table 1). There were several documents which provided numerical data on Pacific Saury (Table 1), the most significant ones were: Cooke (1991); Olsen et al. (2009); Thompson & Therriault (2009); Jamieson & Heritage (1987, 1988) and; Workman et al. (2007).

Quite commonly the reference or notation (Table 1) to Pacific Saury would be in the form of a statement or presence of the species, with no numerical data; for example, Bernard (1981) states "The most abundant remains found was myctophids (lanternfish), followed by *Cololabis saura [sic]* (saury)…" or Pike et al. (1960) "Stickleback, sandlance, small sablefish and saury remain at approximately the same relatively low level of occurrence…"

Table 1: Summary of types of information available in DFO reports containing the words *Pacific Saury* and/or *Cololabis saira.*

Author(s)	Year	Focus	Reference to Pacific Saury		Notation	
			Stomach contents	Species	Data	Presence\ statement
Bernard	1981	Squid	√			√
Canessa et al.	2002	Bowie seamount		√		√
Cooke	1991	Pacific salmon and other species		√	√	
Gregr	2004	Marine mammals	√			√
Healey	1976	Pacific salmon	√			√
Jamieson & Heritage	1987	Squid		√	√	
Jamieson & Heritage	1988	Squid		√	√	
Kennedy & Pletcher	1968	Sablefish	√			√
MacAskie	1969	Fur seal	√		√	
Nichol et al.	2002	Database	√			√
Olsen et al.	2009	Groundfish		√	√	
Panina	1966	Fur seal	√		√	
Pike et al.	1959	Fur seal	√		√	
Pike et al.	1960	Fur seal	√			√

Pike et al.	1963	Fur seal	√			√	
Ricker	1959	Commercial fisheries	√				√
Spalding	1964	Marine mammals	√			√	
Taylor et al.	1970a	Pacific herring		√			√
Taylor et al.	1970b	Pacific herring		√			√
Thompson & Therriault	2009	Pacific herring		√		√	
Workman et al.	2007	Groundfish		√		√	

Survey databases

Database extractions were made from juvenile herring, groundfish, salmon, whaling and sardine databases, and are subject to the three party/vessel rule to abide by the Privacy Act.

Groundfish database

Individual groundfish databases have been grouped together into one large database. Within this overarching database can be found both biological as well as commercial catch information for groundfish species. Ms. Kate Rutherford queried the database for references to *Pacific Saury* and *Sauries*, as well as provided a detailed description of these databases.

The trawl database (PHT) contains a merge of at-sea observer logbook data and dockside monitoring program data. From 1997 to 2007 there were 77 records of Pacific Saury, all of which attributed to the observer logbook database. All of the records were of fish captured in a standard bottom trawl, none of the fish were landed. Weight was recorded as was the depth and fisheries management area. A total of 117.2 kg of Pacific Saury were captured by commercial fisheries during that time period.

The trawl database (FOS trawl) from 2007 to present contains the same sources of data as the PHT database however, the data are from an unmanaged dataset. There were 90 records of Pacific Saury in this database, 89 of which were attributed to the groundfish trawl sector with data spanning 2007-2014; 1 record from the halibut fishery in 2006. A mix of gear type was reported with the majority of records coming from bottom trawl gear. Weight was recorded as was the depth and fisheries management area. A total of 90.5 kg of Pacific Saury were capture by commercial fisheries during that time period.

The sablefish database (PHS) extends from 2000 to 2006. They are a merge of logbook data and dockside monitoring program data. There were 5 entries for Pacific Saury in this database, one record from 2003, the remaining from 2004; all gear type used was longline. Weight was recorded as well as fisheries management area. A total of 17 kg of Pacific Saury were capture in commercial fisheries during that time period

The biological database (GFBIO) contains catch and biological data derived from research trips. These two types of data appear separately. 107 records of Pacific Saury were found in the biological data from 1991 to 2009; 100 of the 107 records were from 1 set from the *CCGS W.E. Ricker* in 2001 in Fisheries Management Area 127-4. Individual fork lengths were provided. The

catch portion of this database contains 18 entries for Pacific Saury. These are from a mix of gear type including bottom trawl, midwater trawl and trap. The information provides greater detail regarding fishing information but less detail with respect to the individual fish.

Line gears database (FOS non-trawl) extends from 2006 to present. This database is a merge of logbook data as well as dockside monitoring program data. The data are considered an unmanaged dataset. No records of Pacific Saury were found in this database.

