Chapter 19
Bering Sea and Aleutian Islands sculpins

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Executive Summary

This document summarizes the information currently known about the status of sculpins (Families Cottidae, Hemitripteridae, Psychrolutidae, and Rhamphocottidae) in the Bering Sea/Aleutian Islands (BSAI). In 2010, the North Pacific Fishery Management Council passed amendment 87 to the GOA Fishery Management Plan, which separated the Other Species complex into its constituent species groups. Since that time, BSAI sculpins have been managed as an independent complex with its own harvest specifications.

Summary of Changes

1. Catch and retention data are updated with partial data for 2012. In addition, all sculpin and Other Species catch data from 2003-2012 has been updated as a result of changes to the Catch Accounting System.
2. Biomass estimates and length compositions from the 2011 and 2012 Bering Sea shelf survey, the 2012 Bering Sea slope survey, and the 2012 Aleutian Islands survey have been added.

Summary of Results

	Last year		**This year**	
Quantity/Status	2012	2013	**2013**	2014
sculpin complex average mortality rate (M)*	0.28	0.28	**0.28**	0.28
Specified/recommended Tier	5	5	**5**	5
Biomass	208,181	208,181	**215,713**	215,713
F_{OFL} (*F=complex mortality rate*)	0.28	0.28	**0.28**	0.28
max F_{ABC} (maximum allowable = 0.75 *x* F_{OFL})	0.21	0.21	**0.21**	0.21
Specified/recommended F_{ABC}	0.21	0.21	**0.21**	0.21
Specified/recommended OFL (t)	58,291	58,291	**56,424**	56,424
Specified/recommended ABC (t)	43,718	43,718	**42,318**	42,318
Is the stock complex being subjected to overfishing?	no		**no**	
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)				

** The sculpin complex mortality rate is a biomass-weighted average of the instantaneous natural mortality rates for the six most abundant sculpins in the BSAI: bigmouth (Hemitripterus bolini), great (Myoxocephalus polyacanthocephalus), plain (Myoxocephalus jaok), threaded (Gymnocanthus pistilliger), warty (Myoxocephalus* *verrucosus), and yellow Irish lord (Hemilepidotus jordani). The complex mortality rate may change as new survey data become available. See "results" section for more detail.*

Responses to Comments from the Plan Teams and SSC

In December 2010, the last time a full assessment for BSAI sculpins was performed, the SSC agreed with the BSAI Plan Team that biomass estimates are reliable for sculpins in the BSAI, and supports the estimate of OFLs and ABCs for under Tier 5, as shown in the table below (metric tons), based on an estimate of M that is a weighted average for 6 species. The SSC wanted clarification from the stock assessment author of the zero values in Table 6a as to whether those values represent true zeroes or missing values. These values are missing; not all sculpins were identified to species during those years. In December 2012, the SSC agreed that an average based on the four most recent survey biomass estimates was reasonable for the GOA sculpin complex.

INTRODUCTION

Description, scientific names, and general distribution

Sculpins are relatively small, benthic-dwelling, teleost fish. This group is especially speciose; 48 species of sculpins have been identified in the Eastern Bering Sea (EBS) and Aleutian Islands (AI) region (Table 1). Sculpins are distributed throughout the Bering Sea/Aleutian Island region and they occupy all benthic habitats and depths. In this assessment, we focus on species from the genera *Myoxocephalus*, *Hemitripterus*, and *Hemilepidotus* that observers from the North Pacific Groundfish Observer Program identify to genus in commercial catches.

Management units

Historically, sculpins have been managed as part of the BSAI Other Species complex (sculpins, skates, sharks, and octopus). Specifications for this group were set by summing the individual ABCs and OFLs for each species group to create an aggregate OFL, ABC, and TAC. In 2010, the North Pacific Fishery Management Council passed amendment 87 to the GOA Fishery Management Plan, which separated the Other Species complex into its constituent species groups. Since that time, BSAI sculpins have been managed as an independent complex with its own harvest specifications. Sculpins are currently taken only as bycatch in fisheries directed at target species in the BSAI, and it is likely that future catch of sculpins will continue to be dependent on the distribution and limitations placed on target fisheries, rather than on any harvest level established for this category.

Life history and stock structure (general)

Recent studies on the reproductive biology of the five most abundant sculpin species in the Eastern Bering Sea Shelf area have given us much needed information of sculpin life history in Alaska. Prior to those studies much of the reproductive biology information came from studies in the western North Pacific. Most if not all sculpins lay adhesive eggs in nests, and many exhibit parental care for eggs (Eschemeyer et al. 1983). Markevich (2000) observed the sea raven, *Hemitripterus villosus*, releasing eggs into crevices of boulders and stones in shallow waters in Peter the Great Bay, Sea of Japan. This type of reproductive strategy may make sculpin populations more sensitive to changes in benthic habitats than other groundfish species such as walleye pollock, which are broadcast spawners with pelagic eggs. In the western Pacific, great sculpins (*Myoxocephalus polyacanthocephalus*) are reported to have relatively late ages at maturity (5-8 years, Tokranov, 1985) despite being relatively short-lived (13-15 years). This suggests a limited reproductive portion of the lifespan relative to other groundfish species. Fecundity for the great sculpin in East Kamchatka waters ranged from 48,000 to 415,000 eggs (Tokranov 1985).

