NOAA Technical Memorandum NMFS-AFSC-142

Identification of Skates, Sculpins, and Smelts by Observers in North Pacific Groundfish Fisheries (2002-2003)

by
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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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ABSTRACT

Recent emphasis on ecosystem-level management of federally regulated marine fisheries, as well as a rapidly developing skate fishery in the Gulf of Alaska, has led to an increasing need for basic population data for skates (Rajidae), sculpins (Cottidae and allied families), and forage fishes (e.g., Osmeridae, Clupeidae, and Ammodytidae). Observers in the North Pacific Groundfish Observer Program could provide a wealth of such data by routinely identifying these fishes to the species level. The objectives of this project were 1) to quantify the additional time observers would require on a per-haul basis to complete species-level identifications of all skates and smelts, and genus-level identifications of selected sculpins; and 2) to develop and assess the adequacy of an introductory training presentation and a series of materials for use by observers in the field.

Over 130 returning fisheries observers were trained to identify skates, smelts, and sculpins. Once deployed, participating observers established an alternating sampling scheme of control hauls and experimental hauls. Participants completed Species Identification forms for each new species encountered and recorded species composition data in the NORPAC database. After deployment, debriefers solicited comments and constructive feedback from participants and assessed the accuracy of field identifications.

Participating observers required an average of 4.27 additional minutes per haul to complete the specific identifications. The time required was not dependent on the gear used or target of the fishery, but variation among observers and among hauls within cruise was substantial. The field identification resources and training presentation were constantly updated throughout this study to reflect participant feedback and new information. Participants were usually able to demonstrate confident knowledge of identifications during debriefings, and

geographic and bathymetric distributions obtained from study data generally did not conflict with published distributions or those obtained from bottom trawl survey data. Therefore, there were no indications of any widespread identification problems in this study.

CONTENTS

INTRODUCTION

Recent emphasis on ecosystem-level management of federally regulated marine fisheries has led to an increasing need for basic population data for species not traditionally targeted by fisheries. Many of these non-target species are relatively large, long-lived, and slow to reproduce and are therefore particularly vulnerable to fishing pressure, even if they are not directly targeted. The skates of Alaska (family Rajidae) and some genera of the sculpin families Cottidae (*Hemilepidotus* and *Myoxocephalus*) and Hemitripteridae (*Hemitripterus*) fall into this category (Zolotov and Tokranov 1989, Zeiner and Wolf 1993, Gallagher and Nolan 1999, Markevich 2000, Panchenko 2001). Skates are of particular concern due to the recent development of a commercial fishery targeting the largest of the skate species in the Gulf of Alaska near Kodiak. Additionally, many fishes – including walleye pollock and Pacific cod (Gadidae), herring (Clupeidae), smelts (Osmeridae), salmon (Salmonidae), and sandlances (Ammodytidae) – are widely recognized for their importance as forage for larger, commercially targeted fishes as well as marine mammals (e.g., Pitcher 1981, Merrick et al. 1997).

As the need for basic data on these groups of fishes has increased, researchers and fisheries managers have begun to seek additional sources of data to fill gaps in current knowledge. Currently, fisheries observers with the North Pacific Groundfish Observer Program (NPGOP) are required to identify all forage fishes except smelts to the species level, and to identify smelts, as well as skates and sculpins, only to the family level. Identification of these fishes to the species level would provide a great deal of additional species-specific population data to fisheries managers.

The objectives of this project were 1) to quantify the additional time observers would require on a per-haul basis to complete species-level identifications of all skates and smelts, and genus-level identifications of sculpins of the genera *Hemilepidotus* (Irish lords and butterfly sculpin), *Hemitripterus* (bigmouth sculpin), and *Myoxocephalus* (great sculpin, plain sculpin, etc.); and 2) to develop and assess the adequacy of a field guide to the skates of Alaska, a key to the smelts of Alaska, and a key to selected genera of North Pacific sculpins for use by observers in the field, as well as a training presentation to introduce these materials.

MATERIALS AND METHODS

This project focused on observers with prior experience who returned for briefing at the Seattle office from July 2002 through March 2003. An attempt was made to train observers being deployed in as many different fisheries and seasons as possible. The training consisted of a 45-minute lecture session followed by a hands-on laboratory session with preserved specimens. The training session covered the project protocol (Appendix A) and tools, as well as the morphological features important in species-level identification of the skates and smelts and genus-level identification of species of *Hemilepidotus*, *Hemitripterus*, and *Myoxocephalus* likely to be encountered in commercial fisheries. Observers trained in this project were issued a Field Guide to the Skates of Alaska (Appendix B), a Key to the Smelts (Appendix C), and a Key to Selected Genera of North Pacific Sculpins (Appendix D). These materials were generated for this project and were continually updated and refined throughout the duration of the project.

Once deployed at sea, observers were instructed to establish a block of approximately 40 hauls during which to perform this project. Observers were instructed to employ an alternating sampling scheme to produce a series of experimental hauls and a parallel series of control hauls. During the designated block of hauls, species composition of the subsample was determined using standard procedures (AFSC 2003) for the first haul (with skates, smelts, and sculpins identified to the family level), and the time required to perform these identifications was estimated by the observer and noted on a Species Identification Time Form (Appendix E). For the next haul, and alternating subsequent hauls within the project block, all skates and smelts were identified to species and the selected groups of sculpins were identified to genus. The time to perform these identifications was estimated by the observer and noted on the Species Identification Time Form. Each participant thereby recorded a baseline series of identification times under control circumstances (Non-project hauls) and a parallel series of identification times including the experimental identification responsibilities (Project hauls). Species composition data were entered into the NORPAC database using species codes established for the project (Appendix F).

Quantitative analysis of observer effort was accomplished by compiling the identification times reported by participants for both Project hauls (identification of skates and smelts to species and sculpins to genus) and Non-Project hauls (identification of skates, smelts, and sculpins to family). Mean identification time per haul was computed for Project and Non-Project hauls for each gear type and target species. Species composition data were retrieved from the NORPAC database for all project participants.

Several approaches were used to assess the field guide and keys used to identify skates, smelts, and sculpins. Species Identification Time Forms included a “comments” field, in which participants were encouraged to describe any problems encountered while using the keys and field guide. Participants were also asked to identify any problems to their in-season advisors during deployment, and to their debriefers after deployment. Collection of specimens was encouraged whenever possible, and completion of a Species Identification Form was required each time a previously unidentified species was encountered. A new Species Identification Form for skates was generated for this project (Appendix G), and several copies were issued to each observer during training. Finally, haul position and fishing depth data recorded for target species during this project were compiled and compared with geographic and bathymetric distribution data from recent Resource Assessment and Conservation Engineering (RACE) Division groundfish bottom-trawl surveys (1999-2003). Due to factors such as differences in seasonality of collections and the variety of gear types used in observed fisheries, RACE bottom-trawl surveys are not directly comparable with observer data as discussed below. However, these surveys have produced the most detailed and accurate distribution data available for non-commercial species in Alaskan waters and were therefore used along with published distributions (Mecklenburg et al. 2002) to help identify potential inconsistencies and misidentifications. Identifications were assessed by the author and NPGOP debriefers using Species Identification forms, interviews with observers, and collected specimens.

RESULTS

A total of 131 observers were trained in this project from July 2002 through March 2003. Of those trained, 67 submitted identification time data for a total of 1,917 hauls sampled. The distribution of effort represented by these hauls is summarized in Table 1. Most observer effort was distributed among the three major gear types (29% bottom trawl, 40% longline, and 30% pelagic trawl), but pot gear was represented by very few hauls (1%). Pacific cod (*Gadus macrocephalus*) fisheries accounted for nearly half (47%) of the sampling effort, while walleye pollock (*Theragra chalcogramma*) fisheries accounted for 30% and flatfish (primarily yellowfin sole, *Limanda aspera*, rock soles, *Lepidopsetta* spp., and flathead sole and Bering flounder, *Hippoglossoides* spp.) fisheries accounted for 18%. Atka mackerel (*Pleurogrammus* *monopterygius*), Pacific ocean perch (*Sebastes alutus*), sablefish (*Anoplopoma fimbria*), and Pacific halibut (*Hippoglossus stenolepis*) fisheries accounted for much smaller proportions of the data (4% total).

Mean identification times per haul are summarized in Table 2 and Figures 1 and 2. The overall mean identification time was significantly greater for Project hauls than Non-Project hauls ($P < .001$). The mean overall difference between Project and Non-Project hauls was 4.27 minutes, meaning that Project hauls required an average of 4.27 more minutes for specimen identification. For Project hauls, identification times were fairly consistent (approximately 15 minutes per haul) among the three major gear types and among all target species. In pot fisheries, identification times were somewhat shorter. For Non-Project hauls, identification times were more variable among gear types, with means ranging from 8.53 to 13.24 minutes per haul for the three major gear types and from 9.17 to 14.55 minutes per haul for different target species. All mean identification times were associated with large standard deviations. For all gear types except pots and all target species except the “other” category, mean identification times were significantly greater for Project hauls than for Non-Project hauls, with differences between means ranging from 0.45 to 5.91. For Project hauls, mean identification time was highest (25.4 minutes) for the first haul of the series and declined over the first four hauls before stabilizing around 15 minutes per haul (Fig. 3).

Skates, sculpins, and smelts were identified in 5,648 hauls (including 3,731 hauls for which no identification time data were collected) between 6 July 2002 and 25 October 2003. Unlike National Marine Fisheries Service (NMFS) bottom trawl survey data, which have been collected primarily during early summer, data for this project were collected throughout the year, with most effort occurring during late winter and late summer (Fig. 4). The number of hauls in which each taxon was encountered during the project and the total number of specimens of each taxon reported are summarized in Table 3, and broken down by gear type in Table 4. The Alaska skate (*Bathyraja parmifera*) was the most frequently encountered skate, and the most frequently encountered taxon overall. Other common skates included the Bering skate (*B. interrupta*) and Aleutian skate (*B. aleutica*). Sculpins of the genera *Hemilepidotus* and *Myoxocephalus* were also frequently encountered, with *Hemilepidotus* spp. often encountered in large numbers. Smelts were encountered much less frequently than either skates or sculpins. Species composition of skates was generally similar among the three major gear types, although deepwater species (e.g., Commander, roughtail, and whitebrow skates) were encountered almost exclusively in longline fisheries. One specimen of *Bathyraja lindbergi* was the only skate reported in a pot fishery. Sculpins were most abundant in the bottom trawl fisheries, although large numbers were reported in all types of fisheries. *Hemilepidotus* was the most commonly encountered sculpin genus in all types of fisheries except bottom trawls, in which *Myoxocephalus* was more common. Smelts were encountered primarily in pelagic trawl fisheries, with small numbers also being reported in bottom trawl fisheries. Eulachon was the most commonly encountered smelt species in both pelagic and bottom trawls.

Participant feedback resulted in numerous refinements in the identification materials and training presentation. Comments on Species Identification Time forms were generally positive, indicating that participants were willing and able to learn to use the identification materials quickly and efficiently. Debriefing interviews with participants indicated similar results. Negative comments generally fell into two categories: extra time required to complete project paperwork, and poor durability of the identification materials and data sheets. Specimen collections were rare, and generally consisted of problematic specimens retained for confirmation. Of approximately 10 specimens collected by participants and examined by the author, only 2 were misidentified. These two specimens were mud skates (*B. taranetzi*) misidentified as Okhotsk skates (*B. violacea*).

Project participants reported 11 of the 13 species of skates known from Alaskan waters. Skates of the genus *Raja* (big skates and longnose skates) were reported throughout the western Gulf of Alaska and into the southern Bering Sea, with some reports in the Pribilof Islands region and farther north (Figs. 5–8), and a small number of reports from the eastern Gulf of Alaska. Depth ranges for reports of big skates and longnose skates were 34–495 m and 61–391 m, respectively. The three most common species of *Bathyraja* (Alaska, Bering, and Aleutian skates) were all reported throughout the eastern Bering Sea (Figs. 9–14). Aleutian skates were also reported throughout the Aleutian Islands region and the western Gulf of Alaska. Alaska skates were commonly reported in the Aleutian Islands region, but only rarely reported from the Gulf of Alaska, and Bering skates (also known as sandpaper skates) were commonly reported from the Gulf of Alaska, but only rarely in the Aleutian Islands. All three species were reported at depths of approximately 30–700 m. Several less common species of *Bathyraja* (whiteblotched, Commander, and Okhotsk skates) were reported only from the outer shelf of the eastern Bering Sea and from the Aleutian Islands region (Figs. 15–20). The reported depth distributions of these three species were quite different. Whiteblotched skates were reported at a very broad range of depths (75–639 m), while Commander skates were reported only from deeper waters (367–828 m) and Okhotsk skates only from shallower waters (74–205 m). Roughtail, whitebrow, and mud skates were rarely reported by project participants (Figs. 21–26). With one exception, roughtail and whitebrow skates were reported only from deep longline fisheries (506–695 m and 432–716 m, respectively), while mud skates were reported from shallow depths (115–378 m) in trawl fisheries. Two species of skates known in Alaska only from deep waters, Roughshoulder skates (*Raja badia*) and deepsea skates (*Bathyraja abyssicola*), were not reported by any observers. All sculpin genera included in the study (*Myoxocephalus*, *Hemitripterus*, and *Hemilepidotus*) were reported throughout the western Gulf of Alaska, Bering Sea, and Aleutian Islands (Figs. 27–32), generally at depths of less than 200 m. The only two species of smelt that were commonly encountered were eulachon (*Thaleichthys pacificus*) and rainbow smelt (*Osmerus mordax*), and both were reported from the eastern Bering Sea and western Gulf of Alaska (Figs. 33–34). Capelin (*Mallotus villosus*) were more rarely encountered, and only in the Bering Sea (Fig. 35).

Table 1.--Distribution of hauls used to calculate mean identification times, by gear type and target species (see text for details of target species).

	Project	Non-Project	Total
Gear type			
Bottom trawl	314	235	549
Longliner	411	363	774
Pelagic trawl	362	214	576
Pot	8	10	18
Target species			
Flatfishes	192	160	352
Pacific cod	499	408	907
Walleye pollock	362	214	576
Atka mackerel	26	28	54
Pacific ocean perch	4	0	4
Sablefish	5	4	9
Pacific halibut	7	8	15
Grand total	1,095	822	1,917

Table 2.--Mean identification time per haul (in minutes) for Project and Non-Project hauls, by gear type and target species (standard deviations in parentheses), difference between Project and Non-Project means, and one-tailed P values for two sample t-test.

	Project	Non-Project	Difference	P
Gear type				
Bottom trawl	16.35 (21.17)	13.24 (20.69)	3.11	0.043
Longliner	14.44 (15.14)	8.53 (10.52)	5.91	< 0.001
Pelagic trawl	14.91 (15.72)	12.43 (13.62)	2.48	0.023
Pot	7.13 (8.36)	2.30 (2.83)	4.83	0.078
Target species				
Flatfishes	13.32 (15.63)	9.17 (15.59)	4.15	0.007
Pacific cod	15.91 (19.27)	10.25 (15.82)	5.66	< 0.001
Walleye pollock	14.91 (15.72)	12.43 (13.62)	2.48	0.023
Other	15.00 (9.14)	14.55 (8.26)	0.45	0.408
All	15.09 (17.24)	10.82 (14.98)	4.27	< 0.001

Table 3.--Number of hauls in which each taxon of skates, sculpins, and smelts was encountered during the project and total number of specimens of each taxon reported.

Taxon	Hauls	Specimens
Skates		
Alaska skate (*Bathyraja parmifera*)	2,856	21,740
Bering skate (*B. interrupta*)	575	1,999
Aleutian skate (*B. aleutica*)	414	1,816
Big skate (*Raja binoculata*)	151	915
Whiteblotched skate (*B. maculata*)	94	337
Longnose skate (*R. rhina*)	52	148
Commander skate (*B. lindbergi*)	49	269
Okhotsk skate (*B. violacea*)	42	199
Roughtail skate (*B. trachura*)	37	74
Whitebrow skate (*B. minispinosa*)	22	46
Mud skate (*B. taranetzi*)	7	8
Sculpins		
Hemilepidotus spp. (Irish lords, etc.)	2,010	32,794
Myoxocephalus spp. (great sculpin, etc.)	1,988	7,545
Hemitripterus spp. (bigmouth sculpin)	996	1,996
Smelts		
Eulachon (*Thaleichthys pacificus*)	225	4,393
Rainbow smelt (*Osmerus mordax*)	99	2,806
Capelin (*Mallotus villosus*)	10	42

Table 4.--Number of hauls in which each taxon of skates, sculpins, and smelts was encountered by each gear type during the project.

Taxon	Bottom trawl	Pelagic trawl	Pot	Longline
Skates				
Alaska skate (*Bathyraja parmifera*)	726	1,400		730
Bering skate (*B. interrupta*)	45	151		379
Aleutian skate (*B. aleutica*)	128	36		250
Big skate (*Raja binoculata*)	115	6		30
Whiteblotched skate (*B. maculata*)	17			77
Longnose skate (*R. rhina*)	40	3		9
Commander skate (*B. lindbergi*)	1	1	1	46
Okhotsk skate (*B. violacea*)		5		37
Roughtail skate (*B. trachura*)				37
Whitebrow skate (*B. minispinosa*)	1			21
Mud skate (*B. taranetzi*)	5	2		
Sculpins				
Hemilepidotus spp. (Irish lords, etc.)	859	399	169	583
Myoxocephalus spp. (great sculpin, etc.)	1,119	290	40	539
Hemitripterus spp. (bigmouth sculpin)	191	387	2	416
Smelts				
Eulachon (*Thaleichthys pacificus*)	7	218		
Rainbow smelt (*Osmerus mordax*)	6	93		
Capelin (*Mallotus villosus*)	5	5		

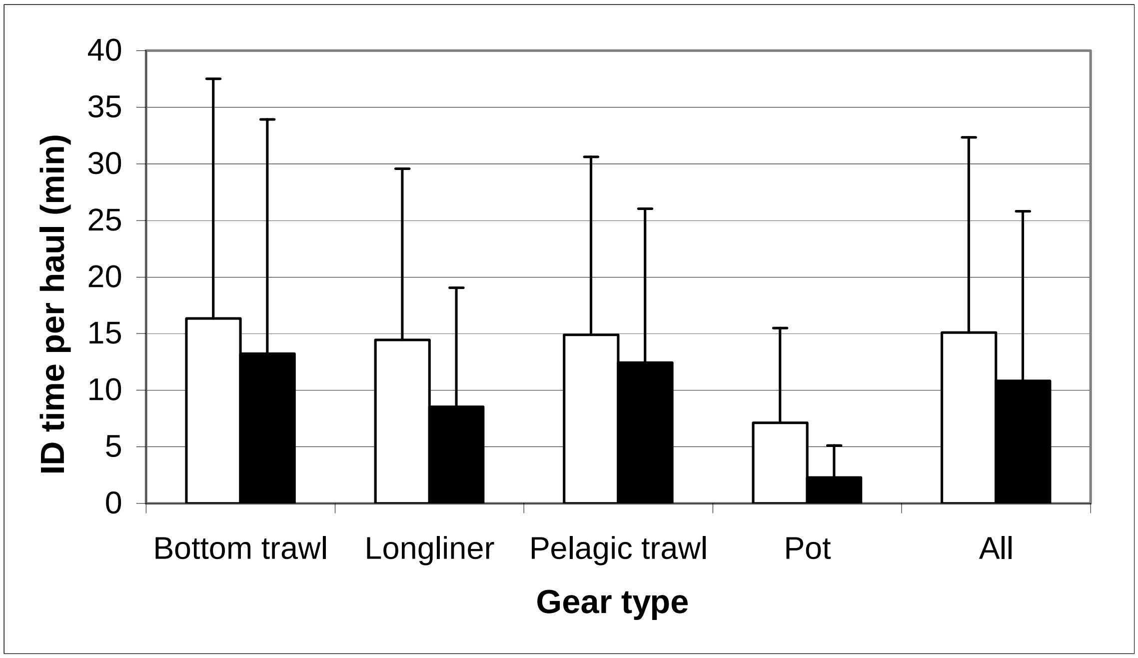

Figure 1.--Average identification (ID) time (+ SD) per haul by gear type for Project hauls (white bars) and Non-Project hauls (black bars).

