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A BRIEF SURVEY OF THE MESOPELAGIC FISHES OF THE GULF OF ALASKA

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In April 2007 and March 2008 a midwater-trawl survey of the mesopelagic zone was conducted over the continental slope of the Gulf of Alaska between Kodiak Island and Prince William Sound. A total of 59 hauls were made at 6 sample stations during both day and night at target depths of 250, 500, and 1000 m using an open-mouth net. Fifty-two species of fishes representing 29 families were identified during the course of this survey. The Myctophidae was the most diverse as well as the most abundant family encountered, followed by the Bathylagidae, Melamphaidae, and Stomiidae. The most common species caught was *Stenobrachius leucopsarus*, which accounted for nearly half of the fish, and the 10 most abundant species accounted for over 90% of all specimens. Myctophids were found in every haul and the families Bathylagidae, Microstomatidae, Melamphaidae, Macrouridae, Stomiidae, and Scopelarchidae were present in more than half of the hauls.

Keywords: Bathylagidae, fish, Gulf of Alaska, mesopelagic, Myctophidae, subarctic

INTRODUCTION

Little is known of the fishes and invertebrates that inhabit the mesopelagic depths (200 – 1000 m) of the subarctic Pacific Ocean and most of the recent work done in this region has focused on the Bering Sea (e.g., Sinclair and Stabeno 2002, Kosenok and Sviridov 2006). Although of limited economic value, many of these species are important food sources for larger predators in the food web, including many economically important fishes (Yamamura and Inada 2001, Kosenok and Naidenko 2008), as well as seabirds (Vermeer and Devito 1988, Van Pelt et al. 1997) and marine mammals (Kajimura and Loughlin 1988, Ohizumi et al. 2003).

While previous studies of these fishes are not as common as those focusing on species of commercial interest, there have been historical efforts to which comparisons can be made. Frost and McCrone (1979) studied vertical distributions, diel vertical migrations, and abundance of several species of mesopelagic fishes in the eastern subarctic region of the Pacific Ocean. While their study included several families, their emphasis was on the ontogenetic trends in vertical distribution of myctophids and their role as a component of the scattering layer. Pearcy et al. (1979) conducted a midwater trawl survey to assess faunal distributions in the Bering Sea and North Pacific Ocean. Samples were collected over a wide longitudinal range and at depths from 450 m to 1400 m, demonstrating the broad geographical distribution of many fish and invertebrate species found on this survey. Willis and Pearcy (1982) used a large pelagic net with multiple opening and closing codends for a survey of the mesopelagic zone off the Oregon coast. The net used in that survey allowed depth-discrete sampling, which was particularly helpful in studying the diel vertical migrations common in mesopelagic species. Willis (1984) analyzed catches from Isaacs-Kidd midwater trawls as well as temperature and salinity data collected on 4 separate cruises over a broad latitudinal and temporal range of the Eastern Pacific Ocean to establish separate faunal regions. Willis et al. (1988) compiled data from previous cruises to describe the distribution of midwater fishes in the subarctic Pacific. Beamish et al. (1999) compared previous studies of the mesopelagic zone, primarily in the subarctic Pacific gyres, and focused on distribution and abundance of the midwater species. Most recently, Sinclair and Stabeno (2002) conducted a brief survey of the midwater fishes and invertebrates of the southeastern Bering Sea.

The Gulf of Alaska (GOA) is the subject of several ongoing surveys conducted by the Alaska Fisheries Science Center (AFSC) of the National Marine Fisheries Service, each of which focuses on different marine communities. Although bottom trawl, hydroacoustic, and larval fish surveys are conducted on a regular basis in the Gulf of Alaska, little work has been done to examine the fauna of the mesopelagic ecosystem. The objective of this brief study was to address this gap, thereby gaining a better understanding of faunal distributions in the mesopelagic zone of the GOA and providing a baseline for comparison with the distribution of similar species collected elsewhere in the subarctic Pacific Ocean and Bering Sea.

MATERIALS AND METHODS

Sampling was conducted aboard the NOAA ship R/V *MILLER FREEMAN*, a 66-m stern trawler using an open-mouth 30/26 Aleutian wing trawl. The headrope and footrope each measured 81.7 m. Mesh size tapered from 3.25-m stretched-mesh at the forward end of the trawl to 0.1 m just forward of the codend, with a 1.2-cm stretched-mesh codend liner. The net was spread using 5 m^2, 1247-kg steel doors. Gear depth was recorded using a bathythermograph attached to the net.