The diversity of sculpin species in the FMP areas suggests that each sculpin population might react differently to natural or anthropogenic environmental changes. Within each sculpin species, observed spatial differences in fecundity, egg size, and other life history characteristics suggest local population structure (Tokranov 1985). All of these characteristics indicate that sculpins as a group might be managed separately from the Other Species complex, and perhaps most efficiently within a spatial context rather than with a global annual aggregate TAC. A recent study by TenBrink and Buckley (2012) found evidence for habitat partitioning among species *M. jaok, M. polyacanthocephalus,* and *M. scorpius*. They found that within species, larger individuals tend to be found in deeper water and diet composition differed among and within species.

Life history (BSAI-specific)

Although life history information is limited for sculpins, age and growth information is available for the great sculpin, yellow Irish lord, bigmouth, plain and warty sculpin based on samples collected from the 2005-2008 EBS shelf survey. Known life history characteristics for the most abundant sculpin species along the EBS shelf are presented in Table 2.

FISHERY

There is no directed fishing for any sculpin species in the BSAI at this time.

Background on sculpin bycatch

Skates and sculpins constitute the bulk of the Other Species catches in the BSAI, accounting for between 66-96% of the estimated totals in 1992-1997. Based on total catch estimates from 1998-2012 (Table 3), sculpins comprised 19-28% of the total Other Species catch during this time period (skates, approx. 70%). Sculpins are caught by a wide variety of fisheries, but trawl fisheries for yellowfin sole, Pacific cod, walleye pollock, Atka mackerel and flathead sole, and the Pacific cod hook-and-line fishery catch the most (Table 4a).

In 2002-2003, the observer program of the Alaska Fisheries Science Center (AFSC) initiated a species identification project which was prompted by the need to gather basic population data for groups in the Other Species complex. Beginning in January 2004, sculpin catch was identified to genus for the larger sculpin species: *Hemilepidotus, Myoxocephalus, and Hemitripterus.* In the BSAI region, *Hemitripterus* probably represents only one species, the bigmouth sculpin (Stevenson 2004). Another member of this genus, the sea raven, may occur in Alaskan waters but has never been identified in any of the BSAI shelf and slope trawl surveys conducted by AFSC. Therefore, it is reasonable to assume that all sculpins identified by observers as *Hemitripterus* sculpins were bigmouth sculpins. Beginning in 2008, all observers were required to identify to species all sculpins in the genera *Hemilepidotus, Myoxocephalus, and Hemitripterus.* According to observer catch totals, these genera form over 90% of all sculpin catch in the BSAI (Table 5).

Total sculpin catch was calculated for each target fishery responsible for sculpin bycatch (Table 4b). This analysis indicates that in the Aleutian Islands both the Pacific cod and Atka mackerel fisheries were the main fisheries catching sculpins. In the EBS the Pacific cod fisheries and the yellowfin sole fishery were the main fisheries that caught sculpins. Sculpins, in general, are not retained by fisheries in the BSAI region, and fishery observer data indicate that the retention rate has been 4-5% for the past three years (Table 3).

Comparison of the species composition of observed fishery catches to the species composition of the 3-survey average sculpin biomass estimates provides some information on the proportion of sculpin caught relative to their abundance. However, between 76-82% of sculpins in the EBS and 94-97% of sculpins in the AI were not identified to species in 2009-2011 so this analysis is uncertain. Given the data, sculpins appear to be caught in proportion to their relative biomass, with several exceptions (Table 5). Bigmouth sculpins are either overrepresented in the fishery catch in the Aleutian Islands or are more commonly identified to species than other sculpins. Bigmouth sculpins are not overrepresented in the fishery catch in the EBS, which suggests that they may actually be fished a higher proportion in the AI. Fewer Irish lords were caught in the fisheries considering their survey biomass in the EBS but not the AI, where they appear to be caught in proportion to their biomass (Table 5). These data are in contrast to a similar comparison in the Gulf of Alaska, where fishery catch composition varied considerably (see the 2011 GOA sculpin SAFE).

DATA

Commercial Catch Data

Catch trend by genus is not available before 2004, although total sculpin catch from 1998-2012 is available (Table 3). Fishery catch of sculpins has been fairly consistent between 5,000 and 7,500 t since 1998.