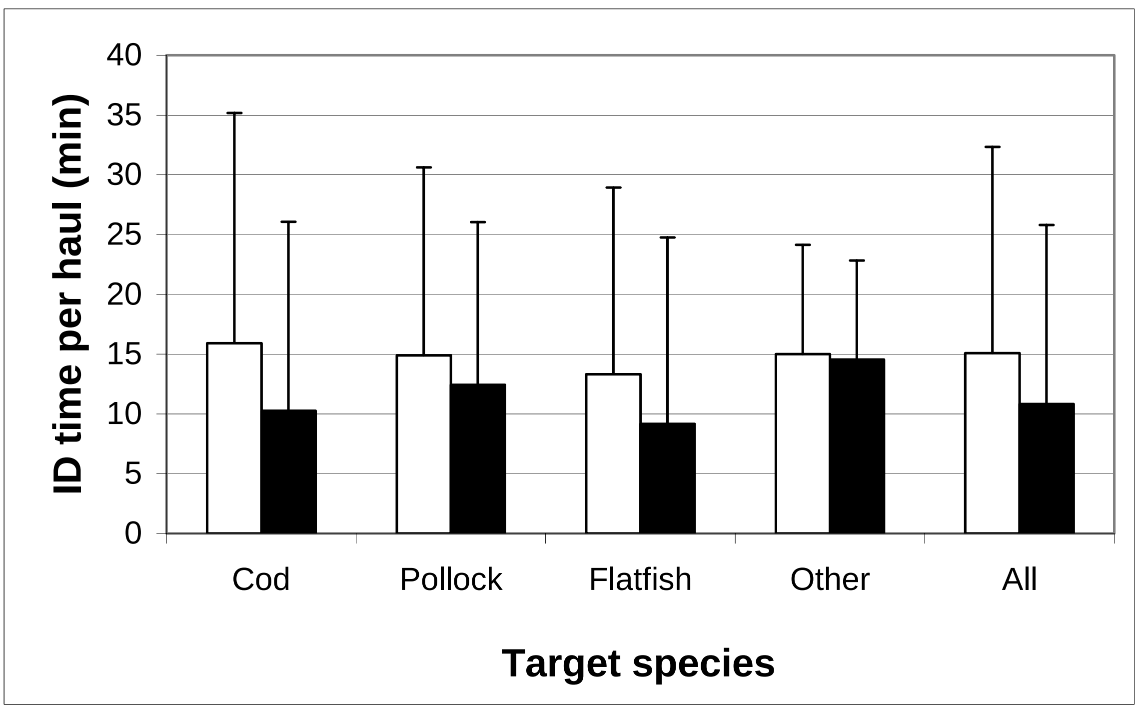

Figure 2.--Average identification (ID) time (+ SD) per haul by target species for Project hauls (white bars) and Non-Project hauls (black bars). "Other" category includes Atka mackerel, Pacific ocean perch, sablefish, and Pacific halibut.

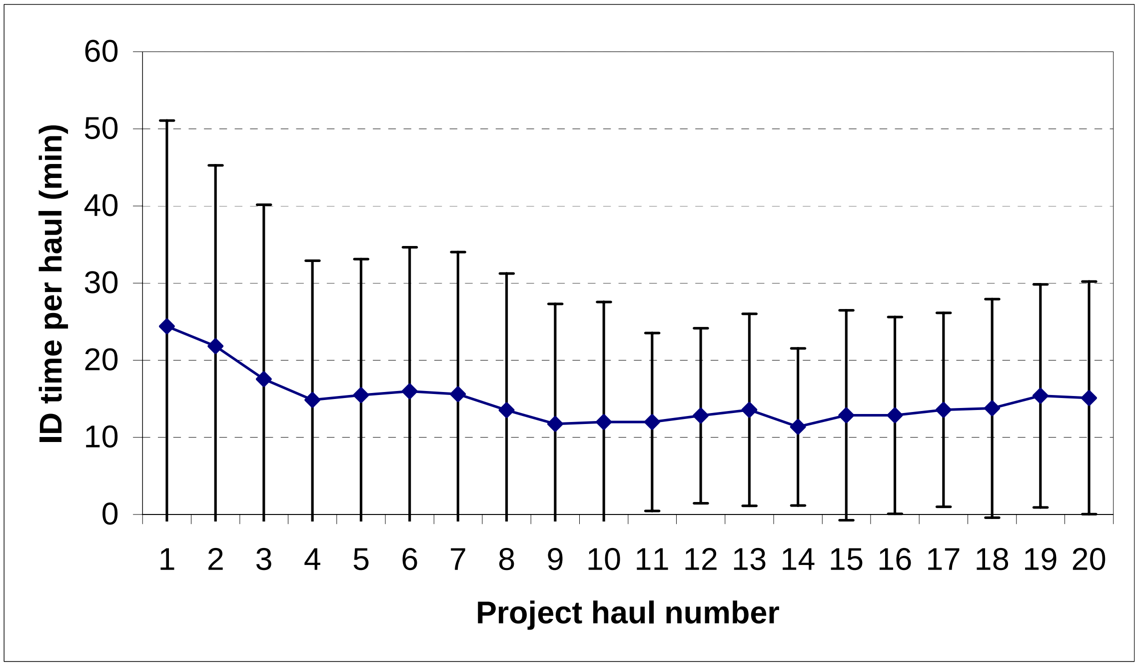

Figure 3.--Average identification (ID) time (+/- SD) per haul for the first 20 Project hauls in a series.

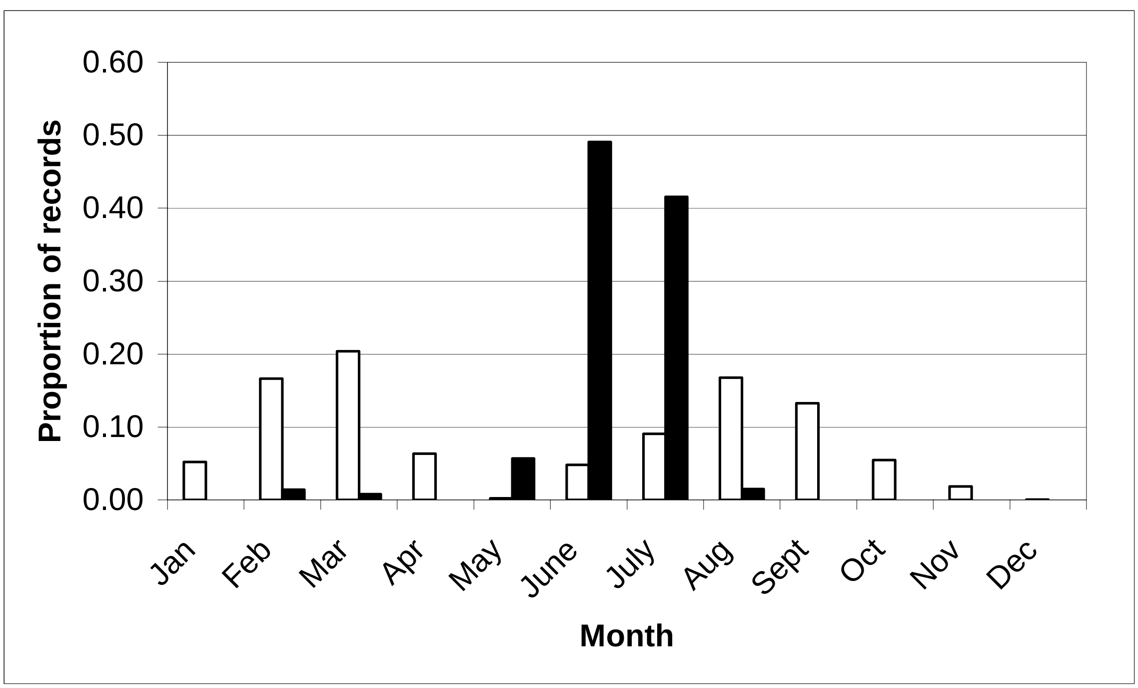

Figure 4.--Seasonal distribution of data collection for this project (white bars) and 1999-2003 NMFS bottom trawl surveys (black bars).

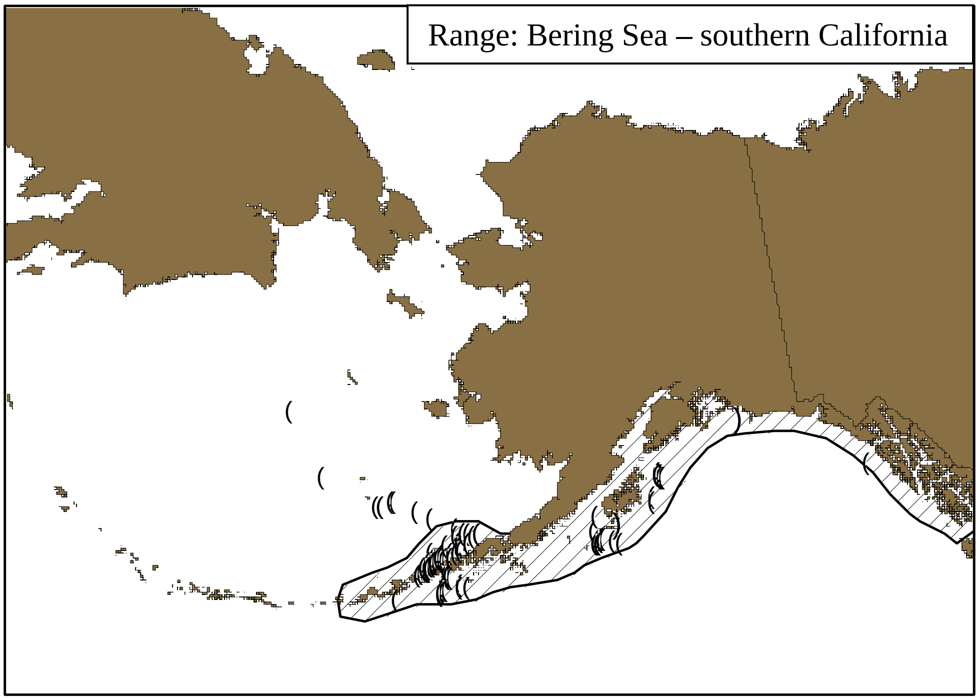

Figure 5.--Geographic distribution of big skates (*Raja binoculata*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

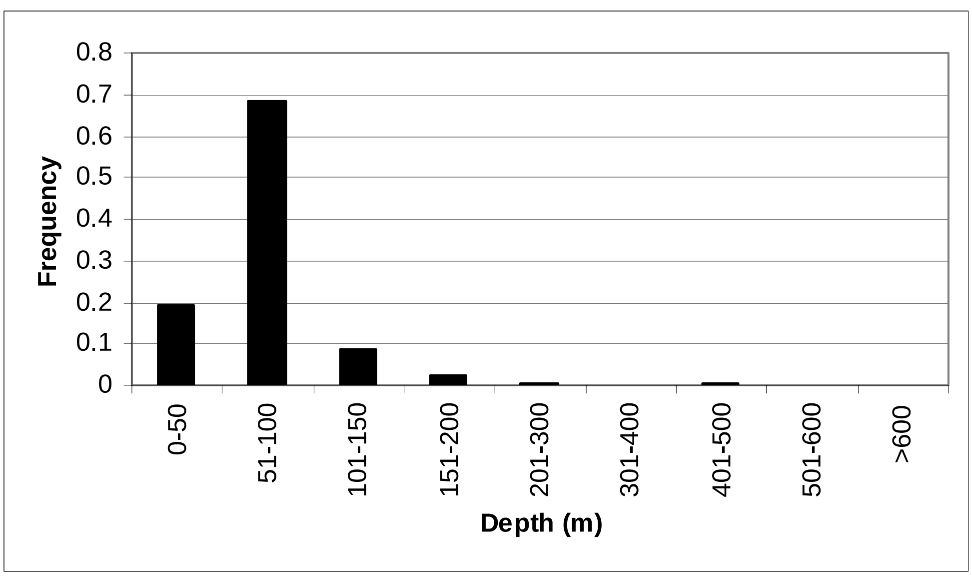

Figure 6.--Bathymetric distribution of big skates (*Raja binoculata*) reported by Project participants.

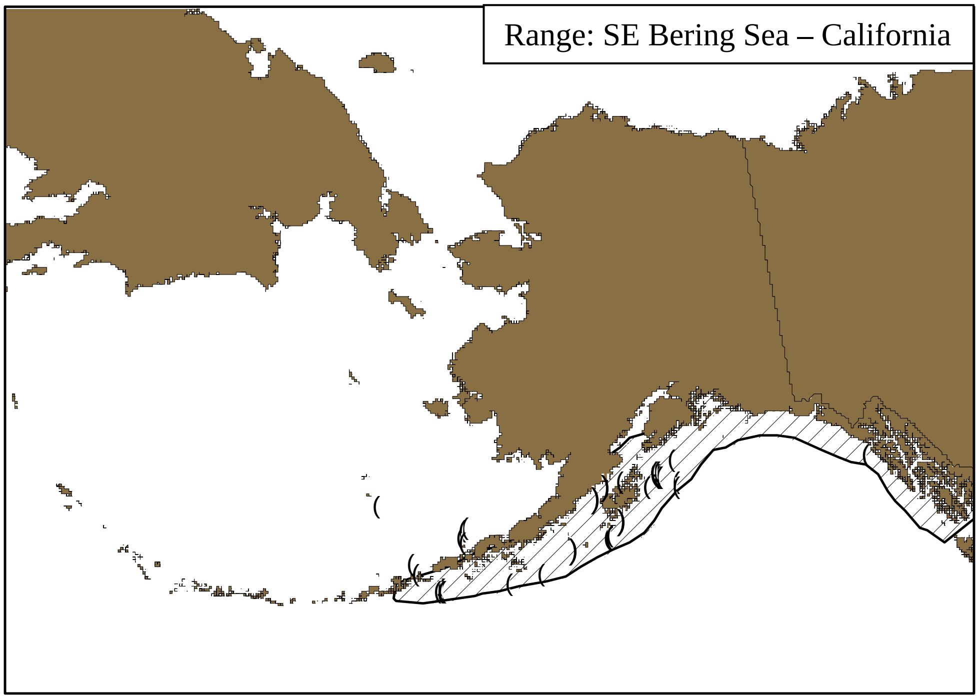

Figure 7.--Geographic distribution of longnose skates (*Raja rhina*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

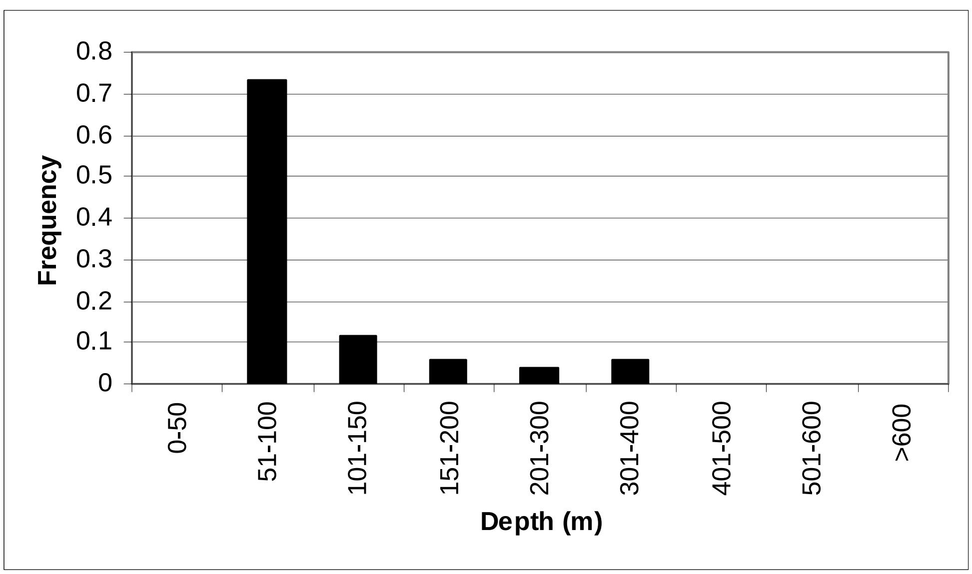

Figure 8.--Bathymetric distribution of longnose skates (*Raja rhina*) reported by Project participants.

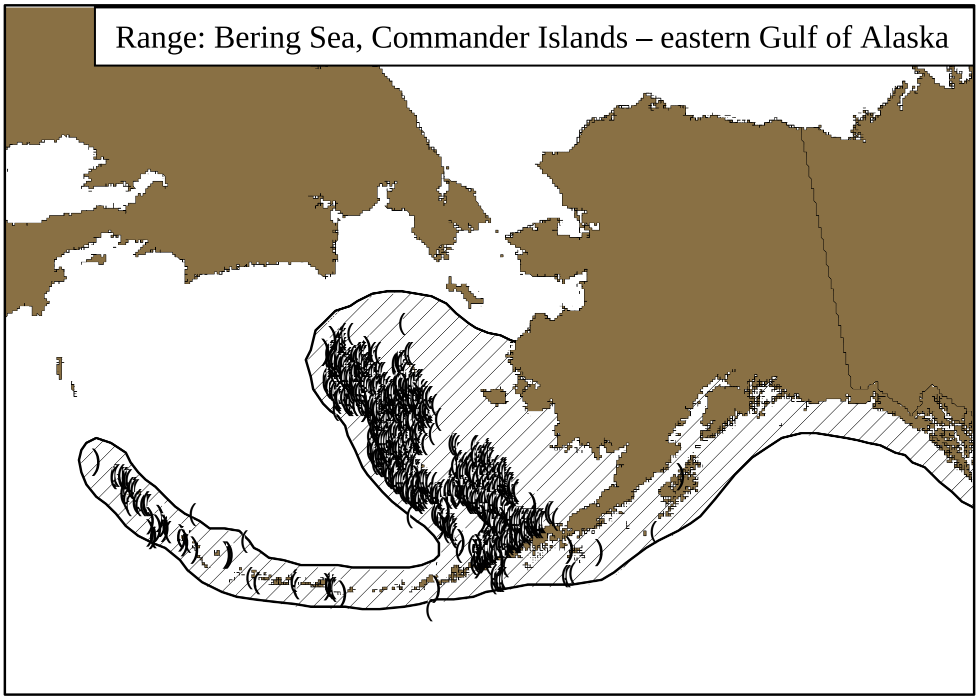

Figure 9.--Geographic distribution of Alaska skates (*Bathyraja parmifera*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

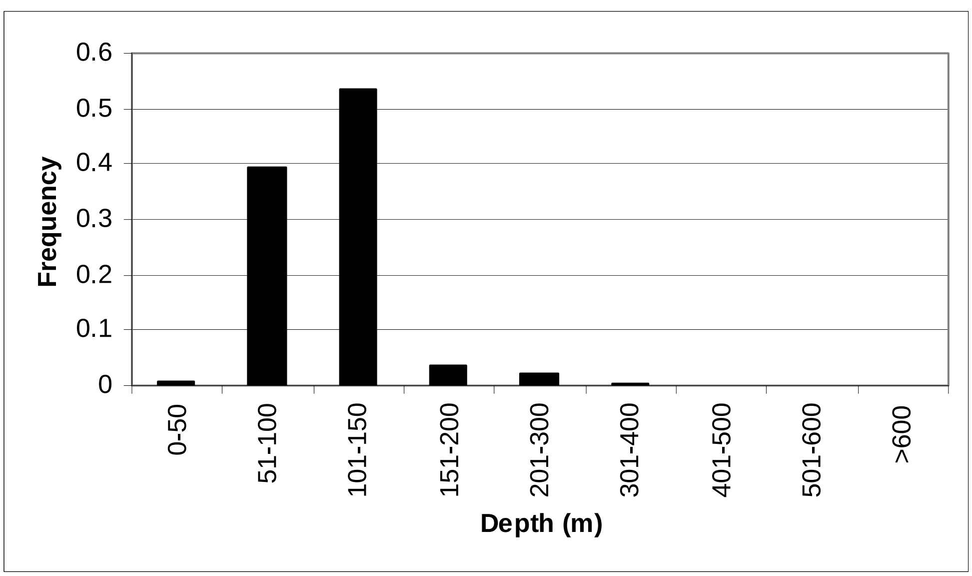

Figure 10.--Bathymetric distribution of Alaska skates (*Bathyraja parmifera*) reported by Project participants.