Small pelagics database

Sardine research survey data have been collected off the west coast of Vancouver Island since the late 1990s and since 2006 night surveys have also taken place. Due to limited resources in recent years, there is no longer a targeted sardine survey, instead the survey is for small pelagics. Ms. Vanessa Hodes has checked the Sardine Trawl Survey Database for the west coast of Vancouver Island for Pacific Saury. There are only three occurrences of Pacific Saury in the database: July 31st, 2008 which records a "trace"; August 3rd, 2008, 1 individual and; August 14th 2013, 1 individual. All of these tows occurred at night.

There is also a separate Pacific herring database specific to La Perouse Bank. Dr. Jennifer Bolt has checked that database for records of Pacific Saury and has found none. There is also a central coast Pacific herring survey database which was searched by Mr. M. Thompson for presence of Pacific Saury. The extraction from the database provides length and weight data on individual specimens. A summary of these data are also presented in Thompson & Therriault (2009) and have been summarized in the annotated bibliography of DFO reports.

Historical Whaling Database

A whaling database has been created and is housed at PBS. A thorough description of the contents of this database can be found in Nichol et al. (2002). Pacific Saury is a category used in the description of diet composition. Ms. Linda Nichol from the PBS Marine Mammal Group has searched the database for mention of Pacific Saury. There were 41 accounts of Pacific Saury found between 1962 and 1967. All of these records were in reference to stomach contents of sei whales (*Balaenoptera borealis*) as either "trace" or "present'. The length and sex of the whales as well as location were recorded.

Catch and Release Estimate Tool

The recreational fishing database, Catch and Release Estimate Tool (CREST) is maintained by the South Coast Salmon Stock Assessment group in Nanaimo. This database contains creel survey data and estimates from when the survey began in 1980 to present. Mr. Dave O'Brien searched the database for reports of Pacific Saury and found none.

Research groups/teams

The High Seas Salmon Research Group ran a query in their database for Pacific Saury. There are more than 380 fork lengths available for Pacific Saury for 6 different time periods beginning August 23rd, 2002 and ending October 21st, 2013. The database was searched from 2000 to 2013. The regions surveyed and represented in this query include: Washington, Vancouver Island, south east Alaska, Queen Charlotte Sound and Queen Charlotte Strait, Hecate Strait, Dixon Entrance, inside south east Alaska and British Columbia, Juan de Fuca and inside Vancouver

Island. The main objectives of the High Seas Salmon Program surveys are to collect information on the distribution and ecology of Pacific salmon; collect data on ambient oceanographic conditions and; collect data on the distribution and biomass of zooplankton (Morris et al., 2010). This work is conducted with a mid-water trawl with either a commercial fishing vessel or a government research vessel. The program has been ongoing since 1995 (Morris et al., 2010). To date there are no published reports available from this group referring to Pacific Saury.

Dr. Beamish's research group queried their Strait of Georgia/Juan de Fuca Sound database and did not find any reference to Pacific Saury. This survey has been conducted twice annually in June/July and September beginning in 1998 and continues today. Dr. Beamish's group also performed surveys off Bowie Seamount. It was reported, anecdotally, that Pacific Saury were present in the vicinity of Bowie Seamount although it was not possible to retrieve the data through the Access database during our review.

Individual accounts

Several other anecdotal accounts were also received from individuals and have been synthesized in this report. These accounts may prove useful in planning future research activities on Pacific Saury in Canadian waters.

Seabirds

Some marine seabird species are known to eat Pacific Saury. Dr. Ken Morgan from Environment Canada and Dr. Mark Hipfner from the Canadian Wildlife Services were contacted and asked whether they had any firsthand knowledge of any data available or databases. They did not know of any databases pertinent to marine seabird predation. In reference to Pacific Saury, Dr. Hipfner stated that "they are regular in the diets of rhinoceros auklets but their importance varies from year to year", as presented in Thayer et al. (2008).

Pacific salmon

In reference to pelagic salmon trawl survey, Dr. Strahan Tucker (DFO) stated that, "Saury is something that very rarely comes aboard".

Groundfish

Ted Sweeten recalls that during Pacific Hake and Humbolt Squid surveys from August 12 to September 8, 2009 they landed large catches of Pacific Saury during their night tows. It is believed that a search of the groundfish database will be able to find these accounts. Dr. Sweeten believed that a squid report had been written by Gillespie and Norgard, however upon contact, Gillespie confirms no report has yet been written.