Six stations were selected on the continental slope equidistant along the 1500-m isobath between the eastern edge of Kodiak Island and the eastern edge of Prince William Sound (Figure 1). The goal at each station in both years (sample dates: 1-6 April 2007; 13-18 March 2008) was to sample each of the 3 target depths (250, 500 and 1000 m) twice, once during hours of daylight and once during hours of darkness. Tows were conducted along the 1500-m isobath at 3 knots for 30 minutes after the net reached equilibrium. Equilibrium was defined as the net reaching the approximate target depth and stopping descent. Equilibrium was estimated in real time using acoustic net mensuration electronics for the 250- and 500-m depths. Although no streaming data were collected, net opening dimensions usually were recorded once or twice during the tow. The net opening averaged 40 m wide

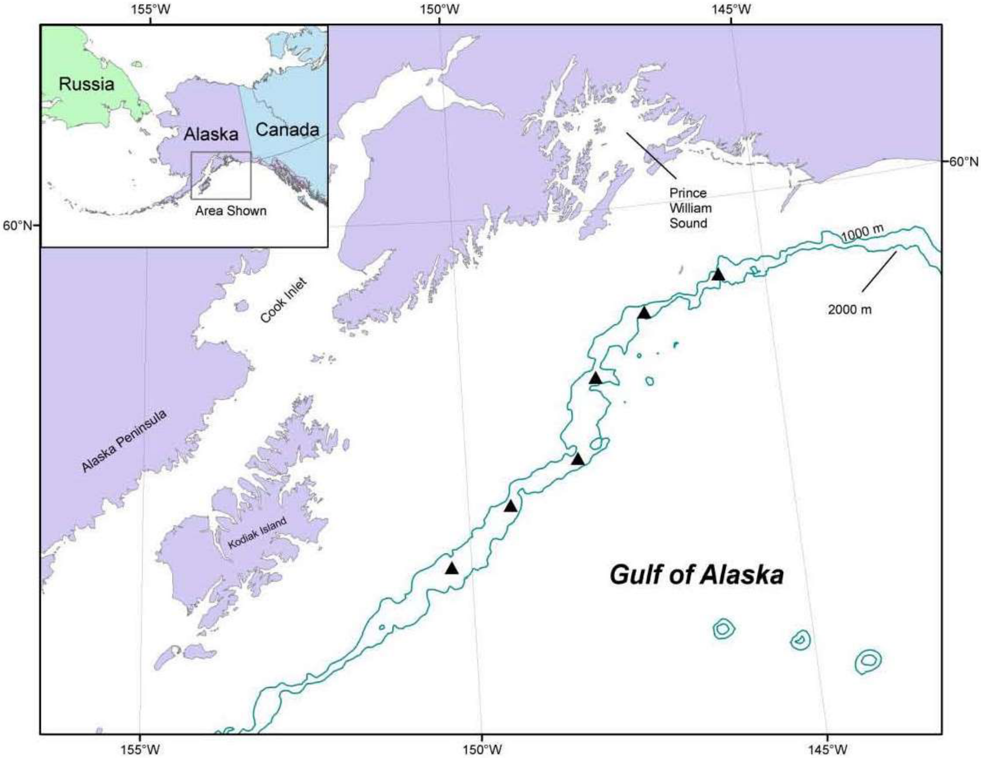

Figure 1. Stations sampled during mesopelagic surveys of the Gulf of Alaska by the R/V *MILLER FREEMAN* in April 2007 and March 2008.

and 30 m high based on these recorded measurements. Because the acoustic signal was unable to reach the net during the 1000-m tows, equilibrium was estimated using data collected from a bathythermograph which was attached to the head rope and recorded depth and temperature at 3-second intervals.

Once on deck the codend was emptied into a portable sorting bin or, if the catch was too large, onto a sorting table on deck. Catches more than about 20 kg total weight were subsampled using a plastic tub to separate a 10-15 kg sample of the unsorted catch from the sorting bin. Samples were sorted to species, counted, and weighed to the nearest gram. Unsampled portions of the catch were weighed and carefully scanned for rare species. Identifications were made using Mecklenburg et al. (2002), as well as several unpublished field guides provided by the Alaska Fisheries Science Center. Specimens of *Poromitra* and *Scopelosaurus* were identified following Kotlyar (2008) and Balanov and Savinykh (1999), respectively. For catches not entirely sampled, subsample weights and numbers were extrapolated to obtain estimates for the total catch. Species of interest were preserved in 10% formalin and later transferred to 70% ethanol for further study. All preserved specimens are archived at the University of Washington fish collection in Seattle. Invertebrates were sampled in the same manner as fishes, and will be reported elsewhere.

Because the Aleutian wing trawl was not designed for discrete depth sampling, specimens from a given haul may not have been caught at the target depth. Although every effort was made to minimize sample contamination by deploying and retrieving the net as quickly as possible, the possibility remains that many of the specimens reported here were not collected at the target depth. Because sample sizes were small (26 hauls in 2007, 33 hauls in 2008), data from the 2 cruises were combined. Specific data from the individual cruises can be obtained from the senior author.

RESULTS

A total of 59 hauls were made at the 6 stations in the northern GOA (Figure 1). Haul duration ranged from 0.30 to 1.00 h at equilibrium depth (mean = 0.52 hr), for a total effort of 30.55 h (Table 1). Fishing effort was evenly distributed between periods of daylight (14.73 h) and darkness (15.82 h) and effort expended at the 3 target depths also was evenly distributed, with the most effort targeting 500 m (10.63 h), followed by 250 m (10.04 h) and 1000 m (9.87 h). Over the course of this study every effort was made to fish the gear at the target depth using onboard electronics, past gear performance, and projected effects of wind and currents. However, 2 hauls originally targeted at 1000 m (the 2nd haul of 2007: 762 m, and the 7th haul of 2008: 867 m) were intentionally fished at shallower depths because of gear performance concerns. Catch and effort data for these hauls were included with the 1000-m data.