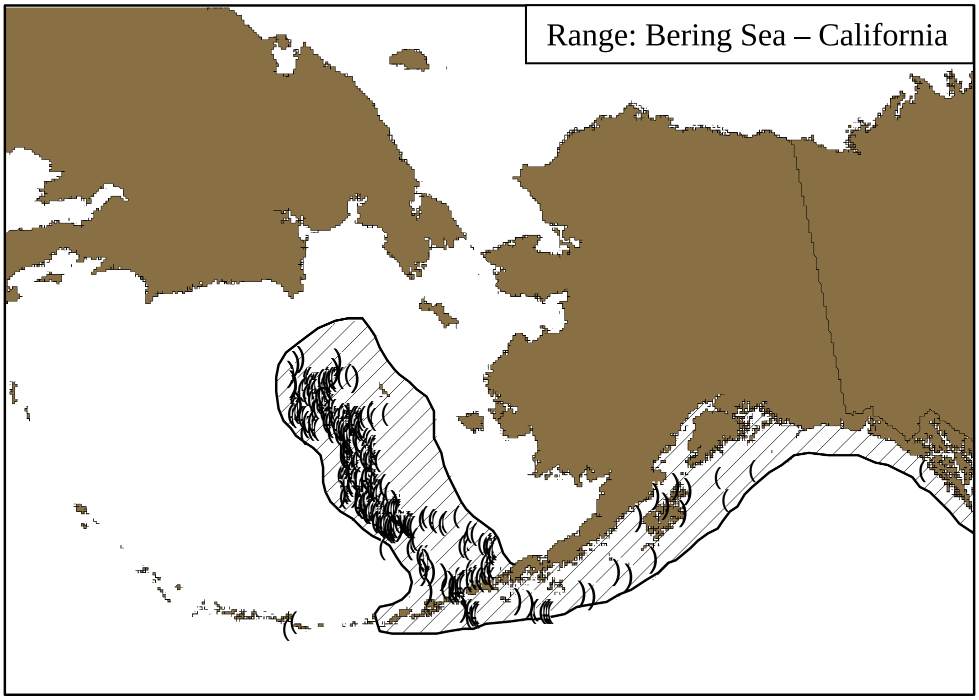

Figure 11.--Geographic distribution of Bering skates (*Bathyraja interrupta*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

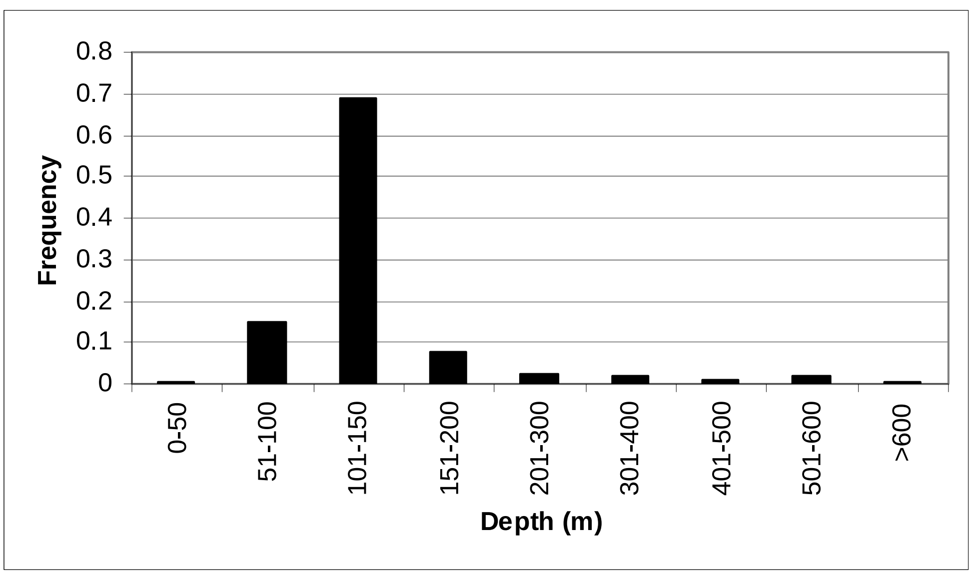

Figure 12.--Bathymetric distribution of Bering skates (*Bathyraja interrupta*) reported by Project participants.

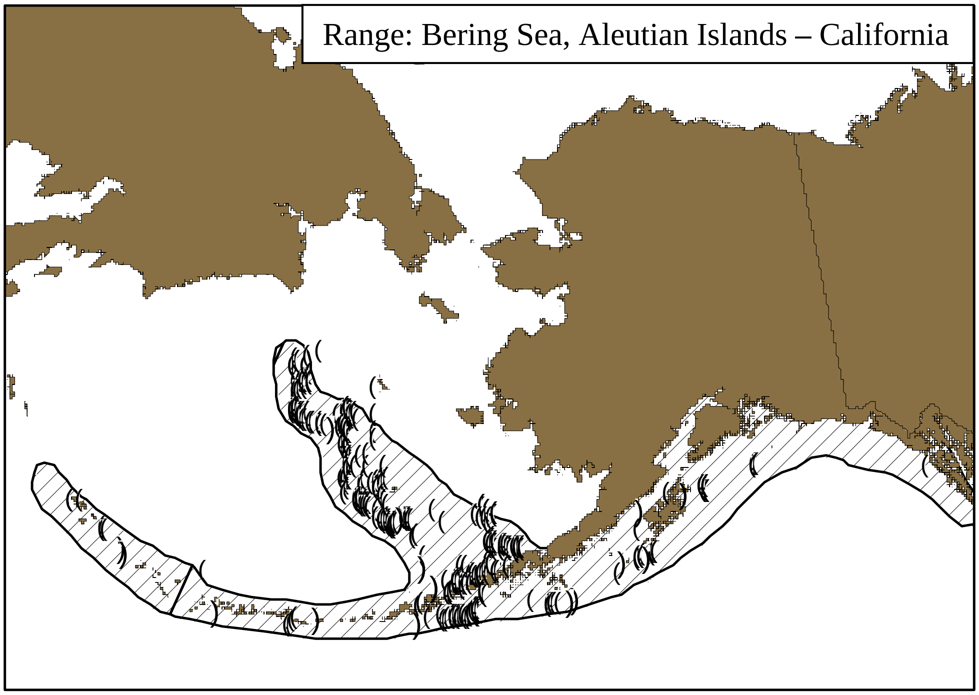

Figure 13.--Geographic distribution of Aleutian skates (*Bathyraja aleutica*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

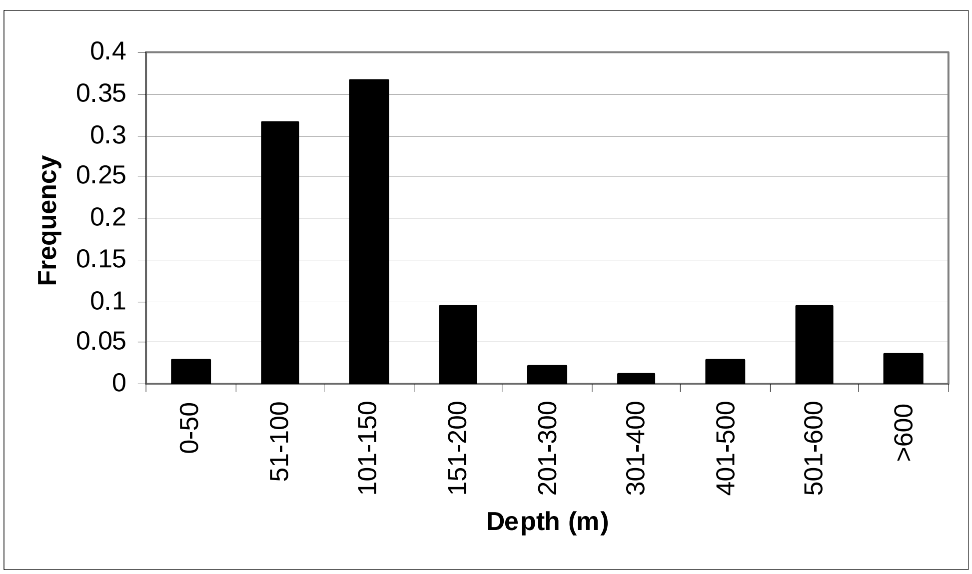

Figure 14.--Bathymetric distribution of Aleutian skates (*Bathyraja aleutica*) reported by Project participants.

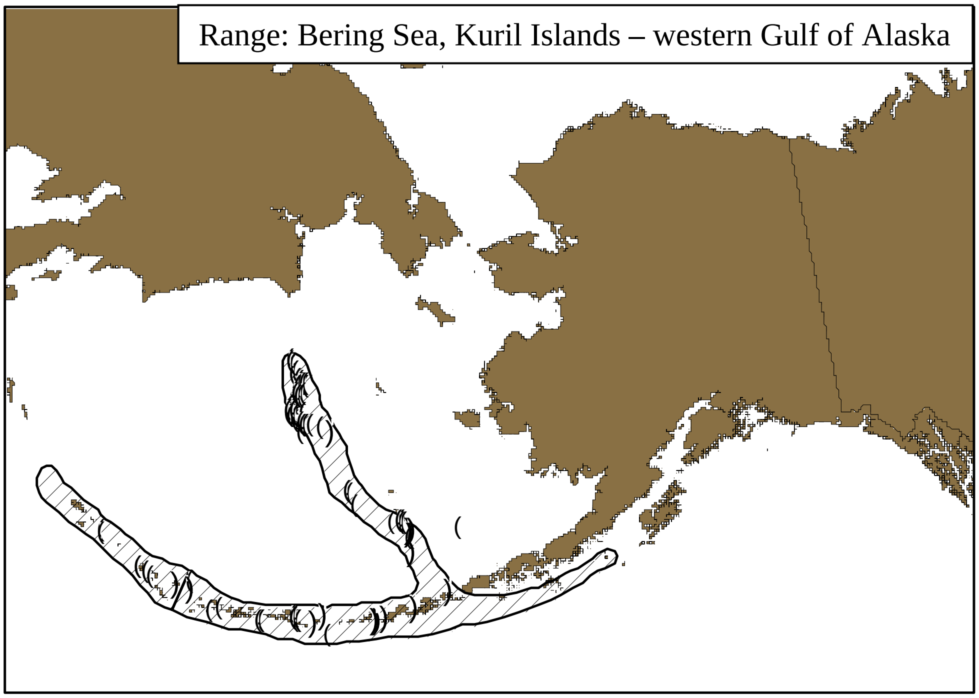

Figure 15.--Geographic distribution of whiteblotched skates (*Bathyraja maculata*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

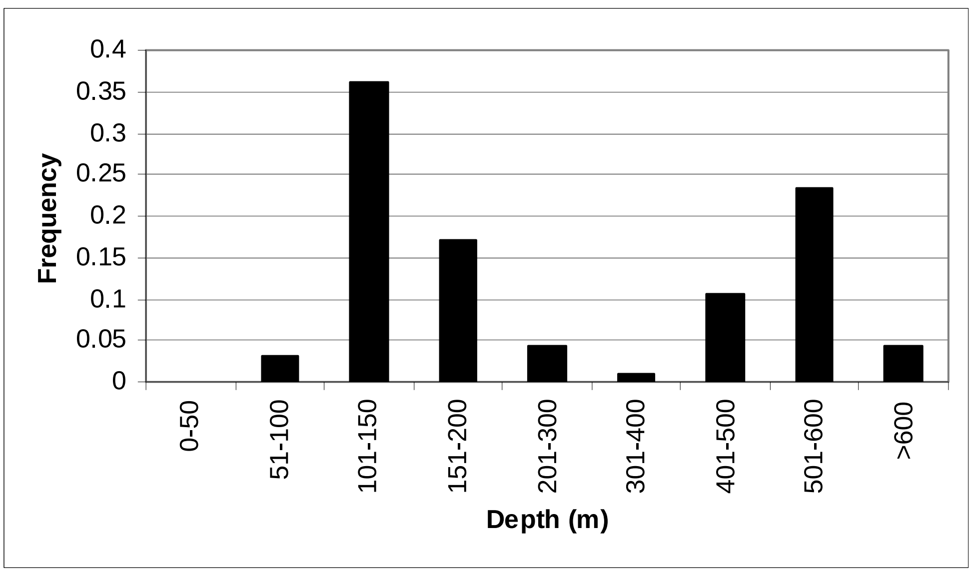

Figure 16.--Bathymetric distribution of whiteblotched skates (*Bathyraja maculata*) reported by Project participants.

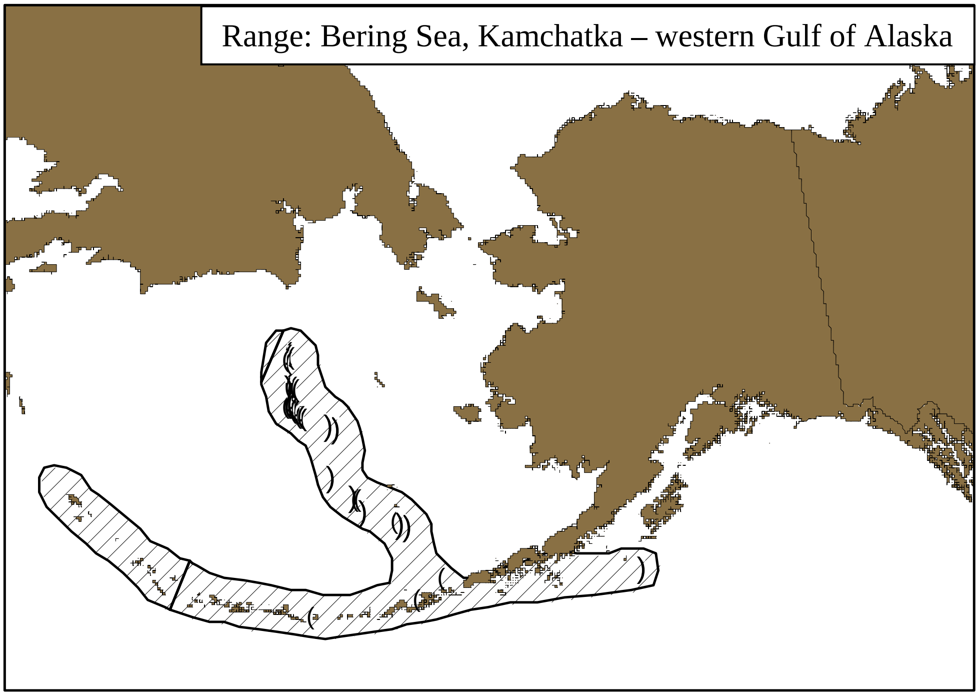

Figure 17.--Geographic distribution of Commander skates (*Bathyraja lindbergi*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

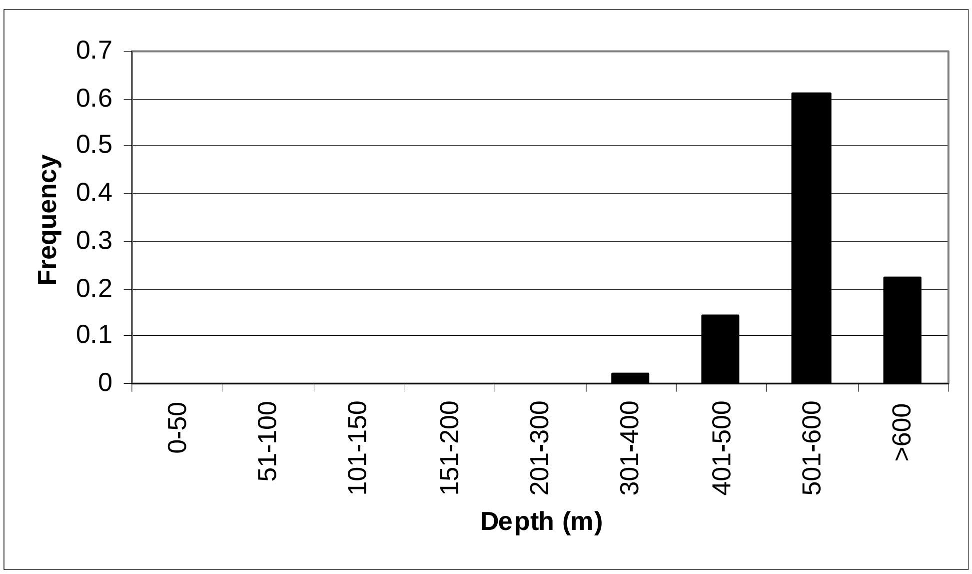

Figure 18.--Bathymetric distribution of Commander skates (*Bathyraja lindbergi*) reported by Project participants.