Survey Data

Survey Biomass Estimates

Biomass estimates are available for all identified sculpin species in the BSAI. The species composition of the sculpin complex as estimated by bottom trawl surveys of the EBS shelf, EBS slope, and AI demonstrates the diversity of this complex and the regional differences in its composition. The larger species dominate the EBS shelf, with great and plain sculpins being the most common, followed by bigmouth sculpins and yellow Irish lords (Table 6a, Figures 1 and 5). A low coefficient of variation for most of the biomass estimates of these more abundant species reflects that the EBS shelf bottom trawl survey adequately estimates the biomass of these species. Biomass estimates for the 5 most abundant sculpin species in the Eastern Bering Sea shelf seem to be relatively stable (Figure 1). However, a declining trend is clear in the butterfly sculpin, *Hemilepidotus papilio*, which declined from an average of approximately15,000 t during the first two years of the survey (1994, 1995) to on the order of 2,000 t during the two most recent survey years (Table 6b). Five trawl surveys conducted on the EBS slope (in 2002, 2004, 2008, 2010 and 2012) show that the slope contains a different sculpin community from the shelf and the AI, likely as a result of greater depths (Figure 7). In the AI, yellow Irish lord account for the highest proportion of sculpin biomass, followed by spectacled sculpin. These are followed by darkfin sculpin, great sculpin, and bigmouth sculpin, which are similar in proportion (Table 8 and Figure 2). The spectacled and scissortail sculpins are two species not found on EBS surveys. The smaller sculpin species may be less vulnerable to capture by the gear used during the bottom trawl survey because they may pass through the net. Biomass trends of sculpin species in the AI seem to be stable except for an overall increase in yellow Irish lord biomass and a decrease in great sculpin since 1980 (Figure 2).

All three regions of the BSAI were sampled in 2004, 2010, and 2012. Total BSAI sculpin biomass dropped slightly from 2004 to 2010 but increased in 2012 (239,174 t, 207,658 t, and 215,713 t respectively; Table 9). In addition, the distribution of sculpins changed slightly: sculpin biomass has decreased slightly on the EBS shelf but increased on the slope and in the AI over the past three surveys (Table 9).

Eastern Bering Sea shelf: length frequency and sample size

Length measurements (fork length, FL) have been collected for a variety of sculpin species during AFSC trawl surveys. The five most abundant species from the EBS shelf survey have been measured annually since 2001: plain sculpin, warty sculpin, great sculpin and bigmouth sculpin, and yellow Irish lord since 2003 (Figure 5). The length composition by species is generally consistent, with few small sculpins caught by the survey.

Eastern Bering Sea slope: length frequency and sample size

Size compositions of the most abundant species on the slope are shown in Figure 5. There appears to be considerable annual variability in the data, which may indicate incomplete sampling of sculpins on the slope. The length composition data for blob and bigmouth sculpins consistently show two size modes, which are unrelated to gender but may indicate that two separate life stages of bigmouth inhabit the slope.

Aleutian Islands: length frequency and sample size

In the AI, few samples have been taken for great and bigmouth sculpin, thus the length frequency analysis does not yield a complete representation of the sculpin species population's size composition, whereas yellow Irish lords show a consistent size composition. Length frequency data since 2002 are shown for these three species in Figure 6. Specimens smaller than 70 mm have not been collected for many sculpins, which may be due to size selectivity of the survey gear.

ANALYTIC APPROACH

The available data do not currently support population modeling for sculpins in the BSAI; therefore, these stocks are managed as tier 5 in the NPFMC's definitions of OFL and ABC, where OFL and ABC are estimated as a function of biomass and natural mortality.

Parameters Estimated Independently

Natural mortality

An analysis was undertaken to estimate natural mortality (M) for sculpin species found in the BSAI. Several methods were employed based on life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993, Jensen 1996), longevity (Hoenig 1983), and reproductive potential (Rikhter and Efanov 1976). Prior to 2007, little information was available for sculpin stocks in the BSAI FMP area, so M was estimated using reproductive potential methods applied to data for Russian sculpin species (Rikhter and Efanov 1976). In 2007 and 2008, the results of aging studies for EBS sculpin were used to produce M estimates specific to this area (Table 10). Estimates generated using different methods vary widely.

RESULTS

ABC and OFL recommendations

Sculpins in the BSAI are managed under Tier 5, where OFL = *M* * average survey biomass and ABC ≤ 0.75 * *M* * average survey biomass. Average biomass for the six most common species (threaded sculpin, yellow Irish lord, bigmouth sculpin, great sculpin, plain sculpin, and warty sculpin)
was calculated as the average of the last 3 surveys (2004, 2010, and 2012) in each area (Table 9). Average biomass for "other sculpins" is an average of the last 3 surveys for the rest of the species surveyed (Table 9). For the BSAI a weighted average of species-specific *M*s is applied to the aggregate sculpin biomass, with the proportional average biomass of each species providing the weights.

2013-2014 sculpin complex harvest specifications

species	3-survey average biomass				*M*	weighted contribution to mort. est.
	EBS shelf	EBS slope	AI	**BSAI**		
threaded	2,595	0	1	**2,596**	0.45	0.01
YIL	25,770	54	12,590	**38,414**	0.17	0.03
bigmouth	30,322	2,908	641	**33,871**	0.21	0.04
great sculpin	40,733	34	1,569	**42,336**	0.28	0.08
plain	59,296	0	0	**59,296**	0.40	0.12
warty	7,902	0	0	**7,902**	0.26	0.01
other	5,975	3,936	7,190	**17,101**		
total	**172,583**	**6,932**	**21,991**	**201,516**		

weighted-average mortality rate	0.28
F_{OFL}	0.28
max F_{ABC}	0.21
rec. F_{ABC}	0.21
OFL	56,424
max. ABC	42,318
rec. ABC	42.318