Over 88,000 individual fishes were caught during the course of this study, representing 52 species and 29 families (Table 2). Total haul weights (fish species only) ranged from 0.096 kg to 469.795 kg with a mean of 54.682 kg. Only 8 hauls had total weights over 100 kg and each of those exceeded this mark due to 1 species, *Albatrossia pectoralis*. The 2 most abundant families were Myctophidae, comprising 76.9% of the individuals, and Bathylagidae, which accounted for 10.2%. Other abundant families included Melamphaidae, Stomiidae, Macrouridae, Scopelarchidae, and Microstomatidae. Five families (Alepocephalidae, Anotopteridae, Icosteidae, Sternoptychidae, and Petromyzontidae) were each represented by only a single specimen throughout the survey.

A total of 7 myctophid species were identified, the most common being *Stenobrachius leucopsarus*, which accounted for over 60% of the myctophids and over 46% of all fishes. The 2nd most abundant species, *Nannobrachium regale*, accounted for 7.5% of all myctophids and 5.8% of all fishes. Other abundant myctophids included *Diaphus theta*, *Stenobrachius nannochir*, and *Protomyctophum thompsoni*. Because of the poor condition of the specimens, a relatively large number of myctophids, primarily of the genus *Stenobrachius*, could not be identified to species (Table 2). The family Bathylagidae was represented by 4 species, the most abundant of which were *Bathylagus pacificus* and *Leuroglossus schmidti* (>46% and 13.4% of all bathylagids, respectively). Three other families (Stomiidae, Macrouridae, and Scorpaenidae) were represented by at least 3 species.

Overall abundance was highest in the 500-m depth hauls, in which 50.4% of all fishes were collected (Table 2). Fish numbers were slightly lower at 1000 m (39.1%), and much lower at 250 m (10.5%). Myctophids were most abundant in the 500-m hauls, where 56.9% of the specimens were caught, and least abundant in the 250-m hauls, where only 12.6% were caught. Stomiids were also most common in the 500-m hauls and least common in the 250-m hauls. Bathylagids, however, were most abundant in the 1000-m hauls, which produced 84.0% of all specimens, and least abundant at 250 m. Melamphaids exhibited the same pattern, with 72.9% of the specimens coming from the 1000-m hauls and only 2.3% from 250-m hauls. Only 1 family, Osmeridae, was most common in the 250-m hauls.

Table 1. Summary of midwater trawls performed in the Gulf of Alaska, 2007 and 2008.

Date	Latitude	Longitude	Depth Target (m)	Depth Mean(m)	Day or Night
4/1/2007	57°10.96′	150°18.88′	500	485	N
4/1/2007	57°10.31′	150°16.35′	800	762	N
4/1/2007	57°31.11′	149°29.26′	250	247	D
4/1/2007	57°10.31′	149°29.15′	500	481	D
4/1/2007	57°30.12′	149°28.01′	1000	1014	D
4/1/2007	57°10.31′	148°26.82′	250	243	N
4/2/2007	57°50.94′	148°26.04′	500	495	N
4/2/2007	57°10.31′	148°25.47′	1000	1000	N
4/2/2007	58°21.07′	147°50.75′	250	ND	D
4/2/2007	57°10.31′	147°49.97′	500	492	D
4/2/2007	58°21.04′	147°48.50′	1000	ND	D
4/2/2007	57°10.31′	147°19.02′	250	ND	N
4/3/2007	58°55.86′	147°19.68′	500	485	N
4/3/2007	57°10.31′	147°19.32′	1000	926	N
4/3/2007	59°10.75′	146°11.51′	250	249	D
4/3/2007	57°10.31′	146°04.81′	500	488	D
4/3/2007	59°08.81′	146°04.43′	1000	1024	D
4/3/2007	57°10.31′	146°11.73′	250	250	N
4/4/2007	59°09.25′	146°05.99′	500	492	N
4/4/2007	57°10.31′	146°05.11′	1000	1052	N
4/4/2007	58°55.56′	147°20.89′	500	493	D
4/4/2007	57°10.31′	147°19.96′	250	255	D
4/5/2007	57°51.89′	148°27.80′	250	ND	D
4/5/2007	57°10.31′	147°49.44′	250	243	N
4/6/2007	58°21.13′	147°49.66′	500	498	N
4/6/2007	57°10.31′	147°49.48′	1000	1089	N
3/13/2008	57°12.85′	150°19.13′	500	481	N
3/13/2008	57°10.31′	150°18.02′	250	250	N
3/13/2008	57°10.62′	150°18.19′	250	246	D
3/13/2008	57°10.31′	150°21.61′	1000	1023	D
3/13/2008	57°39.75′	149°20.47′	250	244	N
3/14/2008	57°10.31′	149°19.26′	500	487	N
3/14/2008	57°39.36′	149°20.21′	1000	867	N
3/14/2008	57°10.31′	149°21.60′	250	241	D
3/14/2008	57°40.38′	149°22.48′	500	490	D
3/14/2008	57°10.31′	149°17.81′	1000	938	D
3/14/2008	57°59.90′	148°15.69′	250	241	N
3/15/2008	57°10.31′	148°16.71′	500	476	N
3/15/2008	57°53.66′	148°13.11′	1000	932	N
3/15/2008	57°10.31′	148°17.66′	250	239	D
3/15/2008	57°59.95′	148°16.16′	500	483	D
3/15/2008	57°10.31′	148°14.18′	1000	910	D
3/16/2008	58°38.99′	147°53.73′	500	478	N
3/16/2008	57°10.31′	147°55.15′	1000	1030	N
3/16/2008	58°38.86′	147°53.32′	250	238	D
3/16/2008	57°10.31′	147°52.97′	500	485	D
3/16/2008	58°39.01′	147°54.90′	1000	997	D
3/16/2008	57°10.31′	147°01.79′	250	244	N
3/16/2008	59°09.41′	147°00.86′	500	478	N
3/17/2008	57°10.31′	147°01.96′	1000	1061	N
3/17/2008	59°09.44′	147°00.84′	250	241	D
3/17/2008	57°10.31′	147°01.72′	500	482	D
3/17/2008	59°07.12′	146°55.06′	1000	1009	D
3/17/2008	57°10.31′	145°45.05′	250	240	N
3/17/2008	59°23.09′	145°44.12′	500	482	N
3/18/2008	57°10.31′	145°43.82′	1000	981	N
3/18/2008	59°23.72′	145°45.09′	250	238	D
3/18/2008	57°10.31′	145°45.04′	500	481	D
3/18/2008	59°21.95′	145°43.74′	1000	1002	D