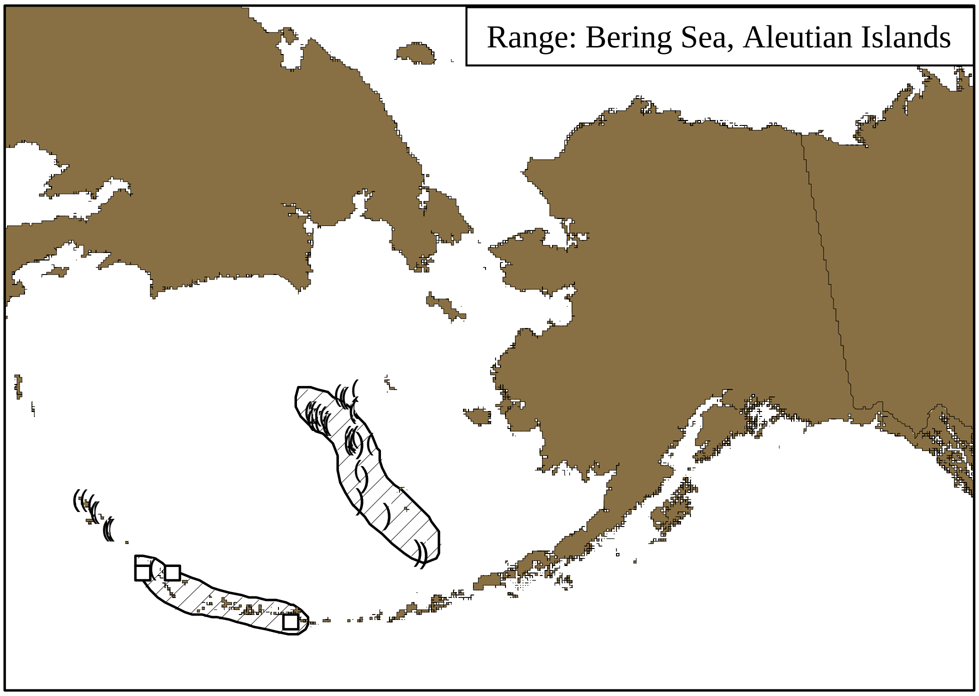

Figure 19.--Geographic distribution of Okhotsk skates (*Bathyraja violacea*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

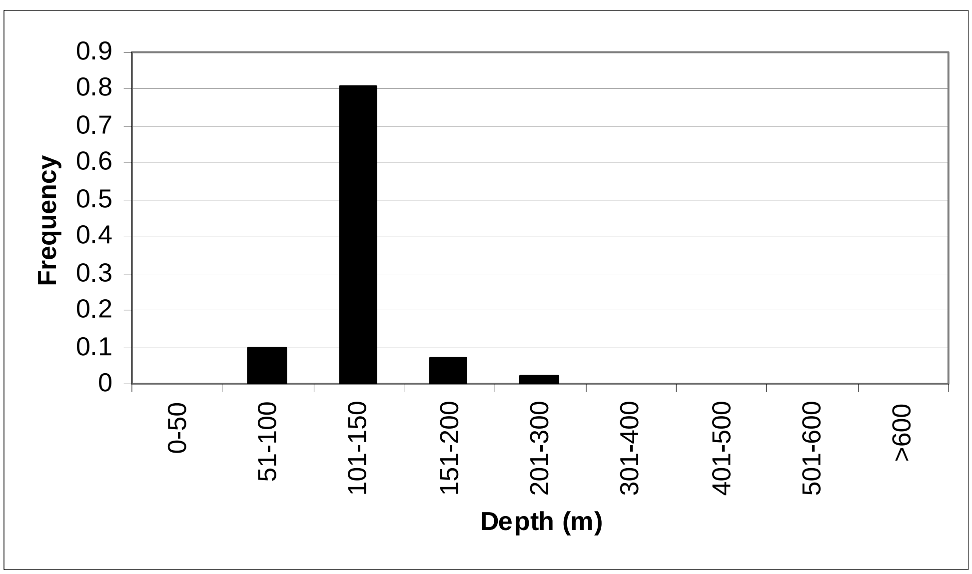

Figure 20.--Bathymetric distribution of Okhotsk skates (*Bathyraja violacea*) reported by Project participants.

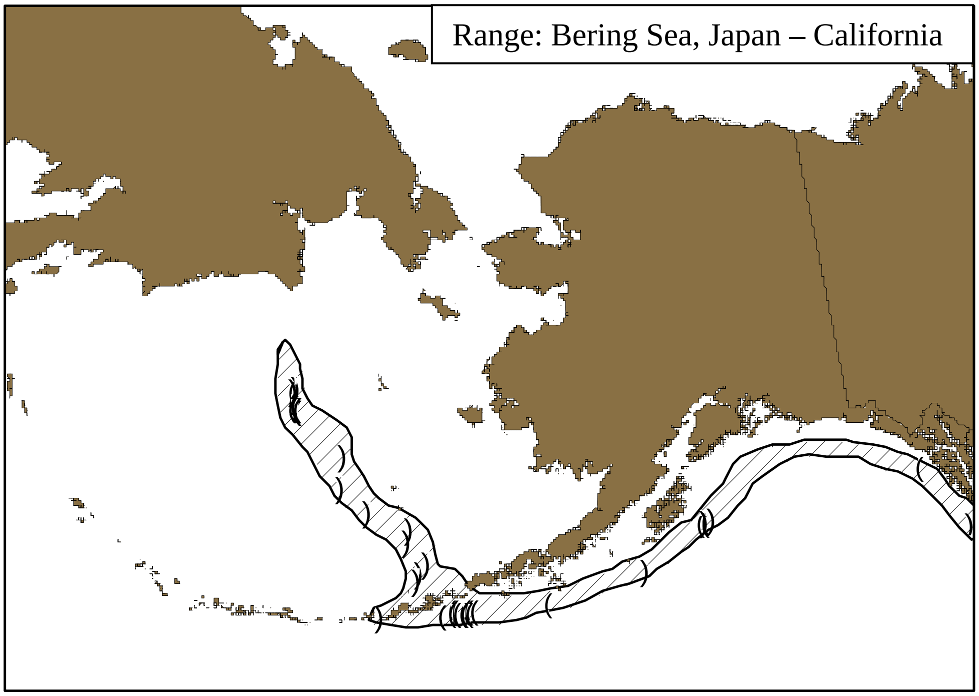

Figure 21.--Geographic distribution of roughtail skates (*Bathyraja trachura*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

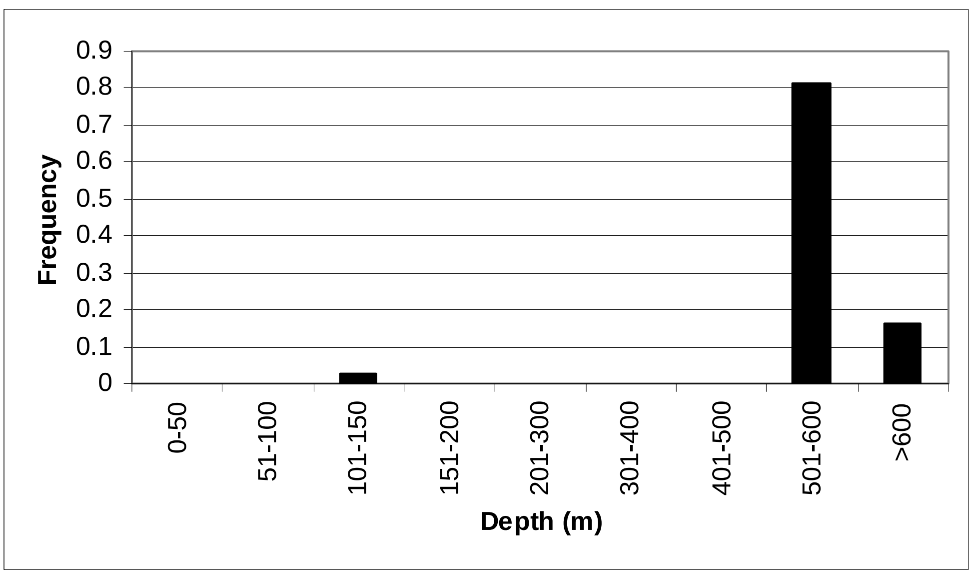

Figure 22.--Bathymetric distribution of roughtail skates (*Bathyraja trachura*) reported Project participants.

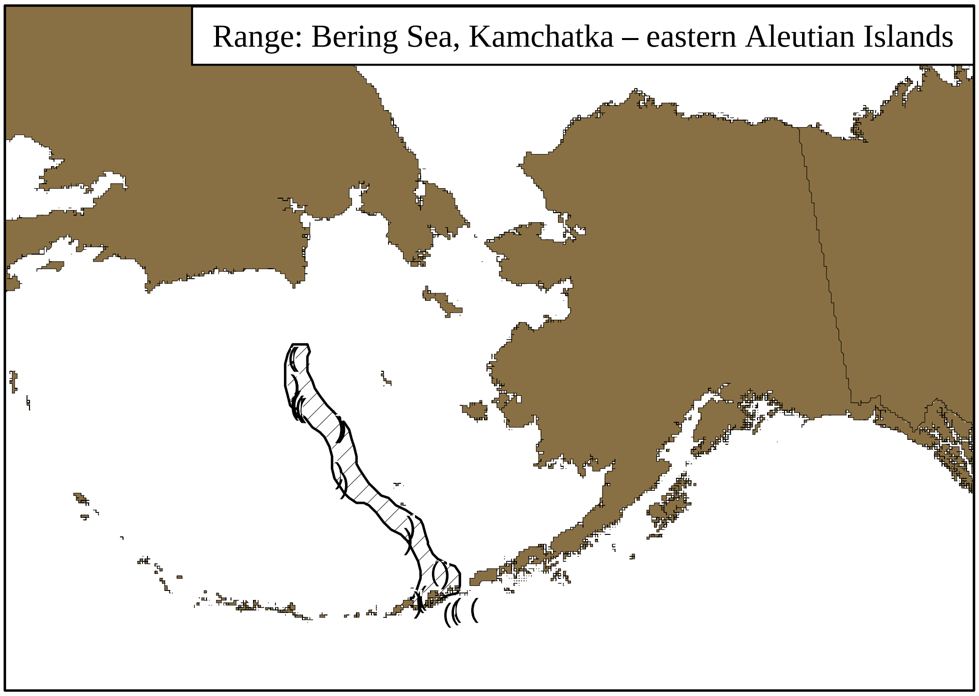

Figure 23.--Geographic distribution of whitebrow skates (*Bathyraja minispinosa*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

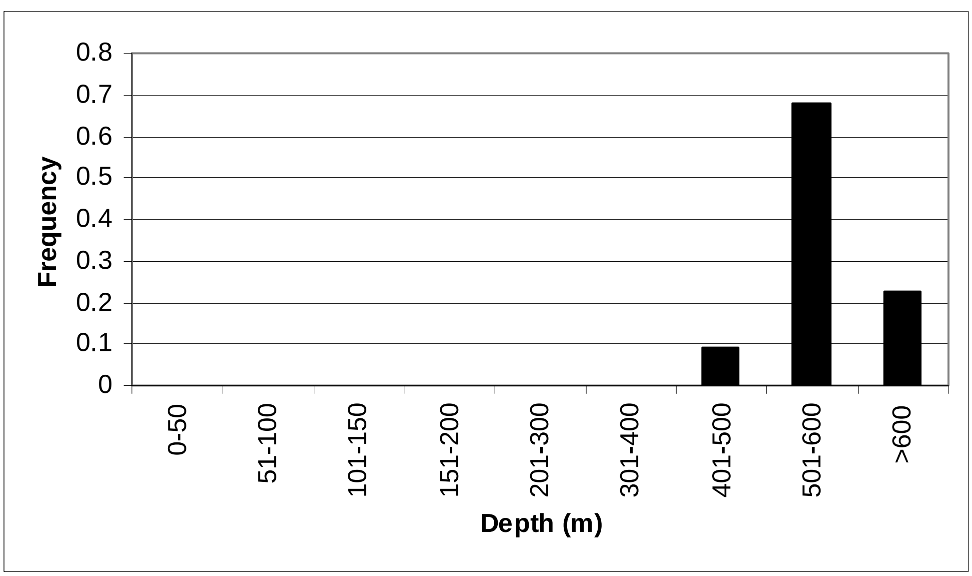

Figure 24.--Bathymetric distribution of whitebrow skates (*Bathyraja minispinosa*) reported by Project participants.

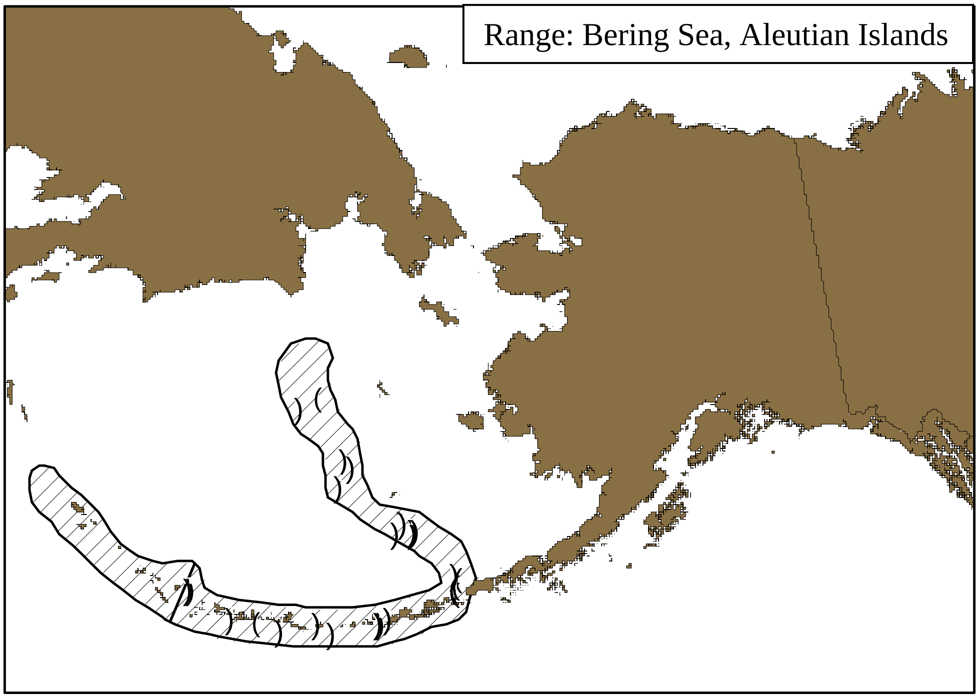

Figure 25.--Geographic distribution of mud skates (*Bathyraja taranetzi*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

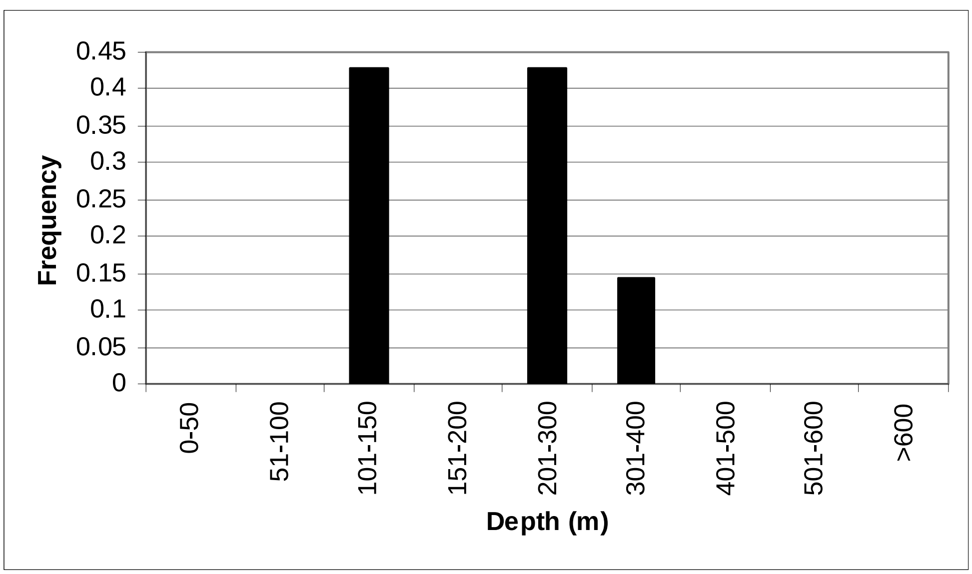

Figure 26.--Bathymetric distribution of mud skates (*Bathyraja taranetzi*) reported by Project participants.

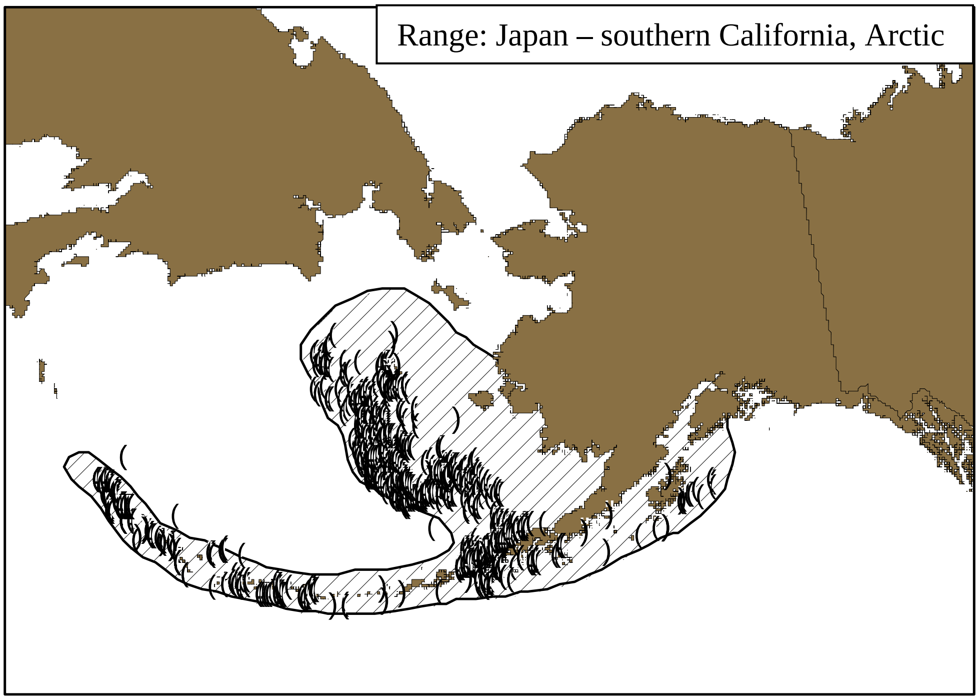

Figure 27.--Geographic distribution of *Hemilepidotus* spp. reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

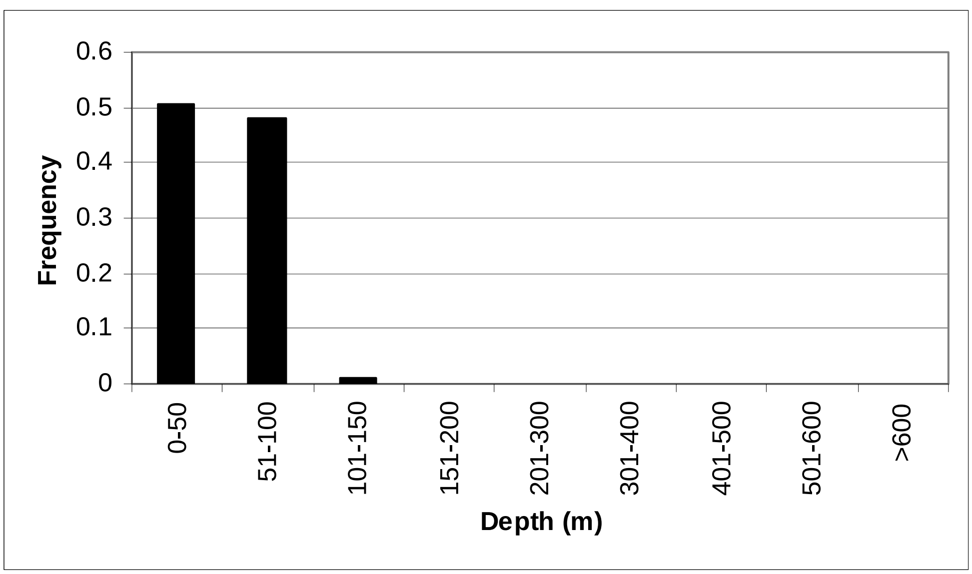

Figure 28.--Bathymetric distribution of *Hemilepidotus* spp. reported by Project participants.