ECOSYSTEM CONSIDERATIONS

Ecosystem Effects on Stock

Little is known about sculpin food habits in the BSAI, especially during fall and winter months. Aydin et al. (2007) have produced some diet analyses and consumption/predation tables based on ecosystem modeling and direct species data for the BSAI. Limited information indicates that in the EBS the larger sculpin species prey on shrimp and other benthic invertebrates, as well as some juvenile walleye pollock (Figure 9). In the EBS the main predator of large sculpins (sculpins from the genera *Myoxocephalus*, *Hemitripterus* and *Hemilepidotus*) is Pacific cod (Figure 9). Although the greatest mortality of large sculpins is unexplained in the ecosystem model, their fishing mortality is due to the flatfish trawl fishery and Pacific cod longline, trawl and pot fisheries (Table 4a). Other sculpins (those sculpins not in the above genera) in the EBS feed mainly on shrimp and benthic amphipods (Figure 10). Other sculpins are preyed upon by pinnipeds, Pacific cod and small demersal fish, but their main source of mortality is from consumption by eelpouts, wintering seals and the Alaska skate (Figure 10). In the AI large sculpin have a different diet than in the EBS, consisting of crabs, Atka mackerel and miscellaneous shallow water fish (Figure 10). Large sculpins in the AI are preyed upon mainly by Pacific halibut, but the main source of their mortality is from the groundfish bottom trawl fishery (Figure 11). Diet of other sculpins in the AI consists of infauna such as polychaetes and benthic crustaceans (Figure 12). Pacific cod and walleye pollock are the main predators of other sculpins and are the main source of mortality of other sculpins in the AI (Figure 12).

Fishery Effects on the Ecosystem

Analysis of ecosystem considerations for those fisheries that affect the stocks within this complex (see Table 5) is given in the respective SAFE chapters for those fisheries The BSAI sculpin complex is not a targeted fishery; therefore reference to the effects of the fishery on the ecosystem will be described in those chapters of the fisheries that catch sculpins incidentally.

Ecosystem effects on *Sculpin complex*				
Indicator		Observation	Interpretation	Evaluation
Prey availability or abundance trends				
	Zooplankton	Stomach contents, ichthyoplankton surveys, changes mean wt-at-age	No effect	Probably no concern
a.	*Predator population trends*			
	Marine mammals	Fur seals declining, Steller sea lions increasing slightly	No effect	Probably no concern
	Birds	Stable, some increasing some decreasing	No effect	Probably no concern
	Fish (Pollock, Pacific cod, halibut)	Stable to increasing	Effects not known	Probably no concern
b.	*Changes in habitat quality*			
	Temperature regime	Butterfly sculpin biomass increases during years the cold pool extends throughout EBS shelf.	Warming of EBS shelf may shift population northward	Unknown
	Winter-spring environmental conditions	None	Probably a number of factors	Unknown
	Production	Fairly stable nutrient flow from upwelled BS Basin	Inter-annual variability low	No concern
Targeted fisheries **effects on ecosystem (see relative chapters)**				

DATA GAPS AND RESEARCH PRIORITIES

Sculpin life history has been studied more extensively in the western Bering Sea and associated waters than in the EBS or AI. Although we have recently acquired substantially more life history data for five species in the EBS concerning age and growth, data gaps continue to persist for other species in the eastern Bering Sea and Aleutian Island regions. Age validation studies could be conducted to validate the newly acquired age data from the five species in the EBS. Genetic analysis of species found in different regions would help determine if there are several stocks of sculpin species within the BSAI. Studies of habitat use and catchability studies of smaller sculpin species would be useful for determining why larger species make up most of the sculpin complex biomass. These data are necessary to improve management strategies and stock assessments for this non-target species group.

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Table 1. Members of the Sculpin complex observed during eastern Bering Sea and Aleutian Islands bottom trawl surveys. Updated 2004.