Mr. Malcolm Wyeth, a biologist with the groundfish section of the Marine Ecosystem and Aquaculture Division at PBS has reported that Pacific Saury do wash up on deck during Sablefish surveys. They may or may not be accounted for in the groundfish database.

George Cronkite recalls that during the 2007 Pacific Hake survey, Pacific Saury were observed at night in the surface waters off the west coast of Vancouver Island while they were fishing for squid. These data may have been recorded in the groundfish database.

Other

Ken Cooke provided a very descriptive account of catches of Pacific Saury he and his team encountered while fishing with a Bernard-Sigmund surface trawl during surface zone sampling. The type of gear allowed for the collection of many different species, including Pacific Saury. Cooke states "I recall our first encounter with this species was related to a complete change in ocean conditions…If I remember correctly, all saury were caught north of Brook's Penninsula and nothing south." Their catches were so great that they had to reduce fishing effort in order to keep up with sampling and reduce mortalities. He said "I made note of the significant numbers to Dick Beamish when we returned to PBS and I recall him commenting on how little was known about one of the most abundant species on our coast and trophically, one of the most important." Cooke hypothesizes that Pacific Saury are more common off northern Vancouver Island and Haida Gwaii and are highly associated with the upwelling zones at the shelf edge.

Ms. Carol Cooper from Zotec Services was contacted to see if she had any recollection of Pacific Saury during her more than 27 years of on-board stomach analysis. Ms. Cooper has analyzed over 65,000 stomachs from species such as Pacific Herring, Pacific salmon, sardines, dogfish, Walleye Pollock and Pacific Hake. She has performed plankton analysis on both freshwater and marine samples collected from lakes in BC and marine samples from the Strait of Georgia Puget Sound and all the way to Bowie Seamount. Ms. Cooper has not encountered Pacific Saury during any of this work.

Bruce McCarter from DFO received an inquiry from a fisher who caught a Coho Salmon off Skidegate Point (Tcenakun Point in Cartwright Sound) with what was later identified as Pacific Saury in its stomach. The coho salmon was captured in September 2013 in 90ft of water in Tana Bay. Further inquiry determined that Pacific Saury had been observed "skipping" out of the choppy waters across from Tana Bay earlier that same summer.

Annotated Bibliography of DFO reports

Bernard, F. 1981. Canadian west coast flying squid experimental fishery. Canadian Industry Report of Fisheries and Aquatic Sciences 122: 23p.

Analysis of 200 flying squid stomachs in 1980 off Vancouver Island found that Pacific Saury was the second most abundant prey item; no abundance values or data are provided for Pacific Saury. The document is focused on the abundance of flying squid and where they were captured.

Canessa, R., Conley, K., and Smiley, B. 2003. Bowie seamount pilot marine protected area: an ecosystem overview. Canadian Technical Report of Fisheries and Aquatic Sciences 2461: xi + 85p.

This technical report provides an overview of the limited information available at the time for the Bowie Seamount ecosystem. It is a summary document and provides limited data. The ecological classification is provided based on different classification systems at international, national and regional scales. These classification systems including for instance the International Union of the Conservation of Nature (IUCN) (international level), Parks Canada National Marine

Conservation Are Natural Regions (national level), Large Ocean Management Areas (LOMA (national), and British Columbia Marine Ecological Classification (BCMEC) (regional). Under the BCMEC, there is a description of features including, physiography and oceanography. Pacific Saury are listed as a component of the biological features. This is the only mention of Pacific Saury in this document.

Cooke, K.D., Waddell, B.J., and Groot, C. 1991. Data record of juvenile salmonids and other fish species captured by surface trawl off coastal British Columbia in August, 1988 and September, 1990. Canadian Data Report of Fisheries and Aquatic Sciences 837: 79p.

This data report provides information on species captured by surface trawl in Queen Charlotte Sound, off the west coast of Vancouver Island and, Queen Charlotte Islands in August 1988 and September 1990 using a Bernard-Sigmund beam trawl. Biological data such as length, sex and stomach contents are reported, with a focus on collecting data on juvenile salmon predators. A detailed description of the fishing methodologies is provided in the data report. Fishing occurred at 1700h and continued throughout the night until 0600h. Total numbers of species were recorded or estimated when abundant based on number or weight. Fork lengths were also recorded. Because Pacific Saury, Pacific Herring and lanternfishes were captured "in abundance", mean length and total catch were estimated from sub samples. Length frequencies for Pacific Saury in 1988 and 1990 are provided and can be found in Tables 8 and 9. Table 10 provides a statistical summary of total catch length frequency distribution. For Pacific Saury in 1988, of 188 samples examined, the mean length was 206.0 mm and length ranged from 145 to 304 mm. In 1990, the sample size was 4,999, mean length 209.9 mm and length ranged from 125-454 mm.