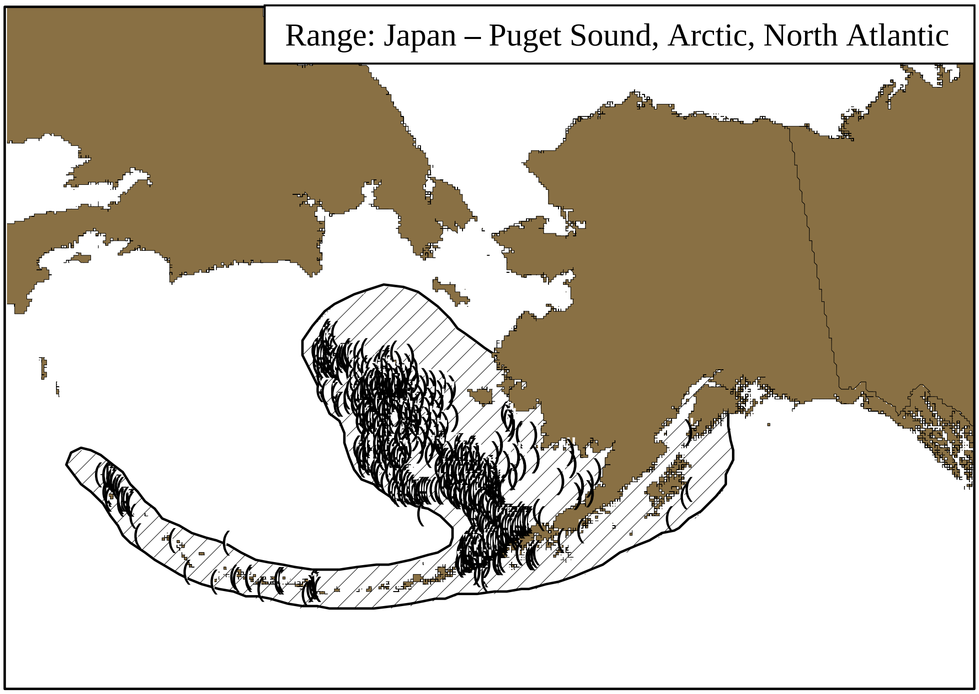

Figure 29.--Geographic distribution of *Myoxocephalus* spp. reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

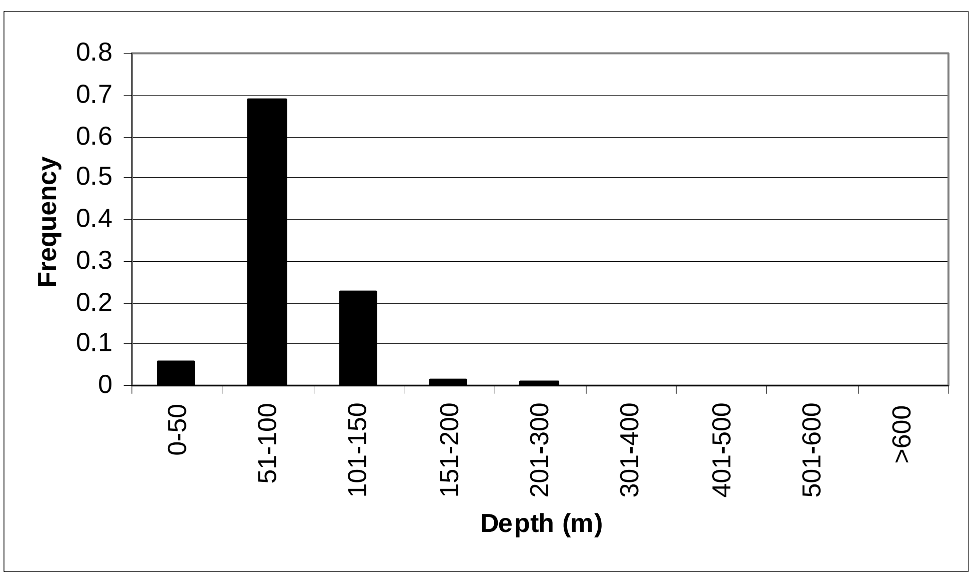

Figure 30.--Bathymetric distribution of *Myoxocephalus* spp. reported by Project participants.

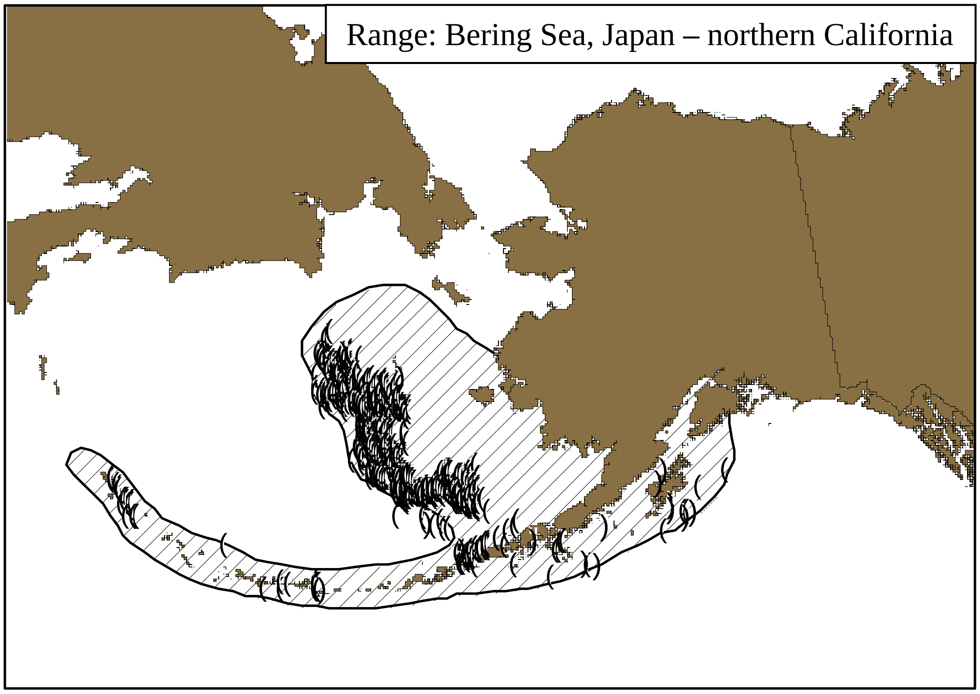

Figure 31.--Geographic distribution of *Hemitripterus* spp. reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

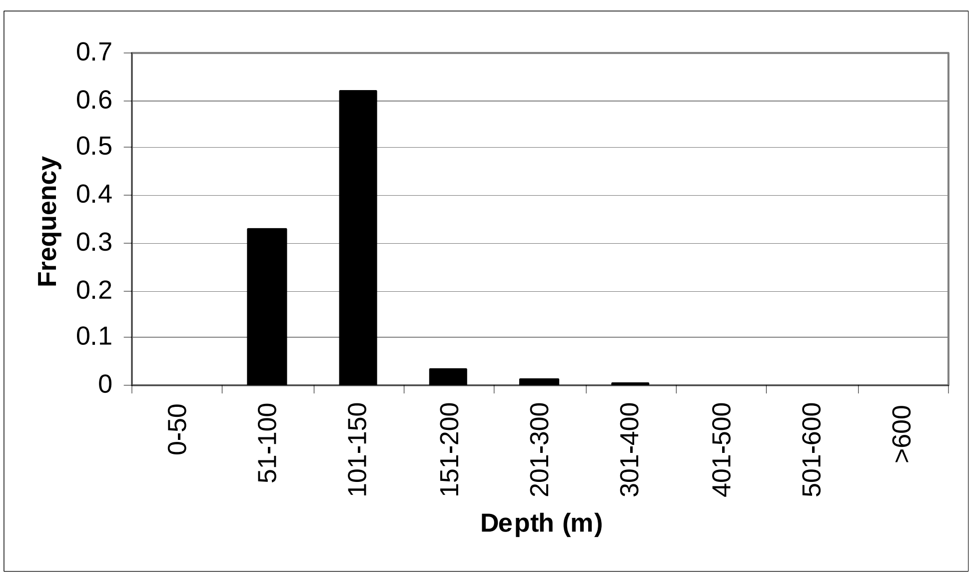

Figure 32.--Bathymetric distribution of *Hemitripterus* spp. reported by Project participants.

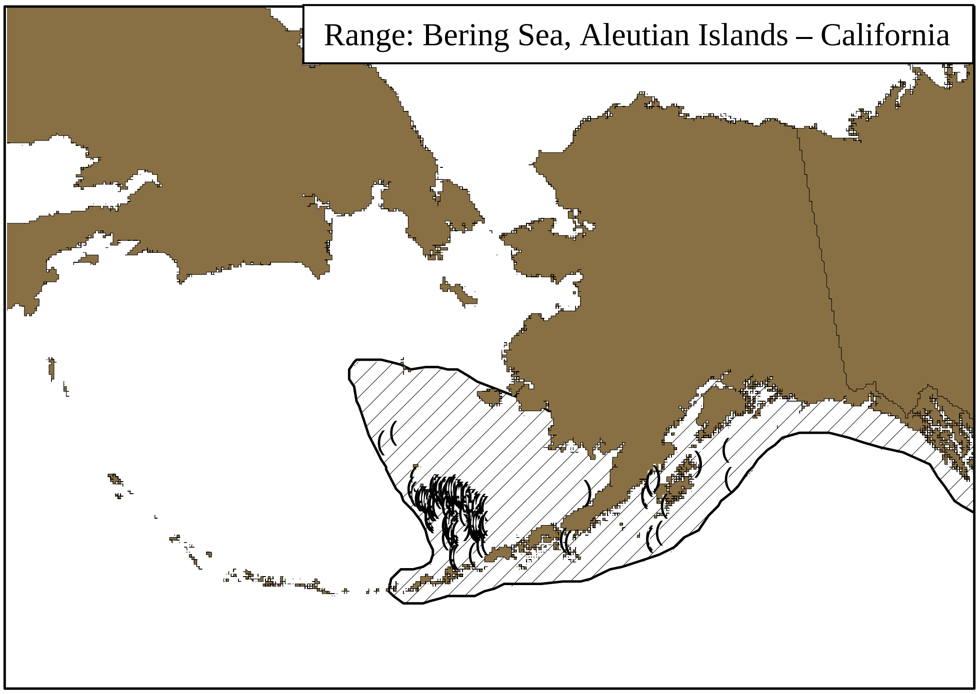

Figure 33.--Geographic distribution of eulachon (*Thaleichthys pacificus*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

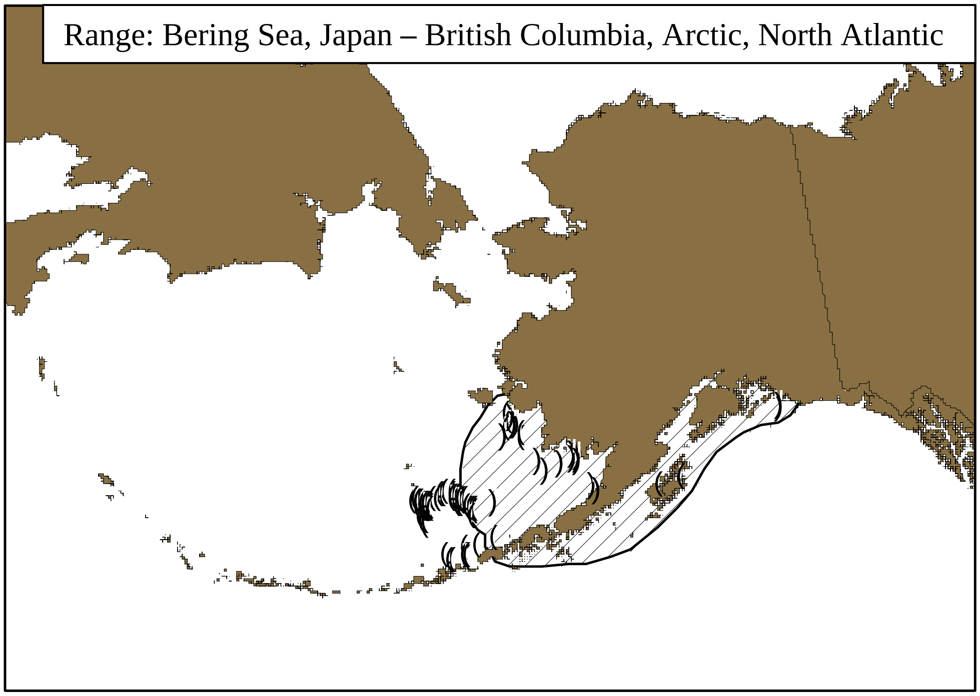

Figure 34.--Geographic distribution of rainbow smelt (*Osmerus mordax*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

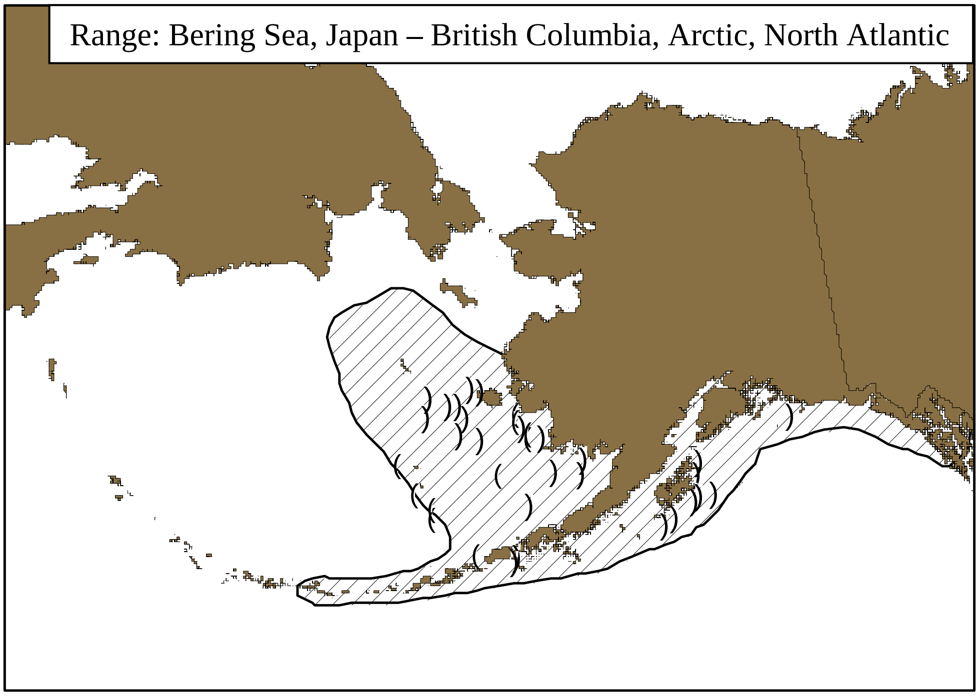

Figure 35.--Geographic distribution of capelin (*Mallotus villosus*) reported by Project participants (open circles), and distribution determined by recent bottom-trawl surveys (diagonally hashed area), including collected voucher specimens (open squares).

DISCUSSION

The implementation of ecosystem-based fisheries management relies on a more complete understanding of the ecosystem and its components. Fisheries observers can provide essential data on rapidly developing fisheries, such as the skate fishery that developed in the Gulf of Alaska in 2003, and are an important source of catch composition, abundance, and distribution data for both target and non-target species. In order to maximize the accuracy and resolution of their data, observers need clear and concise field identification materials, effective training and in-season advising, and efficient data collection strategies that do not place unrealistic demands on their time and resources.

This project clearly demonstrated that additional identification responsibilities require additional time to be completed. Although statistically significant, the data also suggest that the additional effort is on the order of only a few minutes per haul. While observers on trawlers (targeting walleye pollock) appear to be least affected by these additional responsibilities and those on longline vessels appear to be most affected, the additional time required was not heavily dependent on the gear type or the target species. Identification times were greatest during the first few hauls of the project, but stabilized after about the fourth project haul and remained fairly consistent thereafter. This indicates that participants generally required three or four hauls to orient themselves and familiarize themselves with the identification materials. The high standard deviations associated with all mean identification times indicate that identification time varies significantly among different cruises and among different hauls within the same cruise. Causes of this variation may include differences in experience levels among observers, inconsistencies among working environments and conditions, varying diversity of catches, and differences in observer time estimation.

Although this study suggests that observers will only need a few extra minutes per haul to complete these additional identifications, this increase in time requirement may be an underestimate of the effort observers will actually expend. This study did not investigate the possibility that additional time will be required to weigh or otherwise process the catch, and time required to complete additional paperwork, such as species identification forms, was not included in the identification time. In addition, some fisheries that are particularly likely to encounter diverse skate catches, such as the sablefish longline fishery, contributed a very small proportion of the data collected. In cases where an observer is required to identify and weigh several species of skates per haul, particularly if large specimens are encountered, identification and processing time may be significantly greater than estimated in this study. However, species composition data obtained from this study indicate that observers encounter a broad diversity of skates, smelts, and sculpins, and that these species may be encountered in large numbers. Lumping these observations into a few family-level categories can result in the loss of a great deal of information. If the family categories include taxa with dissimilar life histories or differing vulnerability to fishing pressure, then management at the family level may lead to significant declines in some taxa.

A key element of this study was the development and assessment of a new field guide to the skates (Rajidae) of Alaska and new keys to Alaskan smelts and selected North Pacific sculpin genera for use by observers in the field. Progress toward this objective was measured in two ways: 1) by reaction and feedback from participating observers, and 2) by assessing the accuracy of field identifications. Observer feedback was predominantly positive throughout the life of the project, and resulted in numerous corrections, clarifications and updates, as well as one major reorganization of the field materials. Most participants believed the field guides to be clear, concise, and easy to use. When asked whether pre-deployment training was necessary and adequate, participating observers universally answered in the affirmative.

The accuracy of field identifications, particularly for the larger skate species, is difficult to assess directly. Observers often have access to only limited freezer space, and collections of larger specimens usually present significant logistical difficulties, so few specimens were retained for confirmation. However, the specimens that participants did collect were, with rare exceptions, identified accurately.

The information gleaned from Species Identification forms and debriefing interviews is a useful indirect indicator of field identification accuracy, as the degree to which the observer is familiar with identifying features can be assessed. Although the quality of completed Species Identification forms and responses during debriefing interviews varied widely among participants, the majority of observers were able to demonstrate sufficient familiarity with the morphological characters important in identifying these fishes. Those that had difficulty with skate and/or sculpin identifications were quickly identified, and any questionable data for their cruises was scrutinized for accuracy and removed if deemed unreliable by the debriefer. The author provided supplemental identification and verification training for debriefers and assisted in the evaluation of questionable records.

Comparisons of geographic and bathymetric distributions reported by participants in this study with known distributions of skates, sculpins, and smelts is another indirect means of assessing generalized field identification accuracy. This approach has the most potential with skates, many species of which have limited distributions in Alaskan waters. However, cases in which observer-reported distributions differ from survey distributions must be interpreted with caution. RACE bottom-trawl surveys are conducted only during the summer months (generally late May through early August), and very little is known about how much these species migrate seasonally and therefore how their distributions change over the course of the year. Distribution data collected from observers is much more seasonally diverse (Fig. 4). Thus, differences in the seasonality of the two data sets may contribute to differences in distribution reported for a particular species.

Two species of the genus *Raja* (big skates and longnose skates) are known to be common in the Gulf of Alaska but are rarely encountered on bottom trawl surveys in the Bering Sea. As expected, participants in this study recorded these species primarily from the western Gulf of Alaska and southeastern Bering Sea near the western tip of the Alaska Peninsula. A few specimens were also reported further north in the Bering Sea, with one observer reporting big skates north of the Pribilof Islands. However, observers reporting big skates and longnose skates from these northern localities were unable to produce confirmation of their identifications, and therefore these records are of uncertain validity. Survey data indicate that these are generally shallow-water skates: big skates are most common at depths of less than 100 m, and longnose skates are most common at depths of 50–200 m. Project data agree with these bathymetric distributions remarkably well, as 85% of big skates reported by project participants were at depths of less than 100 m and 91% of longnose skates at 50–200 m.