Table 2. Total abundance (count of specimens) by depth for all taxa collected during midwater trawls in the Gulf of Alaska, 2007 and 2008.

Taxon	Depth (m) 250	500	1000	Total Count	Percent
Myctophidae	8,503	38,551	20,643	67,696	76.9
Stenobrachius leucopsarus	4,635	30,149	5,866	40,650	
Nannobrachium regale	140	1,157	3,816	5,113	
Diaphus theta	1,275	840	571	2,685	
Stenobrachius nannochir	104	405	1,275	1,784	
Protomyctophum thompsoni	731	108	122	961	
Lampanyctus jordani	5	24	3	32	
Tarletonbeania crenularis	11	4	2	17	
Stenobrachius sp.	1,569	5,379	7,712	14,660	
Lampanyctus sp.	2	0	0	2	
Myctophidae unidentified	31	485	1,276	1,792	
Bathylagidae	191	1,249	7,539	8,979	10.2
Bathylagus pacificus	0	72	4,095	4,167	
Leuroglossus schmidti	102	604	494	1,200	
Pseudobathylagus milleri	9	142	163	314	
Lipolagus ochotensis	0	1	1	2	
Bathylagidae unidentified	80	430	2,786	3,296	
Melamphaidae	136	1,459	4,283	5,878	6.7
Poromitra curilensis	9	294	2,873	3,176	
Melamphaes lugubris	127	1,165	1,410	2,702	
Stomiidae	267	1,232	755	2,254	2.6
Chauliodus macouni	253	1,175	733	2,161	
Tactostoma macropus	13	48	22	83	
Aristostomias scintillans	0	7	0	7	
Pachystomias microdon	0	2	0	2	
Stomiidae unidentified	1	0	0	1	
Macrouridae	9	478	606	1,093	1.2
Albatrossia pectoralis	9	478	558	1,045	
Coryphaenoides cinereus	0	0	43	43	
Coryphaenoides acrolepis	0	0	4	4	
Coryphaenoides sp.	0	0	2	2	
Scopelarchidae	8	476	267	751	0.9
Benthalbella dentata	8	476	267	751	
Microstomatidae	70	535	111	716	0.8
Nansenia candida	70	535	111	716	
Notosudidae	4	81	57	142	0.2
Scopelosaurus adleri	4	81	57	142	
Platytroctidae	0	116	11	127	0.1
Sagamichthys abei	0	116	10	126	
Maulisia argipalla	0	0	1	1	
Opisthoproctidae	0	52	30	82	0.1
Macropinna microstoma	0	52	30	82	
Scorpaenidae	20	43	6	69	0.1
Sebastes alutus	17	29	1	47	
Sebastes aleutianus	0	11	2	13	
Sebastes melanostictus	0	3	3	6	
Sebastes sp.	3	0	0	3	
Osmeridae	34	14	7	55	0.1
Mallotus villosus	30	11	7	48	
Thaleichthys pacificus	4	3	0	7	
Nemichthyidae	7	10	30	47	0.1
Avocettina infans	7	10	30	47	
Oneirodidae	0	8	25	33	<0.1
Oneirodes thompsoni	0	7	18	25	
Oneirodes bulbosus	0	1	4	5	
Oneirodes sp.	0	0	3	3	

Table 2, continued. Total abundance (count of specimens) by depth for all taxa collected during midwater trawls in the Gulf of Alaska, 2007 and 2008.