A map of catch per set is provided for Pacific Saury for 1988 and 1990 in Figure 10. Individual set data are also provided from which it is possible to determine the sets in which Pacific Saury were captured (Table 3, 1988, Table 4, 1990). Table 5 provides a summary of total catch by species by location for both 1988 and 1990. Here it is shown that overall off the west coast of Vancouver Island in 1988, 5354 Pacific Saury were captured over a 170.5hr time period. In 1990, there were 15,994 Pacific Saury captured over 375.95 fishing hours over the entire study area.

This data report represents the most significant Pacific Saury reference found.

Gregr, E.J. 2004. Marine mammals in the Hecate Strait ecosystem. Canadian Technical Report of Fisheries and Oceans Sciences 2503: 56p.

Pacific Saury is discussed within the context of marine mammal diets. The information is not new data but summarized from other publications with application to marine mammals which would or could be present in Hecate Strait. Some of the references cited are specific to animals found at some point in their life history in British Columbia waters.

Healey, M.C. 1976. Herring in the diets of Pacific salmon in Georgia Strait. Fisheries Research Board of Canada Manuscript Report Series 1382: 38p.

This manuscript report describes the diet of anadromous Pacific salmonids from the Strait of Georgia examined between 1960 and 1970 with particular emphasis on the importance of Pacific herring. The reason for the work was to address the Pacific herring component of the interrelationships among Pacific Herring, salmons and dogfish. At the time, there was only diet information available for Chinook and Coho Salmon in the Strait of Georgia, not for Pink, Chum and Sockeye Salmon. Only salmon over 30 cm fork length were examined. With reference to Pacific Saury, no data are provided. However, a summary of the literature on diet composition of salmon greater than 30 cm does mention that Pacific Saury is a component (assume trace) of Coho Salmon in the North Pacific Ocean (Grinols and Gill, 1968); it is a component of Chinook Salmon diet as presented in Merkel (1957), Coho and Chinook Salmon diet by Prakash (1962); it is listed as a component of Coho but not Chinook Salmon diet by Pritchard and Tester (1944). No further information is provided.

Jamieson, G.S., and Heritage, G.D. 1987. Experimental flying squid fishing off British Columbia, 1985 and 1986. Canadian Industry Report of Fisheries and Aquatic Sciences 179: 103p.

This report details all species captured during an experimental squid fishery in British Columbia in 1985 and 1986. Pacific Saury is listed as one of the species captured during this fishery. Data are provided from each vessel for the year and include average weights and measured average weights, including those for Pacific Saury. Total catch by species and the proportion of the total catch for each species by vessel was also calculated; values are available for Pacific Saury. The counts however are very small, varying from 1 to 14. Individual set data and CPUE are also provided to the species level.

Jamieson, G.S., and Heritage, G.D. 1988. Experimental flying squid fishing off British Columbia, 1987. Canadian Industry Report of Fisheries and Aquatic Sciences 186: 79p.

This report details all species captured during an experimental squid fishery in British Columbia in 1987. Pacific Saury is listed as one of the species captured during this fishery. Data are provided from each vessel for the year and include average weights and measured average weights including Pacific Saury. Total catch by species and the proportion of the total catch for each species by vessel was also calculated; values are available for Pacific Saury. Individual set data and CPUE are also provided to the species level.

Kennedy, W.A., and Pletcher, F.T. 1968. The 1964-65 sablefish study. Fisheries Research Board of Canada Technical Report 74: 24p.

This report examines data collected on sablefish on numerous surveys in 1964 and 1965 from many different locations including but not exclusive to Gulf of Alaska, Smith Sound, west coast of Vancouver Island and Queen Charlotte Sound. Data reported were basic biological measures including lengths, weights, age and stomach contents. There was only one mention of Pacific Saury and that was in relation to stomach contents. However, this notation was not specific to the

surveys described in the report but rather to "accumulated causal records" from "files". The specific notation states "Herring was the predominant fish eaten but saury, sandlance, and ocean perch were recorded and sablefish heads noted."