Family	**Scientific name**	**Common name**
Cottidae	*Archistes biseriatus*	Scaled sculpin
	Artediellus miacanthus	Bride sculpin
	Artediellus pacificus	Pacific hookear sculpin
	Bolinia euryptera	Broadfin sculpin
	Enophrys diceraus	Antlered sculpin
	Enophrys lucasi	Leister sculpin
	Gymnocanthus detrisus	Purplegray sculpin
	Gymnocanthus galeatus	Armorhead sculpin
	Gymnocanthus pistilliger	Threaded sculpin
	Gymnocanthus tricuspis	Arctic staghorn sculpin
	Hemilepidotus gilberti	Banded Irish lord
	Hemilepidotus hemilepidotus	Red Irish Lord
	Hemilepidotus jordani	Yellow Irish Lord
	Hemilepidotus papilio	Butterfly sculpin
	Hemilepidotus zapus	Longfin Irish lord
	Icelinus borealis	Northern sculpin
	Icelus canaliculatus	Blacknose sculpin
	Icelus euryops	Wide-eye sculpin
	Icelus spatula	Spatulate sculpin
	Icelus spiniger	Thorny sculpin
	Icelus uncinalis	Uncinate sculpin
	Jordania zonope	Longfin sculpin
	Leptocottus armatus	Pacific staghorn sculpin
	Myoxocephalus jaok	Plain sculpin
	Myoxocephalus polyacanthocephalus	Great sculpin
	Myoxocephalus quadricornis	Fourhorn sculpin
	Myoxocephalus verrucocus	Warty sculpin
	Radulinus asprellus	Slim sculpin
	Rastrinus scutiger	Roughskin sculpin
	Thyriscus anoplus	Sponge sculpin
	Triglops forficatus	Scissortail sculpin
	Triglops macellus	Roughspine sculpin
	Triglops metopias	Crescent-tail sculpin
	Triglops pingelii	Ribbed sculpin
	Triglops septicus	Spectacled sculpin
	Triglops xenostethus	Scalybreasted sculpin
	Zesticelus profundorum	Flabby sculpin
Hemitripteridae	*Blepsias bilobus*	Crested sculpin
	Hemitripterus bolini	Bigmouth sculpin
	Nautichthys oculofasciatus	Sailfin sculpin
	Nautichthys pribilovius	Eyeshade sculpin
Psychrolutidae	*Dasycottus setiger*	Spinyhead sculpin
	Eurymen gyrinus	Smoothcheek sculpin
	Malacoccottus zonurus	Darkfin sculpin
	Malacocottus kincaidi	Blackfin sculpin
	Psychrolutes paradoxus	Tadpole sculpin
	Psychrolutes phrictus	Blob sculpin
Rhamphocottidae	*Rhamphocottus richardsoni*	Grunt sculpin

Table 2. Life history information available for selected BSAI sculpin species. "O" refers to data from regions outside the EBS and AI (e.g. Kamchatka).

Species	Common Name	Maximum Length (cm)			Maximum Age		Fecundity (x1000)	Age at 50% Maturity
		O	AI	EBS	O	BSAI		
Myoxocephalus joak	Plain sculpin	75	NA	63	15	16	25.4 - 147	5 - 8
M. polyacanthocephalus	Great sculpin	82	76	82	13	17	48 - 415	6 - 8
M. verrucosus	Warty sculpin	78	NA	78		18	2.7	
Hemitripterus bolini	Bigmouth sculpin	83	83	78		20		
Hemilepidotus jordani	Yellow Irish lord	65	65	50	13	28	52 - 389	3 - 5
H. papilio	Butterfly sculpin	38		38				
Gymnocanthus pistilliger	Threaded sculpin	27		20	13	10	5 - 41	
G. galeatus	Armorhead sculpin	46		36	13		12 - 48	
Dasycottus setiger	Spinyhead sculpin	45		34	11			
Icelus spiniger	Thorny sculpin	17		17				
Triglops pingeli	Ribbed sculpin	20			6		1.8	
T. forficata	Scissortail sculpin	30		30	6		1.7	
T. scepticus	Spectacled sculpin	25	25	NA	8		3.1	
Malacoccottus zonurus	Darkfin sculpin		30	NA				

References: AFSC; Panchenko 2001; Panchenko 2002; Tokranov 1985; Andriyashev 1954; Tokranov 1988; Tokranov 1989; Tokranov 1995; Hoff 2000; Tokranov and Orlov 2001; TenBrink unpublished data.

Table 3. Total catch in metric tons (t) of sculpin complex compared to Other species catch (including squid), 1998-2009. *Data source:* NMFS AKRO BLEND/Catch Accounting System.

Year	EBS sculpin catch	AI sculpin catch	BSAI sculpin catch	% of sculpins retained
1998	5,204	1,081	6,285	
1999	4,503	967	5,470	
2000	5,673	1,413	7,086	
2001	6,067	1,603	7,670	
2002	6,043	1,133	7,176	
2003	5,184	599	5,614	1%
2004	5,242	894	6,020	1%
2005	5,114	621	5,642	2%
2006	4,907	911	5,733	3%
2007	6,505	1,016	7,702	5%
2008	6,682	935	7,368	6%
2009	5,915	1,263	7,039	9%
2010	4,210	1,420	5,421	4%
2011	4,856	502	5,358	5%
2012*	4,306	621	4,928	5%

* 2012 data are incomplete; retrieved October 11, 2012.

Table 4a. Total catch in metric tons (t) of all sculpins by target fishery in the eastern Bering Sea and Aleutian Islands, 2003-2012 by gear type (NPT: non-pelagic trawl, PTR: pelagic trawl, TRW: trawl, HAL: hook and line, POT: pot). *Source: NMFS AK regional office catch accounting system. * 2012 catch data are incomplete; retrieved September 28, 2012.*

Aleutian Islands	**Gear Type**					
Target fishery	**NPT**	**PTR**	**TRW**	**HAL**	**POT**	**Total**
arrowtooth flounder	490	0	0	126	0	616
Atka mackerel	6269	0	0	0	0	6269
flathead sole	1	0	0	0	0	1
Greenland turbot	57	0	0	202	0	259
IFQ halibut	0	0	0	1346	0	1346
Kamchatka flounder	293	0	0	0	0	293
other species	0	0	0	175	0	175
Pacific cod	1858	0	0	6572	232	8662
pollock	4	2	0	0	0	6
rock sole	0	0	0	0	0	0
rockfish	1233	0	0	20	0	1253
sablefish	0	0	0	575	9	584
Total	10205	2	0	9016	241	19464