Taxon	Depth (m)			Total Count	Percent
	250	500	1000		
Squalidae	10	10	0	20	<0.1
Squalus acanthias	10	10	0	20	
Cyclopteridae	2	6	6	14	<0.1
Aptocyclus ventricosus	2	6	6	14	
Paralepididae	2	10	1	13	<0.1
Lestidiops ringens	2	4	1	7	
Arctozenus risso	0	6	0	6	
Gonostomatidae	0	0	10	10	<0.1
Gonostomatidae unidentified	0	0	10	10	
Gadidae	0	10	0	10	<0.1
Theragra chalcogramma	0	10	0	10	
Psychrolutidae	1	4	0	5	<0.1
Malacocottus aleuticus	1	4	0	5	
Pleuronectidae	3	2	0	5	<0.1
Microstomus pacificus	2	1	0	3	
Atheresthes stomias	1	1	0	2	
Salmonidae	3	1	0	4	<0.1
Oncorhynchus tshawytscha	2	1	0	3	
Oncorhynchus keta	1	0	0	1	
Neoscopelidae	0	2	1	3	<0.1
Scopelengys tristis	0	2	1	3	
Caristiidae	0	2	0	2	<0.1
Caristius macropus	0	2	0	2	
Alepocephalidae	0	0	1	1	<0.1
Asquamiceps caeruleus	0	0	1	1	
Anotopteridae	0	1	0	1	<0.1
Anotopterus nikparini	0	1	0	1	
Icosteidae	1	0	0	1	<0.1
Icosteus aenigmaticus	1	0	0	1	
Sternoptychidae	1	0	0	1	<0.1
Argyropelecus lychnus	1	0	0	1	
Petromyzontidae	1	0	0	1	<0.1
Lampetra sp.	1	0	0	1	
Totals	**9,273**	**44,352**	**34,390**	**88,015**	

Six of the 10 most abundant species in this study (*Nannobrachium regale*, *Stenobrachius nannochir*, *Bathylagus pacificus*, *Poromitra curilensis*, *Melamphaes lugubris*, and *Albatrossia pectoralis*) were most commonly encountered in the 1000-m hauls. However, the single most abundant species in this study, *Stenobrachius leucopsarus*, was most abundant in the 500-m hauls, where over 74% of specimens were captured. *Leuroglossus schmidti* and *Chauliodus macouni* were also most commonly encountered in the 500-m hauls, but in contrast to *S. leucopsarus*, these 2 species were nearly as common in 1000-m hauls. Only 1 of the 10 most abundant species (*Diaphus theta*) was most common in the 250-m hauls.

Abundance patterns at the 3 target depths for daytime hauls differed from those conducted at night (Table 3). For both day and night hauls, approximately 40% of the total fish abundance was encountered at the 1000-m depth, but the distribution of the other 60% of the specimens was markedly different. For the daytime hauls only 5.3% of specimens were captured in the shallow hauls, while 55.5% were caught in the 500-m hauls. The distribution was more even in the night hauls, with 17.7% of specimens in the shallow hauls and 42.5% in the 500-m hauls. This difference is largely a reflection of the day vs. night distribution patterns of the myctophids *Stenobrachius leucopsarus* and *Diaphus theta*, both of which were much more abundant in the 250-m hauls conducted at night. The remainder of the difference is made up almost entirely of *Stenobrachius* spp. (data not shown). In fact, nearly all of the most abundant species collected in this study showed some tendency to be collected at shallower depths at night - a pattern of vertical migration typical of many species of mesopelagic fishes and invertebrates (Frost and McCrone 1979). The only notable exception was *Albatrossia pectoralis*, which was most abundant in the 500-m hauls during the day and in the 1000-m hauls during the night; it was rarely captured in the 250-m hauls.

The most abundant family encountered in this study, Myctophidae, was the only family present in every haul. Other families with high frequency of occurrence (FO) were Bathylagidae, Microstomatidae, Melamphaidae, Macrouridae, Scopelarchidae, and Stomiidae - all of which were present in over 50% of the hauls. Bathylagids had an overall FO of 0.85. While this family was represented in all of the 500- and 1000-m hauls, it was present in just over half (FO = 0.55) of the 250-m hauls. Microstomatids had similar representation with FO values of 0.90 and 0.95 at 500 and 1000 m, respectively, but only 0.55 at 250 m. Melamphaids were present in all of the 1000-m hauls, but were less frequently encountered in the 500-m hauls (FO = 0.70) and least frequent in 250-m hauls (FO = 0.35). Macrourids exhibited a similar pattern, with FO values of 0.84, 0.60, and 0.15 at 1000 m, 500 m, and 250 m, respectively. All other families were present in fewer than half of all hauls. Six families were encountered in only 1 haul each: Alepocephalidae, Anotopteridae, Gonostomatidae, Icosteidae, Petromyzontidae, and Sternoptychidae.

Four families accounted for over 93% of the fish biomass encountered in this study. Although they represented a relatively small percentage of fish abundance, macrourids comprised over two-thirds of all fish biomass, with an average catch rate of 138.4 kg/hr, primarily due to their large average size (1.98 kg/specimen). Macrourids also exhibited a maximum per-haul catch rate (biomass) an order of magnitude higher than that of any other family. Myctophids produced the 2nd highest biomass with an overall mean catch rate of 34.79 kg/hr, bathylagids averaged 15.17 kg/hr, and melamphaids averaged 5.09 kg/hr. The biomass rankings of these families primarily reflect their relative abundance, as all are relavitely small fishes. Like the Macrouridae, the average biomass for the Scorpaenidae (4.60 kg/hr) and Squalidae (2.44 kg/hr) were relatively high in relationship to their abundance due to their large individual size.