MacAskie, I.B. 1969. Report on Canadian fur seal research in 1969. Fisheries Research Board of Canada Manuscript Report Series 1066: 20p.

1969 marked the twelfth consecutive year of fur seal research in response to the ratification of the Interim Convention on Conservation of the North Pacific Fur Seals in 1957. This manuscript report provides the results of the Canadian research for 1969. Continued presentation of biological and distributional data were provided. Between April and May 1969, 291 fur seals were hunted and sampled between latitudes 46°30'N and 49°00'N. 148 of the 291 stomachs examined contained food. The only records of Pacific Saury were from 3 stomachs out of a total of 54 examined taken from the area between Cobb Seamount and the 1000 fathom contour from the 7-9th of May and 20-23rd of May 1969. Of these 54 stomachs sampled from this area, 39 contained food, with squid occurring in all of these 39 stomachs.

Nichol, L.M., Gregr, E.J., Flinn, R., Ford, J.K.B., Gurney, R., Michaluk, L., and Peacock, A. 2002. British Columbia commercial whaling catch data 1908 to 1967: A detailed description of the B.C. historical whaling database. Canadian Technical Report of Fisheries and Aquatic Sciences 2371: vi + 77p.

This report provides a good description of the contents of the BC Historical Whaling Database. No data are provided in the report however, Pacific Saury are mentioned as they have created a species code used in the database. This information was valuable as it led to the searching of the database itself.

Olsen, N., Rutherford, K.L., Stanley, R.D., and Wyeth, M.R. 2009. Queen Charlotte Sound groundfish bottom trawl survey, July 7th to August 8th, 2009. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2899: vi + 61p.

This manuscript report is a summary of the 2009 demersal trawl survey off Queen Charlotte Sound and Hecate Strait. This series of surveys first began in 2003 with the objective to provide fishery independent abundance indices of all the demersal fish species captured. In addition biological and oceanographic data were collected. Between July 7th and August 8th 250 tows were made with an average of 17 species of fish and invertebrates captured per tow. Pacific Ocean Perch was the most abundant species captured. Pacific Saury is only mentioned twice in this document. It was captured in 2 tows with a total catch weight of 0.5kg, a maximum of 0.3kg and mean weight of 0.2kg and, a biomass calculated at 0.3 tonnes. One sample of 6 specimens of Pacific Saury was examined for biological attributes, only length was recorded. The minimum length was 23 cm, maximum 24 cm and mean 23 cm.

Panina, G.K. 1966. Food of fur seals in the western part of the Pacific Ocean. Fisheries Research Board of Canada Translation Series 766: 28p.

This report is a translation of a document from a TINRO publication in 1966. The work was undertaken in response to the ratification of the Interim Convention on Conservation of the North

Pacific Fur Seals in 1957 by Canada, Japan, the USSR and USA. The work specifically targets the diets of fur seals in commercially important areas of the western Pacific Ocean. It was found that between March and April, fur seals fed only at night or early morning hours when surface water temperatures were "not high" and the migration of pelagic fish species such as anchovies and Pacific Saury had not yet begun. This particular eating pattern is believed to be specific to the environmental conditions of the area. Between 1958 and 1963 (March to June), Pacific Saury were found in only 5 stomachs and only in June. It is difficult to determine how many stomachs were sampled at a given time based on the information provided. However, it was summarized that fish of commercial value such as mackerel, anchovies and Pacific Saury made up only 7% of the total volume of fish consumed and were found in only 54 of 2611 stomachs examined, most likely between 1958 and 1963. The justification for low prevalence of Pacific Saury was that optimal temperatures for Pacific Saury range from 14-18°C and fur seals avoid areas where water exceeds 11-12°C.

Pike, G.C., Spalding, D.J., MacAskie, L.B., and Craig, A. 1959. Preliminary report on Canadian pelagic fur seal research in 1959. Fisheries Research Board of Canada Manuscript Report Series (Biological) 629: 64p.

Following the ratification of the Interim Convention on Conservation of the North Pacific Fur Seals in 1957 by Canada, Japan, the USSR and USA, each nation undertook studies prescribed in the Convention. This report summarizes the Canadian research efforts in 1959. Studies were undertaken from the Columbia River to Kodiak, Alaska from February to July in coastal waters. Over this time period, 491 fur seals were hunted and sampled. Between January 26 and February 4, 27 fur seals were collected in Knight Inlet and Johnstone Strait of which 25 were yearlings, 1 was a two year old and one a mature female. Stomach content analysis showed "Whiting, sablefish and saury contributed 95 % to the total volume of food".