Eastern Bering Sea	**Gear Type**					
Target fishery	**NPT**	**PTR**	**TRW**	**HAL**	**POT**	**Total**
Alaska plaice	109	0	0	0	0	109
arrowtooth flounder	2198	0	4	25	0	2227
Atka mackerel	350	0	0	0	0	350
flathead sole	9796	9	36	0	0	9841
Greenland turbot	44	0	0	1933	0	1977
IFQ halibut	0	0	0	981	0	981
other flatfish	452	0	3	0	0	455
other species	326	0	0	190	212	728
Pacific cod	16744	24	0	149029	3890	169687
pollock	345	29765	0	5	0	30115
rock sole	15312	2	0	0	0	15314
rockfish	152	0	0	19	0	171
sablefish	6	0	0	93	17	116
yellowfin sole	32028	0	0	0	0	32028
Total	77862	29800	43	152275	4119	264099

Table 4b. Total catch in metric tons (t) of all sculpins by target fishery in the eastern Bering Sea and Aleutian Islands, 2003-2011. *Source: NMFS AK regional office catch accounting system. * 2012 catch data are incomplete; retrieved September 28, 2012.*

Eastern Bering Sea										
Target fishery	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Alaska plaice	0	0	0	4	11	3	4	7	62	19
arrowtooth flounder	138	128	262	256	105	399	278	103	214	345
Atka mackerel	25	65	69	35	119	13	15	0	1	7
flathead sole	1058	1805	1376	1405	1257	1286	772	544	230	108
Greenland turbot	221	146	158	106	84	66	191	315	364	327
IFQ halibut	38	28	25	29	9	820	2	11	6	13
other flatfish	89	124	98	18	95	4	16	4	3	5
other target	232	290	33	38	64	57	7	7	2	0
	1784	2155	2214	1739	1545	1559	1329	1187	1890	1562
Pacific cod	9	1	4	6	1	5	8	6	1	6
pollock	2089	2159	2201	3397	2883	4676	4467	2478	3018	2745
rock sole	988	800	912	1595	1772	1663	2230	2137	1621	1595
rockfish	12	10	5	5	4	2	7	40	73	13
sablefish	9	5	5	15	21	18	26	4	11	1
yellowfin sole	2916	1562	2106	2260	3880	4199	4376	3540	3933	3257
	2566	2867	2939	2655	2575	2880	2568	2106	2843	2406
Total catch (mt)	4	3	4	9	5	1	9	6	9	1

Aleutian Islands										
Target fishery	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
arrowtooth flounder	0	0	0	110	8	27	90	236	106	39
Atka mackerel	383	596	517	631	687	643	900	837	494	580
flathead sole	0	0	0	0	1	0	0	0	0	0
Greenland turbot	22	4	15	19	92	11	43	45	8	0
IFQ halibut	254	267	106	61	9	562	24	29	9	24
Kamchatka flounder	0	0	0	0	0	0	0	0	111	182
other target	11	6	3	89	13	6	27	0	18	0
Pacific cod	478	862	635	857	1077	995	1250	1607	280	620
pollock	0	0	1	0	1	1	0	3	0	0
rock sole	0	0	0	0	0	0	0	0	0	0
rockfish	122	70	67	80	149	161	169	84	201	149
sablefish	75	11	26	111	45	27	82	75	95	39
Total catch (mt)	1345	1816	1370	1958	2082	2433	2585	2916	1211	1451

Table 5. Composition of observed fishery catches, 2009-2011, and species composition of the 3-survey average biomass estimate of sculpin complex biomass, by species and/or genus. Fishery catch proportions are based on on fishery observer data. *Source: NMFS AFSC FMA program.* Between 76-82% of sculpins in the EBS and 94-97% of sculpins in the AI were not identified to species in 2009-2011; therefore percentages represent relative proportions of those identified to species here.

taxon	EBS (shelf and slope)				AI			
	fishery catch composition			proportion of average survey biomass	fishery catch composition			proportion of average survey biomass
	2009	2010	2011		2009	2010	2011	
Hemitripterus* spp.*				**16%**				**1%**
H. bolini (bigmouth)	8%	12%	9%	16%	14%	9%	15%	1%
***Hemilepidotus* spp.**				**13%**				**50%**
Hemilepidotus unidentified	<1%	1%	1%	n/a	13%	22%	8%	n/a
H. hemilepidotus (RIL)	<1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%
H. jordani (YIL)	2%	4%	5%	13%	42%	42%	48%	50%
H. spinosus (BIL)	<1%	0%	0%	< 1%	0%	0%	0%	< 1%
***Myoxocephalus* spp.**				**60%**				**7%**
Myoxocephalus unidentified	1%	1%	5%	n/a	< 1%	< 1%	< 1%	n/a
M. verrucosus (warty)	2%	1%	1%	4%	< 1%	< 1%	0%	< 1%
M. jaok (plain)	26%	32%	29%	31%	< 1%	< 1%	0%	< 1%
M. polyacanthocephalus (great)	53%	42%	37%	24	5%	5%	2%	7%
Malacottus spp.								
M. zonurus (darkfin)	<1%	<1%	2%	1	26%	22%	26%	16%

** *Hemitripterus* spp. is likely all *H. bolini*.

§ Miscellaneous sculpins comprises unidentified sculpins as well as a number of minor sculpin species.