DISCUSSION

The results of this study suggest that the mesopelagic fish community of the northern GOA is relatively species rich but numerically dominated by just a few species. Thus, although 52 fish species were encountered over the course of this study, approximately half of the specimens caught represented a single species, *Stenobrachius leucopsarus*. The 10 most abundant species accounted for > 90% of the specimens, while 17 species were represented by 5 or fewer specimens. In fact, the true abundances of *S. leucopsarus* and *S. nannochir* are higher than our numbers indicate due to the large number of damaged specimens that were identified as “*Stenobrachius* sp.” The same is true of *Bathylagus pacificus* and *Pseudobathylagus milleri*, which are difficult to identify in the field beyond

Table 3. Mean relative abundance (specimens/hr) by time of day and depth for 25 most abundant species encountered during midwater trawls in the Gulf of Alaska, 2007 and 2008.

	Daytime Depths				Nighttime Depths				
Taxon	250m	500m	1000m	All Day	250m	500m	1000m	All Night	Total
Stenobrachius leucopsarus	200.0	3993.0	571.8	1499.0	781.7	1955.4	613.8	1174.0	1330.7
Nannobrachium regale	4.3	73.6	424.2	157.3	25.7	135.6	353.6	176.8	167.4
Bathylagus pacificus	0.0	0.0	474.8	148.5	0.0	11.9	362.3	125.1	136.4
Poromitra curilensis	1.4	0.2	338.5	106.5	0.2	48.5	249.4	101.6	104.0
Melamphaes lugubris	1.8	1.5	192.0	61.2	25.9	191.7	99.7	113.8	88.5
Diaphus theta	81.0	92.3	51.2	75.2	183.2	68.7	63.6	99.7	87.9
Stenobrachius nannochir	0.2	35.7	68.8	32.7	27.9	69.2	297.1	133.3	84.8
Chauliodus macouni	12.8	146.1	79.4	75.2	40.3	83.5	69.7	66.6	70.7
Leuroglossus schmidti	0.0	62.9	47.3	34.4	22.6	52.2	52.4	43.8	39.3
Albatrossia pectoralis	0.9	60.3	52.9	35.7	0.9	33.3	59.7	32.8	34.2
Protomyctophum thompsoni	96.6	11.5	17.8	45.4	43.6	9.1	7.6	18.5	31.5
Benthalbella dentata	0.7	58.6	24.5	26.2	0.9	34.3	29.3	23.1	24.6
Nansenia candida	2.0	91.7	14.5	33.9	13.1	18.9	8.4	13.7	23.4
Pseudobathylagus milleri	0.0	0.0	24.3	7.6	2.0	23.5	9.7	12.8	10.3
Scopelosaurus adleri	0.0	1.3	9.5	3.4	0.9	12.4	2.5	5.8	4.6
Sagamichthys abei	0.0	12.6	1.1	4.3	0.0	9.6	0.9	4.0	4.1
Tactostoma macropus	0.2	8.9	0.9	3.1	2.7	1.2	3.4	2.3	2.7
Macropinna microstoma	0.0	7.0	3.3	3.2	0.0	3.3	2.8	2.2	2.7
Mallotus villosus	3.6	1.7	1.3	2.3	2.2	0.5	0.2	0.9	1.6
Avocettina infans	0.9	0.9	3.7	1.8	0.4	1.0	2.5	1.3	1.5
Sebastes alutus	0.7	5.4	0.2	2.0	2.9	0.7	0.0	1.1	1.5
Coryphaenoides cinereus	0.0	0.0	1.7	0.5	0.0	0.0	6.6	2.2	1.4
Lampanyctus jordani	0.0	1.1	0.4	0.5	1.1	3.1	0.2	1.6	1.0
Oneirodes thompsoni	0.0	0.4	3.3	1.2	0.0	0.8	0.6	0.5	0.8
Squalus acanthias	1.6	1.5	0.0	1.1	0.2	0.5	0.0	0.3	0.7
38 other taxa	89.3	537.1	1260.3	595.3	265.4	616.1	1026.1	652.4	624.9
Total	498.3	5205.5	3667.9	2957.6	1443.7	3385.1	3322.2	2810.1	2881.2

the level of family. Sinclair and Stabeno (2002) found a similar pattern in the southeastern Bering Sea, encountering 46 species of fishes. Nearly half of the specimens they caught represented a single species, *Leuroglossus schmidti*, and 92.6% of the catch represented only 4 species. Willis et al. (1988) reported that 89.0% of the fishes caught in hauls from the region they refer to as the Alaska Gyre came from 6 of the 41 fish species collected in that study. These studies all suggest that while species diversity is high in the mesopelagic zone, the community is generally dominated by a few abundant species.