When comparing age classes, small schooling fish such as Pacific Saury, stickleback, Osmeridae and Clupeidae are a consistent part of the diet of all age groups and have approximately a 50% frequency of occurrence. Diet composition appears to vary significantly between years for many species including Pacific Saury. It was not identified in stomach contents in 1935 or 1959 as it was presumed the species did not move into the waters from which fur seals were sampled however it was identified in 1958 (4.3% by volume). In 1958, saury and eulachon constituted 10% of the total volume of stomach contents from animals sampled from Washington and Oregon; in 1959 they were "unimportant" in the diet.

Pike, G.C., Spalding, D.J., MacAskie, I.B., and Craig, A. 1960. Report on Canadian pelagic fur-seal research in 1960. Fisheries Research Board of Canada Manuscript Report Series (Biological) 700: 109p.

This report is a continuation and expansion of the work conducted and described previously in Pike et al. (1959). Although no data on Pacific Saury are presented in this report, the authors re-iterate the conclusion that small fish such as stickleback, sandlance, small sablefish and Pacific Saury are present in relatively low levels (15-20%) in the diets of all age classes of fur seals.

Pike, G.C., Spalding, D.J., MacAskie, I.B., and Craig, A. 1963. Report on Canadian pelagic fur seal research in 1963. Fisheries Research Board of Canada Manuscript Report Series (Biological) 761: 32p.

This report is a continuation of the work described in Pike et al (1959, 1960). There is however further synthesis and analysis of the time series collected to date in addition to considerable reporting on reproductive condition of specimens. The description and data specific to Pacific Saury are however reduced. There is only one mention of the species a table showing the incidence of food in stomachs on 22nd May 1958, 9th June 1959 and 15th June 1963 according to time of day. Pacific Saury and Pacific herring were the chief food items with an average volume of food per cc of 789. Fish were landed between 0500 and 0700 in the morning. Of the 3 specimens examined, 100% had food in their stomachs.

Ricker, W.E. [Ed]. Survey of Canadian fisheries. 1959. Fisheries Research Board of Canada Manuscript Report Series (Biological) 675: 285p.

This manuscript report was a collaborative effort between biologists of the (then) Fisheries Research Board of Canada and the provinces of BC, Alberta, Saskatchewan, Manitoba, Ontario, Quebec and Newfoundland, compiled and edited by Dr. Ricker. It provides survey information on fisheries throughout Canada with the goal of answering the request to provide information on the present state and future development of fisheries in Canada. This report provides an interesting summary of current stock assessment tools and needs for the future. Pacific Saury is mentioned only twice. Once, in a list of miscellaneous pelagic fishes along with Pacific mackerel, jack mackerel and ragfish. The second instance is in the discussion of this group of fishes as a whole, where their presence is acknowledged off the west coast of Vancouver Island because they were mixed in catches of pilchards or in stomachs of sperm whales. It is acknowledged that information their abundance is lacking however "…one or more may eventually support a commercial fishery…." No data are provided.

Spalding, D.J. 1964. Comparative feeding habits of the fur seal, sea lion and harbour seal on the British Columbia coast. Fisheries Research Board of Canada Bulletin 146: 52 p.

This report summarizes biological information on marine mammals of significant concern to commercial fish stocks in BC. As a part of this summary, stomach contents of 2113 fur seals, 393 sea lions and 126 harbour seals were examined. Pacific Saury was mentioned as being a component of fur seal stomach contents in March, April, May and June in a total of 15 individual animals (ranges from 1 to 7 animals per area) out of a possible 2,112 animals. The study period extended from the end of January to the end of June. There were no records of Pacific Saury in the stomach contents of either harbour seals or sea lions.

Taylor, F.H.C., Barner, L.W., and Miller, D.C. 1970a. The British Columbia offshore herring survey, 1969-70. Report on cruises SK 69-4, -5, and -6. Fisheries Research Board of Canada Technical Report 177: 72p.

This report presented preliminary results of three offshore Pacific herring surveys conducted off the west coast of Vancouver Island, Hecate Strait and Queen Charlotte Sound in 1969.