Table 6a. Eastern Bering Sea (EBS) shelf sculpin complex biomass estimates (t) and coefficients of variation (CV) for the five most abundant BSAI sculpin species, from EBS shelf surveys 1982-2010. YIL = yellow Irish lord. Asterisks represent cases in which sculpin were not identified to species.

	YIL		bigmouth		great		plain		warty	
	biomass	CV	biomass	CV	biomass	CV	biomass	CV	biomass	CV
1982	52,700	0.33	22,841	0.22	6,026	0.29	58,297	0.19	*	
1983	46,475	0.40	19,945	0.21	37,989	0.27	86,344	0.16	2,008	0.63
1984	31,569	0.32	27,644	0.21	19,204	0.33	57,482	0.12	54,900	0.33
1985	13,116	0.24	14,219	0.22	30,234	0.19	37,122	0.10	1,985	0.78
1986	25,810	0.31	11,234	0.23	56,836	0.11	48,549	0.09	293	0.50
1987	41,574	0.48	22,996	0.18	50,845	0.13	55,852	0.11	3,938	0.24
1988	24,867	0.33	22,038	0.25	47,806	0.13	53,772	0.13	3,794	0.32
1989	22,047	0.39	16,636	0.22	37,244	0.16	57,857	0.15	*	
1990	10,212	0.18	16,123	0.24	37,573	0.26	36,991	0.26	*	
1991	10,258	0.17	20,483	0.23	67,848	0.23	113,180	0.08	3,306	0.45
1992	17,091	0.20	18,300	0.21	95,097	0.15	74,712	0.13	*	
1993	22,031	0.46	19,630	0.18	67,549	0.12	87,653	0.13	49	1.00
1994	17,911	0.28	28,426	0.22	99,271	0.10	44,319	0.15	*	
1995	19,112	0.28	29,492	0.18	88,622	0.18	67,240	0.13	*	
1996	14,573	0.19	31,250	0.22	90,999	0.13	54,096	0.10	*	
1997	23,727	0.28	29,722	0.17	85,371	0.24	73,287	0.08	3,915	0.48
1998	13,913	0.31	36,276	0.24	65,840	0.22	57,306	0.09	8,968	0.33
1999	13,229	0.20	24,681	0.18	50,039	0.14	47,324	0.12	11,090	0.19
2000	11,249	0.22	26,200	0.19	62,963	0.40	43,618	0.08	11,744	0.18
2001	9,121	0.35	25,760	0.16	41,071	0.28	48,449	0.10	15,726	0.15
2002	9,415	0.35	32,180	0.34	65,888	0.19	52,525	0.17	9,630	0.20
2003	14,205	0.25	29,161	0.14	67,357	0.19	80,187	0.09	7,098	0.17
2004	33,637	0.33	34,409	0.14	61,176	0.11	69,363	0.10	10,212	0.18
2005	27,444	0.26	31,289	0.13	60,100	0.09	76,426	0.10	25,500	0.51
2006	31,720	0.44	30,118	0.13	57,804	0.10	66,851	0.10	16,136	0.25
2007	23,765	0.34	27,859	0.18	66,000	0.11	77,922	0.11	13,370	0.27
2008	32,389	0.35	30,846	0.14	70,223	0.13	56,914	0.15	11,392	0.27
2009	23,056	0.43	20,196	0.16	44,901	0.12	47,322	0.09	7,952	0.26
2010	21,518	0.45	32,477	0.13	49,665	0.14	55,132	0.12	6,991	0.27
2011	20,212	0.59	31,643	0.11	54,177	0.17	59,306	0.09	6,472	0.27
2012	22,154	0.54	24,080	0.14	40,733	0.14	53,271	0.12	6,477	0.24

Table 6b. Eastern Bering Sea (EBS) shelf sculpin complex biomass estimates (t) and 2010 coefficients of variation (CV) for the less abundant BSAI sculpin species, from EBS shelf surveys 1994-2010.