Most of the fish species encountered in our study are typical of the mesopelagic communities in the subarctic Pacific, and were listed by both Willis et al. (1988) and Beamish et al. (1999). Of the 52 species of fishes collected in this study, 39 were listed by Willis et al. (1988) from the Alaska Gyre or by Beamish et al. (1999) from the eastern subarctic region. Of the other 13 species collected in this study, 5 are typically benthic species (*Atheresthes stomias*, *Microstomus pacificus*, *Sebastes aleutianus*, *S. alutus*, and *S. melanostictus*), 3 are epipelagic species (*Oncorhynchus keta*, *O. tshawytscha*, and *Thaleichthys pacificus*), and 3 were listed by Beamish et al. (1999) from the adjoining Bering Sea (*Coryphaenoides acrolepis*, *Malacocottus aleuticus*, and *Scopelengys tristis*). The other 2 species (*Asquamiceps caeruleus* and *Maulisia argipalla*) were reported for the 1st time from the eastern subarctic Pacific as part of this study (Stevenson et al. 2009). Thirty-two of the 52 species we collected were also listed by Sinclair and Stabeno (2002) from the Bering Sea, indicating a high degree of faunal overlap between the 2 regions.

The preponderant species of the mesopelagic community in the GOA is clearly *Stenobrachius leucopsarus*. This species dominated the catch in terms of abundance, frequency of occurrence (FO), and biomass at all depths regardless of time of day. *S. leucopsarus* appears to be the largest forage resource available to the mesopelagic community and is, therefore, an important component of the midwater ecosystem in this region. This result echoes the findings of several other studies conducted in the North Pacific. Frost and McCrone (1979) found *S. leucopsarus* to be the most abundant fish species in the eastern subarctic Pacific, and Willis et al. (1988) reported that *S. leucopsarus* dominated mesopelagic catches in all areas of the subarctic Pacific except the Western Transition Zone, where another myctophid, *Diaphus theta*, was most abundant. Beamish et al. (1999) described *S. leucopsarus* as the most ecologically important midwater fish species of the subarctic Pacific gyres and estimated the biomass of this species at approximately 21 million tons in their study area. In contrast to these results, catches reported by Sinclair and Stabeno (2002) from the mesopelagic zone of the southeastern Bering Sea were dominated by *Leuroglossus schmidti*, a bathylagid that comprised nearly half the total catch weight. This relative abundance of *L. schmidti* in the Bering Sea was also reported by Willis et al. (1988), and is more similar to the abundance pattern found in the Sea of Okhotsk (Balanov and Il'inskii 1992) than to the subarctic Pacific. However, as in the present study, Sinclair and Stabeno (2002) also encountered high abundances of *Stenobrachius leucopsarus*, *S. nannochir*, *Bathylagus pacificus*, and *Pseudobathylagus milleri*, indicating that the suite of abundant species in the mesopelagic community of the Bering Sea is not drastically different than that of the GOA.

The methods used in this study in the GOA duplicated those of Sinclair and Stabeno (2002) in the southeastern Bering Sea, so differences in catch rates and depth distributions should give some insight into differences between the mesopelagic communities of the 2 regions. Our results indicate that the most abundant family in the mesopelagic zone of the GOA is the Myctophidae, and Sinclair and Stabeno (2002) reported large numbers of myctophids as well. Although overall catch rates for all myctophids in the present study were substantially higher (34.79 kg/hr vs. 8.07 kg/hr) than those found by Sinclair and Stabeno (2002), the relative depth distributions were the same. In both studies the highest catch rates were recorded at 500 m, with slightly lower catch rates at 1000 m and much lower catch rates at 250 m. Both studies list *Stenobrachius leucopsarus* as the most abundant myctophid, but the reported depth distributions are different. Sinclair and Stabeno (2002) reported nearly equal numbers of this species at all 3 depths, while in the present study nearly 75% of the specimens came from the 500-m hauls.

Relative abundances of the other myctophid species differed as well. Sinclair and Stabeno (2002) reported relatively high catch rates of *Stenobrachius nannochir*, but relatively few *Nannobrachium regale* (reported as *Lampanyctus regalis*). In contrast, this study produced fewer *S. nannochir*, and *N. regale* was the 2nd most common myctophid species.

Bathylagids are also abundant in the mesopelagic zones of both the GOA and the Bering Sea. Sinclair and Stabeno (2002) reported extremely high overall catch rates for bathylagids in the Bering Sea (79.49 kg/hr). Our overall catch rate for this family was much lower (15.17 kg/hr), but still higher than for any other family except macrourids and myctophids. Perhaps the most striking difference between the survey conducted by Sinclair and Stabeno (2002) and our study was the catch rate of *Leuroglossus schmidti*, which accounted for nearly half of the total catch weight reported by Sinclair and Stabeno (2002), but was not even the most common bathylagid and only the 9th most abundant species in our study. Our results indicate that *Bathylagus pacificus* is the dominant bathylagid in the GOA and that *L. schmidti* is present in much smaller numbers. Thus, as noted by Sinclair and Stabeno (2002), the abundance pattern for bathylagids in the eastern Bering Sea is more similar to the Sea of Okhotsk than to the adjacent regions of the subarctic Pacific, including the GOA.