Midwater trawls were made at dawn, noon and dusk each day in addition to whenever concentrations of fish were found on the echo sounder. In addition to reporting basic biological information on the target species, catch by species is also provided. Between 30 and 40 albacore tuna were captured over deep water offshore of La Perouse Bank and stomach contents noted. In the catches that had albacore tuna with stomach contents, there were also "a few" Pacific Saury reported along with euphausiids, rockfish larvae, lanternfish and squid, but no Pacific Herring. This is the only mention of Pacific Saury in this report, no data are provided.

Taylor, F.H.C., Barner, L.W., and Miller, D.C. 1970b. The British Columbia offshore herring survey, 1969-70. Report on cruises SK 69-7, -8, -9, and -10. Fisheries Research Board of Canada Technical Report 183: 60p.

This report presents results on a modification of a long standing Pacific Herring survey for the purposes of establishing the relationship between standard, fork and total lengths in and between fresh and frozen fish. The surveys all took place between the end of October and mid December 1969. Four locations were surveyed including the lower and east coast of Vancouver Island, west coast of Vancouver Island and Hecate Strait. The lower west coast of Vancouver Island location 29 tows were made, 5 of which were oblique tows from 100 fathoms to the surface. Only 1 of the 5 oblique tows contained fish, this tow yielded 2lb of juvenile anchovies, 3lb of lanternfish and a "trace" of saury. While hauling in the gear on this one haul it was reported that "…sauries were seen boiling around the ship". This is the only mention of Pacific Saury in this document.

Thompson, M., and Therriault, T.W. 2009. Central coast juvenile herring survey, August 2007. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2867: vi + 53p.

This report summarizes the 2007 Central coast juvenile herring survey conducted at 13 locations between Meyers Passage to Rivers Inlet. The aim of the study was to address information gaps in distribution, abundance, size and feeding habits of juvenile herring in the survey area. Sixteen species were identified in the purse seine catches, the most frequently encountered being Pacific Herring. The set number, set code, station, location name, number and weight of each species are provided, including Pacific Saury. Pacific Saury is listed as being present in 3 of the 65 sets. A calculation of % occurrence was made and provided for all species reported. In addition, plankton tows and CTD casts were made.

Workman, G.D., Olsen, N., and Rutherford, K.L. 2007. West coast Charlotte Islands groundfish bottom trawl survey, August 28th to September 25th, 2006. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2804: vii + 44p.

This manuscript report is a summary of a trawl survey off the west coast of the Queen Charlotte Islands in 2006. The objective of the survey was to be able provide fishery-independent abundance indices of all demersal species captured and collect biological samples of selected species. 130 tows were made from August 28th to September 25th with an average of approximately 23 different species of fish and invertebrates per tow. Some oceanographic data were also collected. The three most abundant species of fish captured were rockfish namely, Pacific Ocean Perch, Rougheye Rockfish and Silvergray Rockfish. Pacific Saury was captured

in one tow only with a total weight of 0.1 kg. The relative abundance was calculated to be 0. This is the only mention of the species in the document.

CONCLUSIONS

Pacific Saury is an elusive fish in Canadian waters and only small catches are reported from Canadian research surveys or commercial fisheries. Saury are known to be present in the stomachs of sea birds, whales and some fish species. They have been found in association with large abundances of Humbolt Squid and as stomach content of Neon Flying Squid and some fish species.

Trawls appear to be the most frequent method of capture for Pacific Saury based on the incidences of Pacific Saury in the DFO databases and reports. In addition, there may be reason to believe that nighttime fishing may result in greater capture success. Indeed, commercial fisheries in the western Pacific Ocean employ high powered lights to attract and harvest Pacific Saury at night.

The data which are available in any of DFO's reports or databases are not from surveys of Pacific Saury but provide information or data about the species because it was found as either stomach content or bycatch to the main species of study. Of the databases examined, the Groundfish Database had the greatest number of Pacific Saury records. The Historical Whaling Database only provides information on Pacific Saury as stomach content and it is recorded as either "present" or "trace". A search of both the Central Coast Juvenile Herring Database and the Sardine Trawl Survey Database shows the occasional presence of Pacific Saury in small pelagic research tows and in the former database, provides individual weights and lengths, although only for 2007.

Pacific Saury are not of commercial important for Canadian fisheries. From 1997 to 2013, 224 kg of saury were captured by Canadian commercial fisheries, and all captured saury were released. The small catches also indicate that the Canadian fishing fleet likely has a negligible influence on the status and dynamics of Pacific Saury populations.

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