The three most common species of *Bathyraja* have slightly different distributions in Alaskan waters. The Aleutian skate (*B. aleutica*) is the most widely distributed species, found throughout the Gulf of Alaska, Aleutian Islands, and Bering Sea. In contrast, the Alaska skate (*B. parmifera*) is rare in the Gulf of Alaska, and the Bering skate (*B. interrupta*) is not found in the Aleutian Islands. Aleutian skates have a very broad depth range, extending from the upper continental shelf to depths of at least 1,200 m, but appear to be most common at depths of 100–

300 m. In contrast, Alaska and Bering skates are generally restricted to shallower waters, and are rarely encountered at depths greater than 200 m. In general, distributions reported by participants in this project reflected these known skate distributions. Aleutian skates were reported throughout the western Gulf of Alaska, Aleutian Islands, and Bering Sea. Although most were reported at depths of less than 100 m, where the majority of observed fishing effort was concentrated, a significant number (17%) were at depths greater than 300 m. Alaska skates were reported throughout the Aleutians and Bering Sea, but from only a few locations in the Gulf of Alaska; Bering skates were reported throughout the Gulf of Alaska and Bering Sea, but only twice from the Aleutians. The Aleutian records of Bering skates could not be verified and their validity remains uncertain. Almost 97% of Alaska skates and 85% of Bering skates were encountered at depths of less than 200 m. These geographic and bathymetric distributions closely match expectations based on survey data.

Several of the less common species of *Bathyraja*, including whiteblotched, Commander, whitebrow, and mud skates, have historically only been encountered in the Aleutians and Bering Sea, and are generally found in deeper waters. Whiteblotched and mud skates are most common at depths of 100–400 m, and Commander and whitebrow skates are only common at depths greater than 400 m. Again, data compiled from participants in this study generally reflect these distributions, as all four species were reported from the outer Bering Sea shelf and upper slope and the Aleutian Islands. Approximately 59% of whiteblotched skate reports and 100% of mud skate reports were at depths of 100–400 m, and 98% and 100% of Commander and whitebrow skate reports, respectively, were at depths greater than 400 m.

Three of Alaska's species of skates, the roughtail, roughshoulder, and deepsea skates, are restricted to deep waters. The roughtail skate is found throughout the Eastern Bering Sea and

Gulf of Alaska but is rarely collected at depths of less than 500 m. Project participants reported this species primarily from the western Gulf of Alaska and Bering Sea, with 97% of the records occurring deeper than 500 m. The roughshoulder and deepsea skates are known from very few records in Alaska, and all have been encountered at depths greater than 1,200 m (Stevenson et al. in prep). As expected, participants in this project did not encounter these two species.

The only skate species for which project distribution data differ markedly from survey distribution data is the Okhotsk skate (Figs. 19–20). This species is only rarely encountered on bottom trawl surveys, and has only been collected from the outer Bering Sea shelf and upper slope and from the central Aleutian Islands. Project participants reported this species much more frequently than expected (199 specimens in 42 hauls), primarily in the northern Bering Sea and far western Aleutians. The Okhotsk skate is much more common in the western Bering Sea and Sea of Okhotsk, so the distribution reported by observers is not entirely unreasonable. However, the lack of records in the survey data from these areas (particularly the western Aleutians) and the overall rarity of this species raise questions about the accuracy of these observer identifications. In addition, this species is generally difficult to identify and is commonly confused with the mud skate. In fact, the two specimens of Okhotsk skates that observers collected for confirmation were later reidentified as mud skates. Moreover, observers identified mud skates much less frequently than expected (8 specimens in 7 hauls). Survey data indicate that mud skates are much more common than Okhotsk skates in the eastern Bering Sea and Aleutians. Although these discrepancies could certainly be due to differences in seasonality of collections and gear types, it is perhaps more likely that participants in this project were commonly misidentifying mud skates as Okhotsk skates.

All three genera of sculpins included in this project are distributed throughout the Bering

Sea, Aleutian Islands, and western Gulf of Alaska. Reports of *Hemilepidotus* are likely to include several species. The yellow Irish lord (*Hemilepidotus jordani*) is the most common Irish lord in Alaskan waters and is found throughout the continental shelf in the Gulf of Alaska, Aleutian Islands, and Bering Sea. However, the red Irish lord (*H. hemilepidotus*) is also found throughout the Gulf of Alaska and Aleutian Islands, the longfin Irish lord (*H. zapus*) is found throughout the central and western Aleutians, and the butterfly sculpin (*H. papilio*) is locally common on the Bering Sea shelf. Therefore, although the majority of records of *Hemilepidotus* are probably yellow Irish lords, at least three additional species are probably represented in these data. Reports of *Myoxocephalus* are also likely to include several species. The great sculpin (*M. polyacanthocephalus*) is the most common member of this genus in Alaskan waters, but the plain sculpin (*M. jaok*) and warty sculpin (*M. verrucosus*) are also found throughout the Bering Sea, and the warty sculpin (*M. scorpius* of Mecklenburg et al. 2002) is also found throughout the Gulf of Alaska and Aleutian Islands. Reports of *Hemitripterus* probably represent only one species, the bigmouth sculpin (*H. bolini*). The only other species of this genus known from Alaska is the shaggy sea raven (*H. villosus*), which has been reported only once from Alaska (Mecklenburg et al. 2002). Although their bathymetric ranges differ slightly, with *Hemilepidotus* and *Myoxocephalus* generally found at shallower depths than *Hemitripterus*, there is broad overlap in the depths at which these genera may be found. Survey distributions and project distributions were generally congruent for these taxa. As expected, project participants encountered all three genera frequently in all fisheries and in all regions.

For smelts, comparisons of survey distribution data with project distribution data are problematic. Survey distributions are based on data from bottom trawls, which are an inefficient means of collecting midwater fishes such as smelts. These distributions are probably skewed toward shallower depths, as a bottom trawl sweeps a larger percentage of the water column when fishing in shallow water. As anticipated, project participants encountered smelts most frequently in pelagic trawl fisheries, and much less frequently in bottom trawl fisheries. Despite the differences in gear type, smelt distributions reported by project participants appear to be largely in agreement with those established by survey data for eulachon and capelin. However, the distribution of rainbow smelt reported for this project differs markedly from the survey distribution. It is possible that this difference is due to widespread misidentification of smelts. However, observers did not report any difficulties in identifying smelts during training, mid-cruise advising, or debriefing for this project; there is no evidence that misidentification of these fishes is a widespread problem. Therefore, this difference is more likely due to biases in gear type or seasonality of collections.

Overall, skate, sculpin, and smelt distributions compiled from study data do not differ dramatically from expectations based on survey data, and therefore, with the potential exception of the Okhotsk-mud skate confusion, do not indicate any widespread identification problems. Additionally, relative rates of encounter for skate species were similar to those indicated by survey data, again with the potential exception of the Okhotsk and mud skates, and bathymetric distributions of skates reported by project participants generally match those obtained from survey data.

Without widespread collection of voucher specimens or some other type of species identity documentation (such as photographs or tissue collections), the reliability of observer identifications cannot be directly assessed. These forms of documentation are logistically difficult or expensive to implement, but remain the only viable means of directly assessing observer identification accuracy on a long-term and widespread basis. For the current study, assessment of identification reliability must be based primarily on the indirect lines of evidence detailed above, supported by the few specimen collections that were made. These data suggest that the second objective of this study has been achieved. The identification materials and training presentation developed for this study constitute an adequate and sufficient set of resources for the reliable identification of skates, smelts, and selected genera of sculpins in the field.

CONCLUSIONS

The results of this project indicate that observers of the North Pacific Groundfish Observer Program (NPGOP) can identify skates and smelts to the species level and selected sculpins to the genus level without a great deal of additional training or time expenditure in the field. Although the reliability of observer identifications cannot be directly assessed without widespread voucher collection, the indirect evidence presented here indicates that observers identifications of these taxa are generally reliable.

The frequency with which skates, sculpins, and smelts were encountered and the numbers of specimens reported during this project reinforce the fact that these fishes are important components of Alaska’s groundfish communities, and that they are at least potentially affected by groundfish fisheries. Therefore, even if these species are not directly targeted, the condition of their populations is relevant to the region’s fishery management strategies and conservation goals.

The training presentation and identification tools developed during the course of this project have provided the classroom and field resources necessary for integrating these taxa into observer training. Therefore, it is now possible to implement this training for all NPGOP observers without major restructuring of the training schedules or sacrifices in data quality, thereby providing a wealth of additional data to scientists and fisheries managers at minimal additional cost.

ACKNOWLEDGMENTS

I thank each and every one of the scores of observers, observer trainers, observer debriefers, and data editors who assisted in the data collection for this project. Jerry Berger and Sheryl Corey assisted in the design and implementation of the project. Gerald R. Hoff, James W. Orr, and other RACE Division personnel provided the photographs used in the skate guide. James W. Orr, Gerald R. Hoff, and Sheryl Corey reviewed earlier drafts of this manuscript.

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APPENDIX A

Sampling Instructions – Incidental Species Identification Project

From time to time, observers are asked to increase the level of resolution associated with the species identification of select species groupings. At this time, we are considering asking observers to identify skates and smelts to the species level and some sculpins to the genus level. You have been assigned this special project to help us judge the feasibility of this request.

This special project will be given to observers of all gear types, throughout 2003.

The purposes of this project are: (1) to assess the adequacy of the tools provided for identifying skates and smelts to species and selected sculpins to genus, and (2) to quantify the amount of additional time observers need to complete these identifications. Sampling for this project consists of the following:

1. Begin this project when your vessel begins encountering skates and/or numerous sculpins on a regular basis. The block of hauls during which you performed this project will hereafter be known as “project hauls.”

2. Beginning with the first project haul, complete sample identifications as usual. Record data as usual for the database, keying all skates, sculpins and smelts only to family, and using standard species codes.

3. Note the amount of time spent for identification of specimens on the Species Identification Time Form, including comments you may have (see sample). If the identifications are not done during one block of time, you may need to estimate the time requirement.

   Haul Number – the sequential haul number of your cruise
   Subsample? – did you subsample the haul or sample the whole haul?
   Date – the date the gear was retrieved
   Special project sample? – did you identify the skates, sculpins and smelts?
   ID time – how long did you spend identifying the entire sample?
   Comments – please be as specific as possible

4. Beginning with the second project haul, and continuing for alternating sampled hauls until at least 20 hauls are sampled, identify all skates and smelts to species, and all sculpins to genus category (*Myoxocephalus*, *Hemitripterus*, *Hemilepidotus*, or other) using the keys provided. Record data for the database, using standard species codes and the new codes on the Special Project list. It is important to also include those that could not be completely identified (e.g. *Bathyraja* unident.).

NOTE: Two of the species codes associated with this special project (roughshoulder skate and mud skate) are not in the ATLAS database. If you are using ATLAS and you encounter these species, write out the species name on the deck form or 3US form, and use species code 90 in the database (Skate unident.).

6. Note the amount of time spent for identification of specimens on the Species Identification Time Form, including comments you may have (see sample). If the identifications are not done during one block of time, you may need to estimate the time requirement. Comments should be related to the success or problems associated with the keys and guides or any difficulties that may have arisen. Note: ID Time does not include the time spent collecting the sample, only the time spent identifying the collected species.

7. Fill out a Skate Species Description Form for each separate species of skate encountered and, if possible, retain the following specimens:
   roughshoulder skate
   deepsea skate
   any other species encountered out of range

8. Make sure that you pick up several large plastic bags and waterproof tags when you pick up your gear.

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APPENDIX B

A Field Guide to the Skates (Rajidae) of Alaska

Compiled by:

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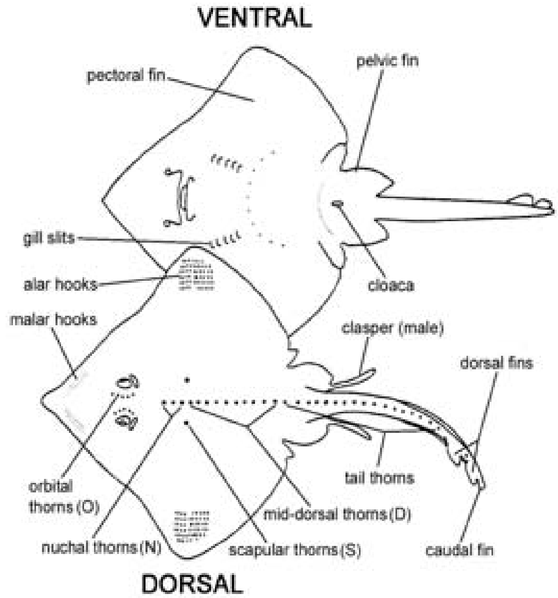
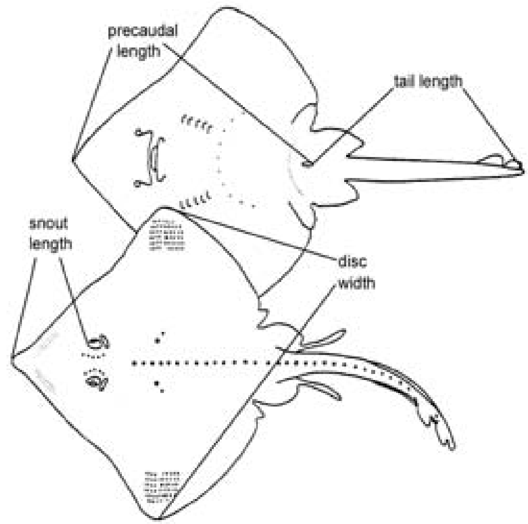
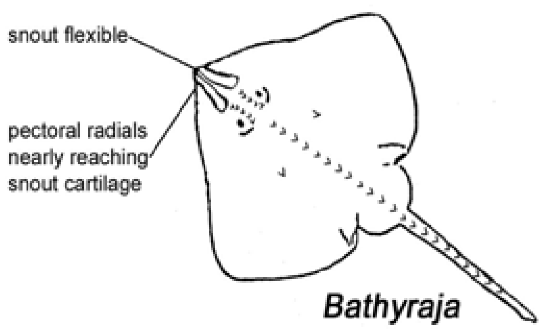
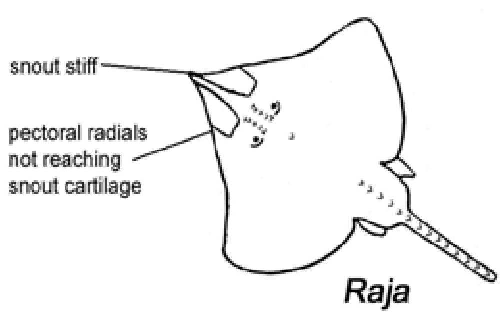
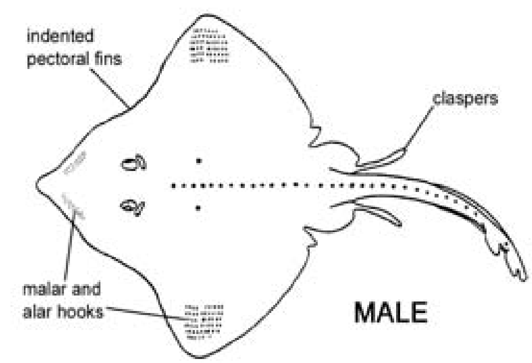
E-mail comments to duane.stevenson@noaa.gov

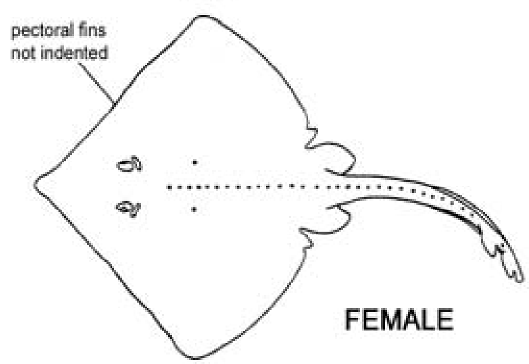

VENTRAL
pectoral fin
pelvic fin
gill slits
alar hooks
cloaca
malar hooks
clasper (male)
dorsal fins
orbital thorns (O)
tail thorns
mid-dorsal thorns (D)
nuchal thorns (N)
scapular thorns (S)
caudal fin
DORSAL


precaudal length
tail length
snout length
disc width


snout flexible
pectoral radials nearly reaching snout cartilage
Bathyraja


snout stiff
pectoral radials not reaching snout cartilage
Raja


indented pectoral fins
claspers
malar and alar hooks
MALE


pectoral fins not indented
FEMALE

KEY TO THE SKATES (RAJIDAE) OF ALASKA

1a. Snout firm to tip; pectoral fin rays fall distinctly short of tip of snout…….…………..
……………………………………………………………………(genus *Raja*)……. **2**

1b. Snout flexible, especially near tip; pectoral fin rays nearly reach tip of snout…………
………………………………………………………………(genus *Bathyraja*)…..**4**

2a.(1) Rostral thornlets present; two or three pairs of scapular thorns………………………..
……………………………………………......**roughshoulder skate** (*Raja badia* p. 4)

2b. Rostral thornlets and scapular thorns absent……………………...……………..……**3**

3a.(2) Posterolateral margin of pelvic fin slightly concave; base of pectoral fin with large ocellus surrounded by ring of light spots; ventral surface nearly white; body diamond-shaped………………...……………………**big skate** (*Raja binoculata* p. 5)

3b. Posterolateral margin of pelvic fin deeply notched; base of pectoral fin with ring of dark pigment; ventral surface dark; body elongate with very long snout…….………
…………………………………...……………..**longnose skate** (*Raja rhina* p. 6)

4a.(1) Scapular thorns present…………………………...…………….………………….. **5**

4b. Scapular thorns absent…………………………...…………………………………**.7**

5a.(4) Denticles absent from area surrounding tail thorns; orbital thorns present (but often obscure)………………………………..…**Alaska skate** (*Bathyraja parmifera* p. 7)

5b. Denticles surrounding tail thorns; orbital thorns absent………………..……………. **6**

6a.(5) Mid-dorsal row of thorns usually interrupted; tail thorns reduced along length of tail, 0-2 reduced thorns between dorsal fins; dorsal surface brown…………………...……
………………………………………….....**Bering skate** (*Bathyraja interrupta* p. 8)

6b. Mid-dorsal row of thorns continuous (may be worn down in older specimens); tail thorns not reduced along length of tail, 1-2 strong thorns between dorsal fins; dorsal surface gray……………………...………….**Aleutian skate** (*Bathyraja aleutica* p. 9)

7a.(4) Ventral surface typically creamy white (may be blotchy); dorsal surface in life brown; disc with thorns absent; median tail thorns weakly developed and progressively smaller towards tip of tail……………………………......……………………….…**8**

7b. Ventral surface dusky, black, or blotchy; dorsal surface in life gray with white blotches, black, or dusky; disc with thorns absent, reduced, or strong; median tail thorns strongly developed along entire length of tail……………….…………………**9**

8a.(7) Body small and rounded, anterior margin of pectoral fin convex; tail length greater than precaudal length…………………………. **mud skate** (*Bathyraja taranetzi* p. 10)

8b. Body large and triangular, anterior margin of pectoral fin concave; tail length less than or equal to precaudal length..…………**Okhotsk skate** (*Bathyraja violacea* p. 11)

9a.(7) Fine denticles on ventral surface of disc and tail…………..………………………….. ………………………………..……….**deepsea skate** (*Bathyraja abyssicola* p. 12)

9b. Ventral surface of disc and tail smooth…………………..…………………………..**10**

10a.(9) Mid-dorsal thorns present………..…**Commander skate** (*Bathyraja lindbergi* p. 13)

10b. Mid-dorsal thorns absent…………………...…………………………………….…..**11**

11a.(10) Nuchal thorns present (rarely absent); dorsal surface with light blotches on disk or white patches between eyes; ventral surface light to medium brown………….… **12**

11b. Nuchal thorns absent; dorsal surface uniformly dark brown to black; ventral surface dark brown or black, often with whitish mouth and cloaca…………………….……. …………………………………...…..**roughtail skate** (*Bathyraja trachura* p. 14)

12a.(11) Nuchal thorns weak, 1-3 (rarely absent); dorsal surface uniform gray-brown to dark brown, usually with white patches between eyes; ventral surface light to medium brown, with white mouth………..…..**whitebrow skate** (*Bathyraja minispinosa* p. 15)

12b. Nuchal thorns moderate, 1-7; dorsal surface dark brown with white blotches; ventral surface of disk light and blotchy, with dark tail typically separated from lighter disk by a distinct line……………………**whiteblotched skate** (*Bathyraja maculata* p. 16)

Raja badia roughshoulder skate

Diagnosis: The only Alaskan species of skate with rostral thornlets, and the only species that commonly has 2-3 pairs of scapular thorns. Also the only Alaskan species of *Raja* with scapular thorns.