The 3rd most abundant family in this survey, Melamphaidae, was represented by 2 species with similar overall catch rates but with slightly different depth profiles. Nearly all *Poromitra curilensis* were caught at 1000 m, while *Melamphaes lugubris* was almost as common in the 500-m hauls as those at 1000 m with a few caught in the 250-m hauls. In contrast, Sinclair and Stabeno (2002) reported these 2 species almost exclusively in the 1000-m hauls. Overall catch rates of melamphaids were much higher in our study (5.09 kg/hr vs. 0.48 kg/hr), suggesting that these fishes are a more prominent component of the mesopelagic fauna in the GOA than in the Bering Sea, particularly in the upper portion of the water column.

While these comparisons provide a more meaningful understanding of the mesopelagic community of this region, they also underscore the need for future work to better understand this important ecosystem. Future studies on the mesopelagic fishes of this region could benefit greatly from the use of a multiple opening and closing (MOC) net, which would allow discrete depth samples. That method would provide a much more precise understanding of the depth stratification of this fauna and provide more insight into diel vertical migrations of these species. Another improvement would be the use of rigid codends, which would significantly improve specimen quality, allowing more specimens to be identified to the species level. Finally, a larger sample size taken over a broader spatial and temporal spectrum, as well as fecundity and larval studies would provide a better understanding of the biology and ecology of these species.

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LITERATURE CITED

Balanov, A. A., and E. N. Il'inskii. 1992. Species composition and biomass of mesopelagic fishes in the Sea of Okhotsk and the Bering Sea. Voprosy Ikhtiologii 32:56-63 (translated into English).

Balanov, A. A., and V. F. Savinykh. 1999. Redescriptions of *Scopelosaurus harryi* and *S. adleri* (Notosudidae): two valid mesopelagic species inhabiting the northern part of the Pacific Ocean. Journal of Ichthyology 39:616-625.

Beamish, R. J., K. D. Leask, O. A. Ivanov, A. A. Balanov, A. M. Orlov, and B. Sinclair. 1999. The ecology, distribution, and abundance of midwater fishes of the subarctic Pacific gyres. Progress in Oceanography 43:399-442.

Frost, B. W., and L. E. McCrone. 1979. Vertical distribution, diel vertical migration, and abundance of some mesopelagic fishes in the eastern subarctic Pacific Ocean in summer. Fishery Bulletin 76:751-770.

Kajimura, H., and T. R. Loughlin. 1988. Marine mammals in the oceanic food web of the eastern subarctic Pacific. Bulletin of the Ocean Research Institute, University of Tokyo 26:87-223.

Kosenok, N. S. and S. V. Naidenko. 2008. Feeding and daily ration of the chum salmon *Oncorhynchus keta* in the western Bering Sea in the summer-fall of 2004. Journal of Marine Biology 34:17-27.

Kosenok, N. S., and V. V. Sviridov. 2006. Feeding and vertical migrations of some mass mesopelagic fishes in the Bering Sea in autumn 2004. Transactions of the Pacific Research Fisheries Centre 146:67-79.

Kotlyar, A. N. 2008. Revision of the genus *Poromitra* (Melamphaidae): Part 2. New species of the group *P. crassiceps*. Journal of Ichthyology 48:553-564.

Mecklenburg, C. W., T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society, Bethesda, Maryland.

Ohizumi, H., T. Kuramochi, T. Kubodera, M. Yoshioka, and N. Miyazaki. 2003. Feeding habits of Dall's porpoises (*Phocoenoides dalli*) in the subarctic North Pacific and the Bering Sea basin and the impact of predation on mesopelagic micronekton. Deep-Sea Research (I) 50:593-610.

Pearcy, W. G., T. Nemoto, and M. Okiyama. 1979. Mesopelagic fishes of the Bering Sea and adjacent northern North Pacific Ocean. Journal of the Oceanographical Society of Japan 35:127-135.

Sinclair, E. H., and P. J. Stabeno. 2002. Mesopelagic nekton and associated physics of the southeastern Bering Sea. Deep-Sea Research (II) 49:6127-6145.

Stevenson, D. E., C. P. Kenaley, and N. Raring. 2009. New records of rare mesopelagic fishes from the Gulf of Alaska. Northwestern Naturalist 90:24-34.

Van Pelt, T. I., J. F. Piatt, B. K. Lance, and D. D. Roby. 1997. Proximate composition and energy density of some North Pacific forage fishes. Comparative Biochemistry and Physiology (A) 118:1393-1398.

Vermeer, K., and K. Devito. 1988. The importance of *Paracallisoma coecus* and myctophid fishes to nesting fork-tailed and Leach's storm-petrels in the Queen Charlotte Islands, British Columbia. Journal of Plankton Research 10:63-75.

Willis, J. M. 1984. Mesopelagic fish faunal regions of the northeast Pacific. Biological Oceanography 3:167-185.

Willis, J. M., and W. G. Pearcy. 1982. Vertical distribution and migration of fishes of the lower mesopelagic zone off Oregon. Marine Biology 70:87-98.

Willis, J. M., W. G. Pearcy, and N. V. Parin. 1988. Zoogeography of midwater fishes in the subarctic Pacific. Bulletin of the Ocean Research Institute, University of Tokyo 26:79-142.

Yamamura, O., and T. Inada. 2001. Importance of micronekton as food of demersal fish assemblages. Bulletin of Marine Science 68:13-25.

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