Denticles: Dorsal surface evenly covered with denticles; ventral surface smooth.

Coloration: Dorsal surface gray-brown, with darker spots and blotches; ventral surface gray-brown, with white blotches on snout, abdomen, and near mouth.

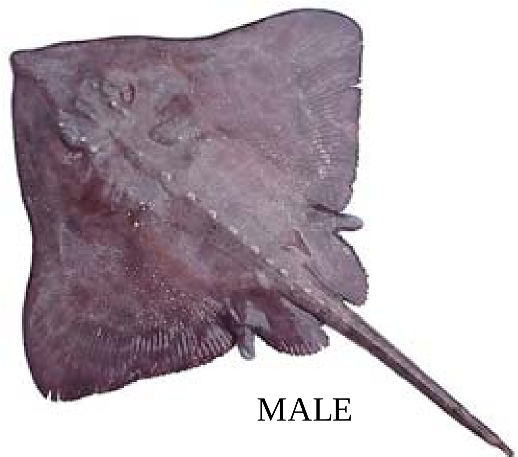
Body Shape: Disc somewhat diamond-shaped, with slightly concave anterior margin; precaudal length greater than tail length.

Juveniles:

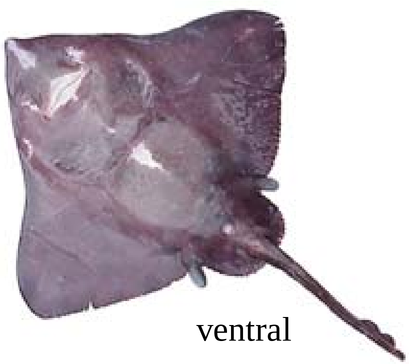
Maximum Size: 98 cm

Range: Bering Sea to California

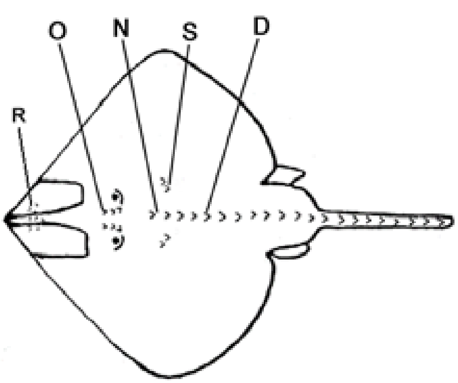
Depth: 1280-2322 m



MALE



ventral



FEMALE

4

Raja binoculata big skate

Diagnosis: The only Alaskan species of *Raja* with the following combination of characters: anterior margin of disk concave; posterolateral margin of pelvic fin slightly concave; and base of pectoral fin with large ocellus surrounded by light spots.

Denticles: Fine denticles on dorsal surface; ventral surface smooth.

Coloration: Dorsal surface brown, gray-brown or reddish brown, often with large ocellus surrounded by smaller spots on pectoral fin; ventral surface white to light gray.

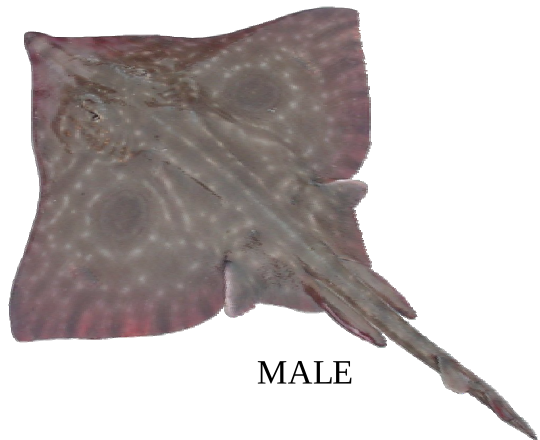
Body Shape: Disc wide, somewhat diamond-shaped, with concave anterior margin; posterolateral margin of pelvic fin slightly concave.

Juveniles:

Maximum Size: 244 cm

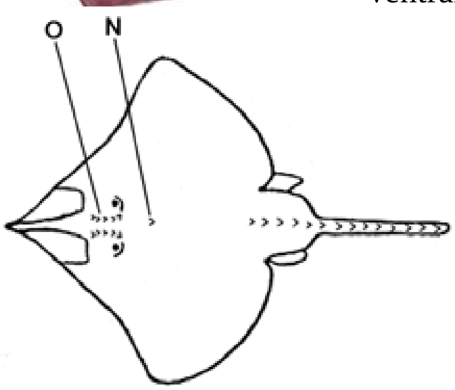
Range: SE Bering Sea to California

Depth: 16-800 m



MALE

ventral



FEMALE

Raja rhina longnose skate

Diagnosis: The only Alaskan species of *Raja* with an elongate snout and deeply notched pelvic fins.

Denticles: Fine denticles on dorsal surface; ventral surface smooth.

Coloration: Dorsal surface brown with dark blotches, may have ocelli on disk; ventral surface gray to black.

Body Shape: Disc elongate with pronounced snout; posterolateral margin of pelvic fin deeply notched.

Maximum Size: 180 cm

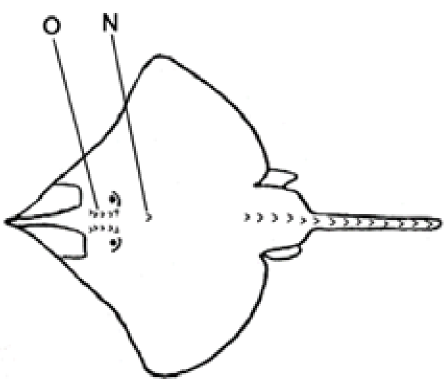
Range: Bering Sea to California

Depth: 24-675 m

MALE

ventral

FEMALE



Bathyraja parmifera Alaska skate

Diagnosis: The only Alaskan species of *Bathyraja* with orbital thorns present and scapular thorns present. Also the only species with naked area surrounding tail thorns. Row of mid-dorsal thorns may be complete or interrupted. (*B. rosispinis* may be a synonym.)

Denticles: evenly distributed on dorsal surface of juveniles, patchy on adults; ventral surface smooth.

Coloration: Dorsal surface dark brown or golden brown, often with lighter spots or blotches; ventral surface brown to white. *In Aleutians, dorsal surface with vivid olive-yellow "leopard" spotting pattern.

Body Shape: Tail length shorter than precaudal length.

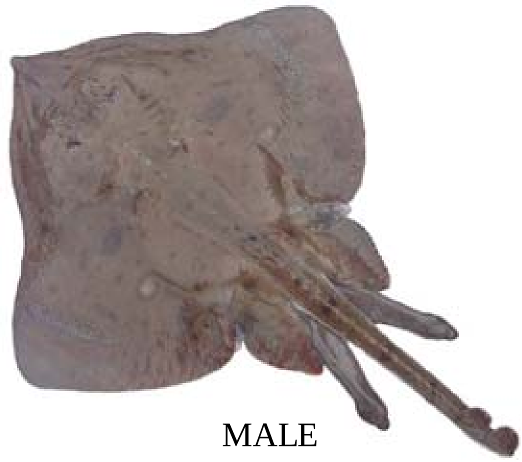
Juveniles: Denticles evenly distributed.

Maximum Size: 112 cm

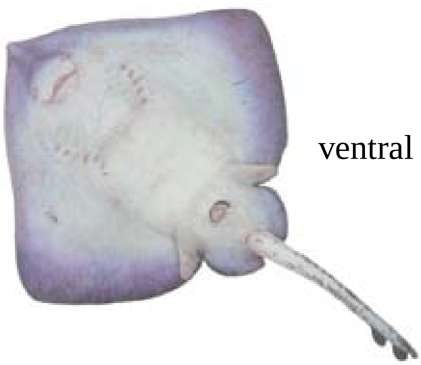
Range: Aleutian Islands, Gulf of Alaska, Bering Sea

Depth: 17-600 m

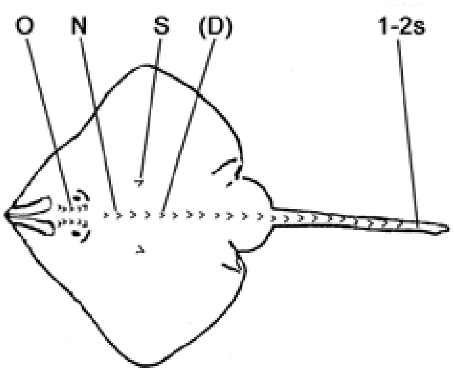
Note: Specimens with no trace of mid-dorsal thorns may be a separate species (*B. smirnovi*).



MALE



ventral



FEMALE

Bathyraja interrupta Bering skate

Diagnosis: The only Alaskan species of *Bathyraja* with the following combination of characters: orbital thorns absent; scapular thorns present; row of mid-dorsal thorns usually interrupted; tail thorns reduced, with 0-2 reduced thorns between dorsal fins.

Denticles: evenly distributed on dorsal surface; ventral surface smooth.

Coloration: Dorsal surface light to dark brown; ventral surface white.

Body Shape: Body roundish with short snout; tail length equal to or greater than precaudal length.

Juveniles: Same as adults.

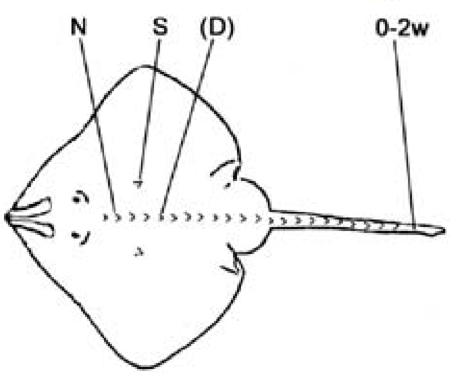
Maximum Size: 80 cm

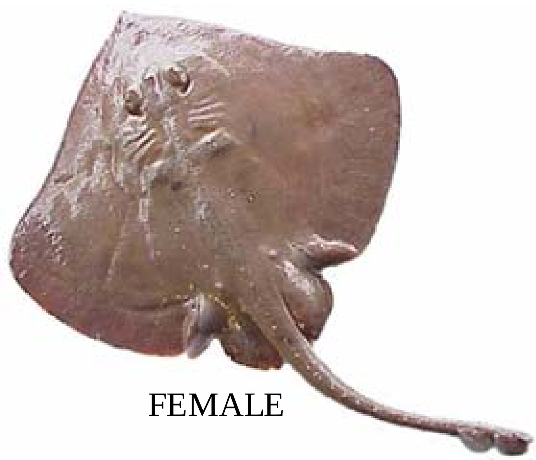
Range: Bering Sea to California

Depth: 37-1372 m

MALE

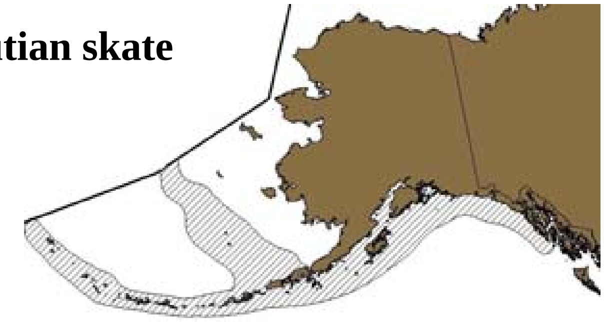
ventral





FEMALE

Bathyraja aleutica Aleutian skate



Diagnosis: The only Alaskan species of *Bathyraja* with the following combination of characters: orbital thorns absent; scapular thorns present; row of mid-dorsal thorns usually continuous; tail thorns large, with 1-2 strong thorns between dorsal fins.

Denticles: evenly distributed on dorsal surface; ventral surface smooth.

Coloration: Dorsal surface gray, with or without vague black ocellus on pectoral fin; ventral surface white with gray margin.

Body Shape: Body angled with elongate snout; tail length equal to or greater than precaudal length.

Juveniles: Same as adults.

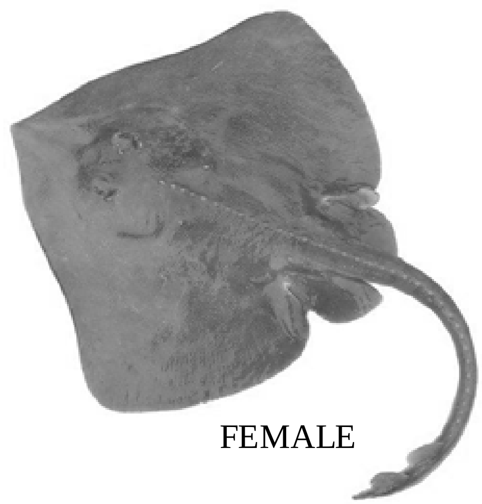
Maximum Size: 150 cm

Range: Aleutian Islands, Gulf of Alaska, Bering Sea

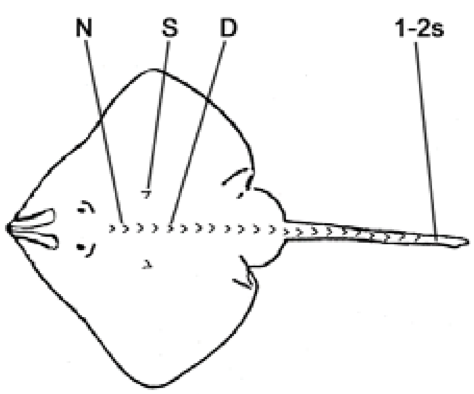
Depth: 29-950 m

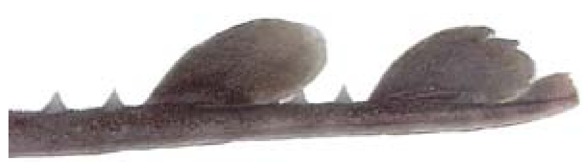
MALE

ventral



FEMALE





Bathyraja taranetzi mud skate

Diagnosis: The only Alaskan species of *Bathyraja* with the following combination of characters: disc free of thorns; body small and rounded, with tail length greater than precaudal length; ventral surface white or cream colored.

Denticles: Small and fine, evenly distributed on dorsal surface; ventral surface smooth.

Coloration: Dorsal surface brown with small darker blotches, and usually a large lighter spot on posterior part of pectoral fin; ventral surface white or cream colored. *In Aleutians, dorsal surface with distinctive yellow spots and blotches.

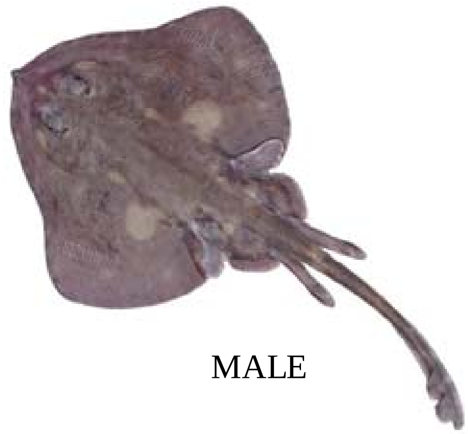
Body Shape: Body small and rounded; tail length greater than precaudal length

Juveniles: Same as adults.

Maximum Size: 70 cm

Range: Aleutian Islands, Bering Sea

Depth: 58-1054 m



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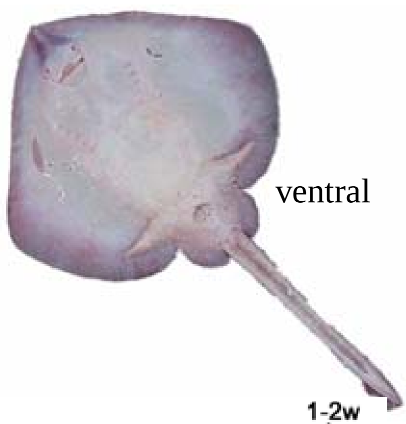
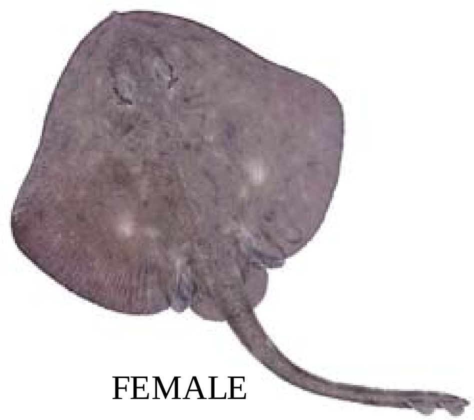


ventral



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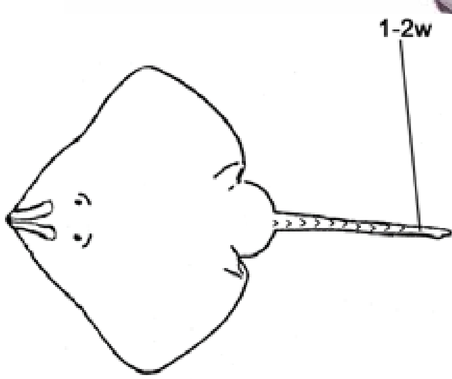


Bathyraja violacea — Okhotsk skate

Diagnosis: The only Alaskan species of *Bathyraja* with the following combination of characters: disc free of thorns; large triangular body, with tail length less than or equal to precaudal length; ventral surface white or cream colored.

Denticles: Dorsal surface with patches of small fine denticles; ventral surface smooth.

Coloration: Dorsal surface gray to brown, often with dark reticulations; ventral surface white or cream colored.

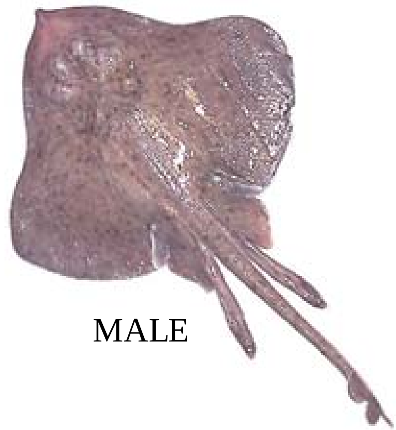
Body Shape: Body large and triangular; tail length less than or equal to precaudal length.

Juveniles: Same as adults.

Maximum Size: 73 cm

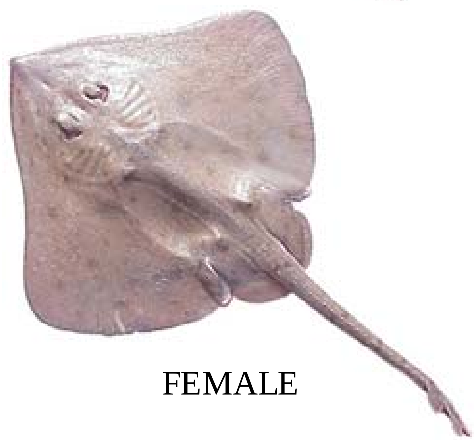
Range: Aleutian Islands, W Bering Sea

Depth: 47-520 m



MALE

ventral



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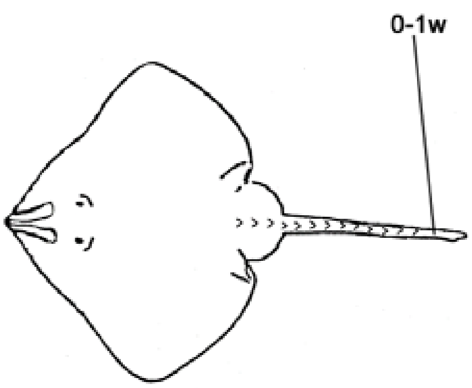


Bathyraja abyssicola deepsea skate

Diagnosis: The only Alaskan species of *Bathyraja* with fine denticles on the ventral surface.

Denticles: Fine, evenly distributed denticles on dorsal and ventral surface.

Coloration: Dorsal surface gray to brown; ventral surface gray to black, mouth and cloaca whitish, may have white blotches.

Body Shape: Tail length greater than or equal to precaudal length.

Juveniles: Same as adults.

Maximum Size: 140 cm

Range: Japan to California, Bering Sea

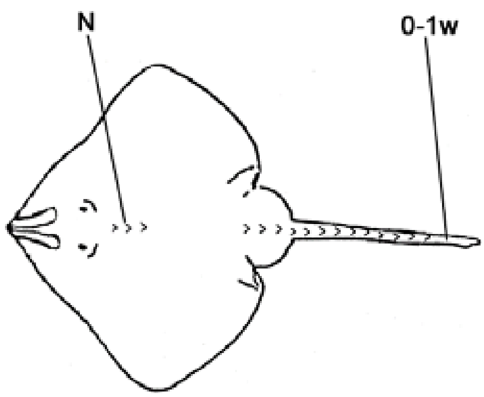
Depth: 362-2904 m

(Photo from Nakaya, 1983)

MALE

ventral

FEMALE



Bathyraja lindbergi Commander skate

Diagnosis: The only Alaskan species of *Bathyraja* with the following combination of characters: scapular and orbital thorns absent; nuchal and mid-dorsal thorns present; ventral surface without denticles.

Denticles: Dorsal surface with few, unevenly distributed denticles; ventral surface smooth.

Coloration: Dorsal surface gray brown to black; ventral surface gray to black, darker around pectoral and pelvic fin margins, white around mouth and nostrils.

Body Shape: Tail length greater than precaudal length.

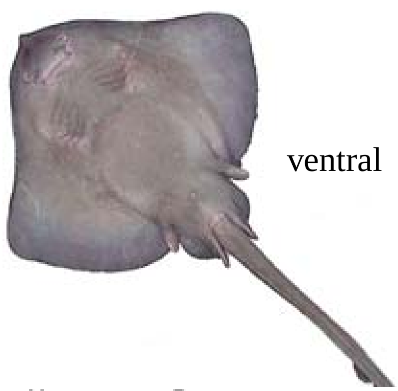
Juveniles: Same as adults.

Maximum Size: 93 cm

Range: Bering Sea, Aleutian Islands, Japan

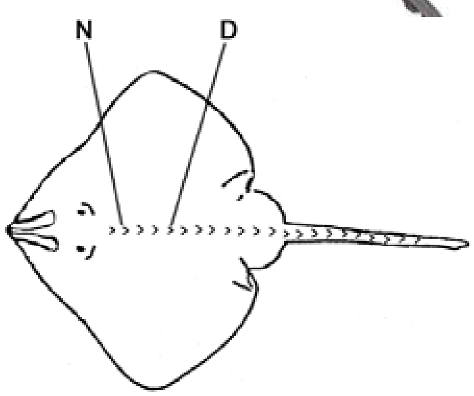
Depth: 160-1193 m

MALE



ventral

FEMALE



Bathyraja trachura roughtail skate

Diagnosis: The only Alaskan species of *Bathyraja* with the disc free of thorns and a dark ventral surface.

Denticles: Small and fine, evenly distributed on dorsal surface; ventral surface smooth.

Coloration: Dorsal and ventral surfaces dark brown to black, mouth and cloaca whitish.

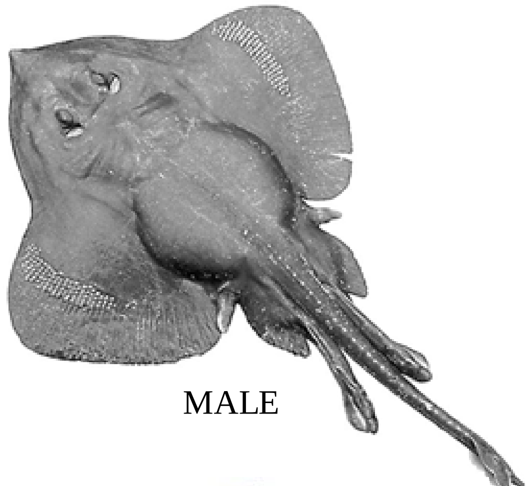
Body Shape: Tail length less than precaudal length.

Juveniles: Same as adults.

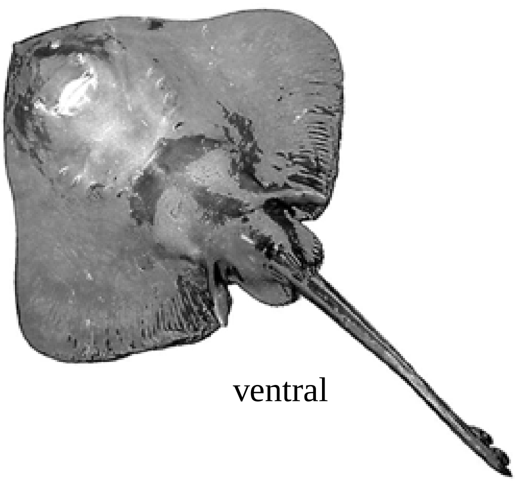
Maximum Size: 85 cm

Range: Japan to California, Bering Sea

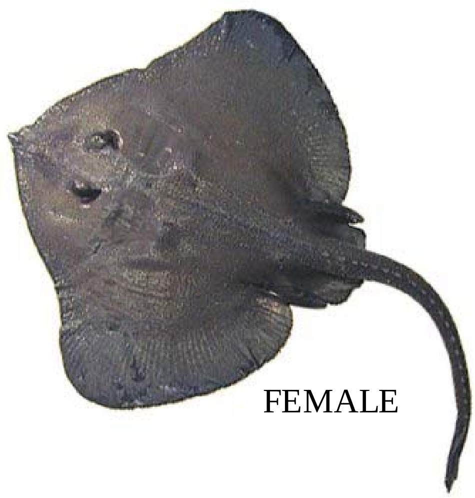
Depth: 213-1504 m



MALE



ventral



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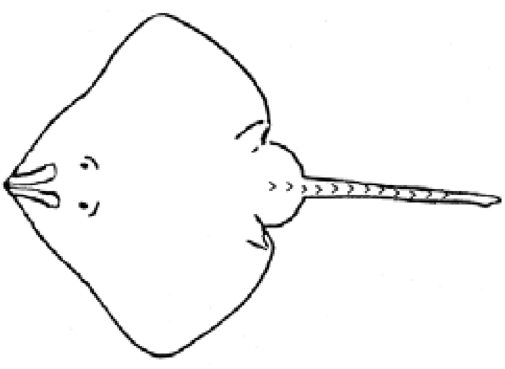


Bathyraja minispinosa whitebrow skate

Diagnosis: The only Alaskan species of *Bathyraja* with white patches around the eyes. Also distinguished by the following combination of characters: scapular, orbital, and mid-dorsal thorns absent; nuchal thorns present, but weak (occasionally absent); dorsal surface with fine denticles, ventral surface without denticles.

Denticles: Fine denticles evenly distributed on dorsal surface; ventral surface smooth.

Coloration: Dorsal surface gray brown to dark brown, interorbital region and margins of orbits white; ventral surface light to medium brown, mouth white.

Body Shape:

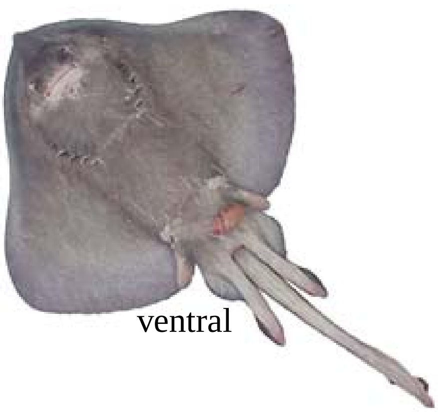
Juveniles: Same as adults.

Maximum Size: 82 cm

Range: Bering Sea, Aleutian Islands, Japan

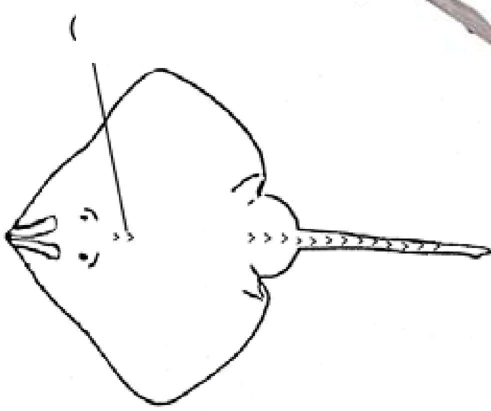
Depth: 160-1420 m

MALE



ventral

FEMALE



Bathyraja maculata whiteblotch skate

Diagnosis: The only Alaskan species of *Bathyraja* with a distinct line on the ventral surface separating the dark tail from the light body. Also distinguished by the following combination of characters: scapular, orbital, and mid-dorsal thorns absent; nuchal thorns present and strong; dorsal surface with strong denticles, ventral surface without denticles.

Denticles: Dorsal surface covered with strong denticles; ventral surface smooth.

Coloration: Dorsal surface gray with white or yellow blotches; ventral surface blotchy gray, with dark border; underside of tail dark, separated from lighter ventral surface of body by distinct line.

Body Shape:

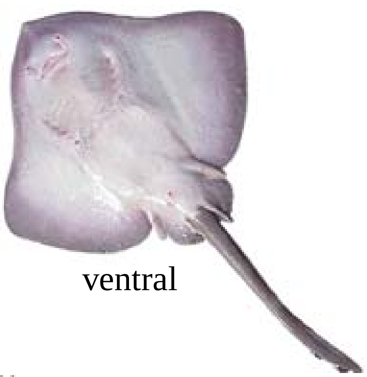
Juveniles:

Maximum Size: 120 cm

Range: Aleutian Islands, Bering Sea, Russia

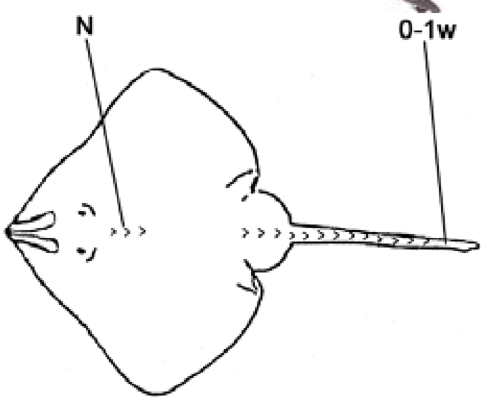
Depth: 84-1193 m

MALE



ventral

FEMALE



APPENDIX C

KEY TO THE SMELTS

(Figures not reproduced due to copyright considerations)

1A Adipose fin rectangular, attached along its entire length.......... **Capelin** (*Mallotus villosus*)
Strait of Juan de Fuca to Bering Sea

1B Adipose fin rounded, attached only in front **2**

2A(1) Opercle with distinct semicircular striations; pelvic fin origin anterior to dorsal fin origin. ....**Eulachon** (*Thaleichthys pacificus*)
Monterey Bay to Bering Sea

2B Opercle without striations; pelvic fin origin posterior to dorsal fin origin..........................**3**

3A(2) Mouth large, maxilla extending to posterior margin of eye; two large canine teeth on roof of mouth, teeth on tongue ....**Rainbow smelt** (*Osmerus mordax*)
Vancouver to Bering Sea

3B Mouth small, maxilla not extending beyond mideye; canine teeth absent, teeth small and of uniform size ....**Surf smelt** (*Hypomesus pretiosus*)
Southern California to Gulf of Alaska

APPENDIX D

Key to Selected Genera of North Pacific Sculpins

(Figures not reproduced due to copyright considerations)

1 Spinous and soft dorsal fins broadly connected..**2**

1 Spinous and soft dorsal fins separate or adjacent **3**

2(1) Spinous dorsal fin with deep notch (in one species 2 deep notches); broad band of scales (3-8 rows) at base of dorsal fin and another band below lateral line...**Genus *Hemilepidotus* (Irish lords)**

2 Spinous dorsal fin without deep notch; scales not arranged as above .... Cottidae sp.

3(1) Body covered with minute spines; head large, broad and depressed...**Genus *Hemitripterus* (Bigmouth sculpin)**

3 Body not covered with minute spines or, if covered .. with minute spines then head small, narrow and compressed...**4**

4(3) Upper preopercular spine long, straight, and without branches or serrations; lateral line smooth, without scales or plates; anterior extent of upper and lower jaws approximately equal...**Genus *Myoxocephalus* (Great sculpin, etc.)**

4 Upper preopercular spine not as described above or, if as described above then lateral line with prominent bony plates and/or lower jaw projecting anteriorly past upper Cottidae sp.

APPENDIX E

Species Identification Time Form (Sample)

Vessel/Code Dominator/A999 Observer/Cruise Mary Jones/8765

Gear Bottom Trawl Target Sp. Atka mackerel

Haul Number	Subsample?	Date	Special Project Sample?	ID Time	Comments
22	Yes	25-May	No	10 min.	No problems.
24	Yes	25-May	Yes	30 min.	Only a few skates, but three different species. Some problems with the key.
25	Yes	26-May	No	12 min.	
26	Yes	26-May	Yes	61 min.	A few skates and many sculpins, but sculpin key works well.
27	Yes	26-May	No	20 min.	
28	Yes	26-May	Yes	10 min.	No skates, sculpins, or smelts.
31	Yes	27-May	No	33 min.	Bad weather made sampling difficult.
33	Yes	27-May	Yes	21min.	Many skates, but getting easier to ID.
37	Yes	28-May	No	18 min.	
38	Yes	28-May	Yes	38 min.	Two new smelt species I haven't seen before.
39	Yes	28-May	No	22 min.	
41	Yes	29-May	Yes	48 min.	The most diverse haul yet.
44	Yes	29-May	No	17 min.	
45	Yes	30-May	Yes	45 min.	Many skates, difficult to identify because of many species.

APPENDIX F

Incidental Species Identification Special Project Species Codes

SKATES

Code	Common Name	Scientific Name
94	Big skate	*Raja binoculata*
95	Longnose skate	*Raja rhina*
166	Roughshoulder skate	*Raja badia*
90	Skate unidentified	*Rajidae*
159	Soft-nosed skate	*Bathyraja sp.*
97	Bering skate	*Bathyraja interrupta*
85	Aleutian skate	*Bathyraja aleutica*
88	Alaska skate	*Bathyraja parmifera*
165	Mud skate	*Bathyraja taranetzi*
161	Okhotsk skate	*Bathyraja violacea*
92	Deepsea skate	*Bathyraja abyssicola*
163	Commander skate	*Bathyraja lindbergi*
89	Roughtail skate	*Bathyraja trachura*
162	Whitebrow skate	*Bathyraja minispinosa*
164	Whiteblotched skate	*Bathyraja maculata*

SCULPINS

Code	Common Name	Scientific Name
407	Red Irish lord	*Hemilepidotus hemilepidotus*
414	Yellow Irish lord	*Hemilepidotus jordani*
410	Brown Irish lord	*Hemilepidotus spinosus*
418	Irish lord unid.	*Hemilepidotus sp.*
405	Great sculpin	*Myoxocephalus polyacanthocephalus*
440	*Myoxocephalus* unident	*Myoxocephalus sp.*
402	Bigmouth sculpin	*Hemitripterus bolini*

SMELTS

Code	Common Name	Scientific Name
604	Capelin	*Mallotus villosus*
601	Eulachon	*Thaleichthys pacificus*
605	Rainbow smelt	*Osmerus mordax*
613	Surf smelt	*Hypomesus pretiosus*

APPENDIX G

Skate Species Identification Form

SPECIES COMMON NAME:____

DATE:________________________

HAUL NUMBER:_______________

TOTAL LENGTH: _______________

PRECAUDAL LENGTH: _______________

TAIL LENGTH: _______________

SPECIMEN COLLECTED? YES NO

WHAT IS THE DORSAL COLORATION OF THE SKATE?

uniform brown or gray dark with light blotches

uniform black dark with white "eyebrows"

other:____

WHAT IS THE VENTRAL COLORATION OF THE SKATE?

uniform light light, with dark tail

uniform dark dark, with white areas

other:____

DENTICLES ON THE VENTRAL SURFACE? YES NO

IS THE SPECIMEN A MATURE MALE?

YES NO, FEMALE NO, IMMATURE MALE

WHICH SERIES OF THORNS ARE PRESENT?

____ Rostral

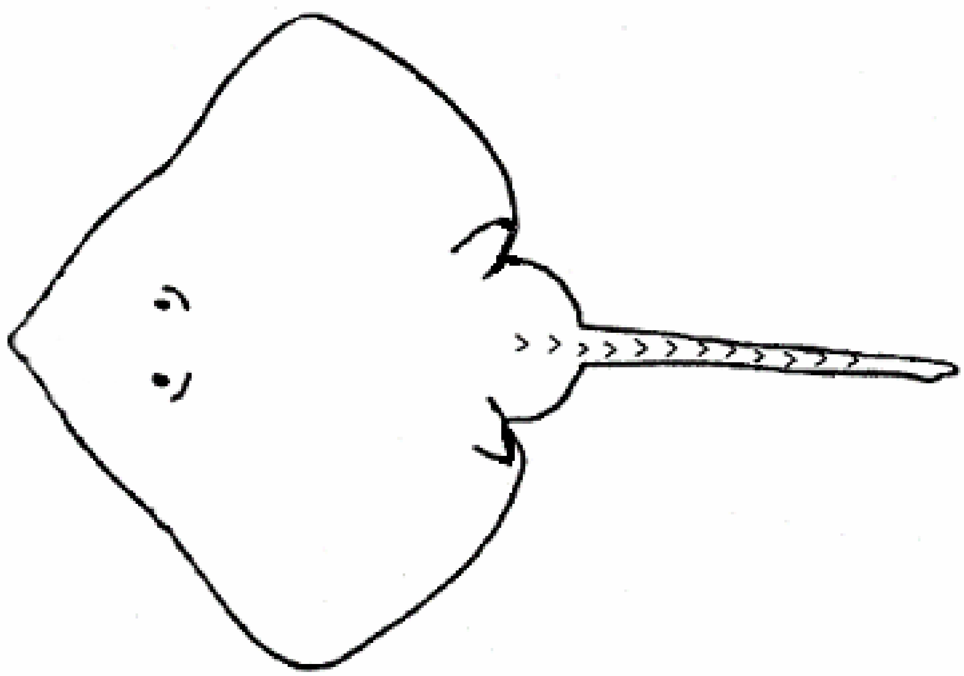
____ Orbital

____ Scapular

____ Nuchal

____ Mid-dorsal

DRAW THE THORNS ON THIS DIAGRAM –



OTHER COMMENTS: ____

____

____

____

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