species	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Pacific hookear	7	3	0	0	12	2	3	4	2	0
crested	0	0	0	0	0	4	4	2	2	2
spinyhead	1,384	1,245	684	874	958	1,462	1,816	1,681	1,194	1,272
purplegray	0	0	0	0	21	0	0	0	0	0
armorhead	5,313	605	523	1,252	916	254	347	289	1,708	729
threaded	0	0	0	3,867	1,801	3,572	1,697	423	1,560	1,154
red Irish lord	0	0	0	0	0	42	0	0	3	0
butterfly	18,619	13,056	2,664	6,070	1,334	3,810	4,501	2,710	2,921	1,067
spatulate	0	0	0	0	14	12	23	16	19	4
thorny	397	71	191	931	1,351	1,036	992	858	814	748
darkfin	0	0	16	45	0	130	49	220	529	11
sailfin	0	0	5	0	0	0	0	0	0	0
scissortail	0	14	10	0	3	3	1	9	2	0
roughspine	0	11	0	6	50	12	35	7	3	10
crescent-tail	0	0	0	0	0	0	0	0	0	0
ribbed	0	6	108	33	71	220	78	188	156	140
spectacled	0	0	9	652	168	200	491	174	255	298

species	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	***2012 CV***
Pacific hookear	0	4	1	4	3	8	17	45	9	*0.37*
crested	0	0	23	0	0	5	0	0	0	
spinyhead	1,027	4,520	2,479	1,949	870	1,586	1,277	1,554	707	*0.19*
purplegray	0	14	4	0	6	29	14	17	21	*0.51*
armorhead	801	1,554	1,734	990	2,113	1,859	1,794	2,102	907	*0.58*
threaded	1,295	1,983	2,385	4,126	2,174	1,166	1,663	962	4,990	*0.29*
red Irish lord	73	15	0	5	0	106	0	0	*85*	*1.00*
butterfly	1,069	1,319	2,766	1,956	541	794	939	1,948	2,426	*0.49*
spatulate	13	23	47	52	23	60	60	118	49	*0.22*
thorny	696	627	667	558	940	1,159	2,384	1,394	784	*0.17*
darkfin	124	36	69	46	1	3	22	17	142	*0.85*
sailfin	0	0	0	0	0	0	1	0	0	
scissortail	0	0	42	20	27	77	9	0	0	
roughspine	62	111	168	57	176	64	77	56	19	*0.69*
crescent-tail	0	0	1	0	0	0	0	0	0	
ribbed	558	261	400	309	368	581	477	84	292	*0.34*
spectacled	29	113	365	217	184	224	503	648	156	*0.48*

Table 7. Eastern Bering Sea (EBS) slope sculpin biomass estimates (t) from the 2002-2010 EBS slope surveys and the coefficient of variation (CV) for 2012.

common name	**2002**	**2004**	**2008**	**2010**	**2012**	***2012 CV***
armorhead	1	0	0	0	0	
bigmouth	1,920	1,286	3,053	3,191	4,245	*0.17*
blacknose	122	50	39	17	21	*0.39*
blob	1,471	1,431	1,110	3,325	1,030	*0.21*
darkfin	1,525	1,804	1,073	1,082	1,530	*0.44*
flabby	0	0	0	0	0	
great	44	5	9	88	309	*0.47*
roughskin	1	0	0	0	0	
spatulate	0	0	0	0	0	
spectacled	58	57	30	29	61	*0.71*
spinyhead	1,158	698	374	372	229	*0.23*
thorny	74	39	6	8	18	*0.34*
wide-eye	12	4	4	0	2	*0.85*
yellow Irish lord	0	113	6	20	29	*0.59*
total	**6,409**	**5,497**	**5,705**	**8,136**	**7,479**	

Table 8. Aleutian Islands (AI) sculpin biomass estimates (t) from 1980-2012 AI trawl surveys and the coefficient of variation (CV) for 2012.

	biomass estimate (t)						
species	**1980**	**1983**	**1986**	**1991**	**1994**	**1997**	**2000**
yellow Irish lord	2,462	5,049	10,065	3,813	7,227	4,667	6,711
darkfin	2,535	3,442	4,245	2,874	3,795	3,442	2,533
great	8,749	11,973	6,325	4,117	2,329	2,138	1,168
spectacled	214	454	1,137	523	1,245	1,344	1,122
bigmouth	1,430	8,644	2,557	1,137	1,830	1,617	1,005
armorhead	8	641	32	168	257	105	288
scissortail	61	14	58	317	298	219	67
unidentified sculpins	436	114	74	3,531	193	75	49
spinyhead	9	7	6	8	7	71	19
threaded	0	0	11	0	0	8	0
thorny	0	36	1	1	8	0	1
antlered	0	5	180	16	0	0	0
butterfly	0	0	1	58	0	0	0
crested	0	0	0	0	0	0	0
Pacific staghorn	0	0	8,253	24	2	0	0
plain	0	0	0	0	0	0	0
warty	0	0	318	3	12	0	0
total	**15,905**	**30,377**	**33,261**	**16,589**	**17,202**	**13,687**	**12,963**

	biomass estimate (t)					
species	**2002**	**2004**	**2006**	**2010**	**2012**	***2012 CV***
yellow Irish lord	4,240	8,357	10,797	15,247	14,166	*0.16*
darkfin	3,971	4,521	4,520	5,431	4,514	*0.16*
great	1,494	1,519	2,121	1,067	1,930	*0.37*
spectacled	2,393	1,040	993	956	746	*0.18*
bigmouth	1,191	790	1,647	794	339	*0.37*
armorhead	208	506	424	637	416	*0.30*
scissortail	442	2,073	136	155	83	*0.39*
unidentified sculpins	138	100	181	124	108	*0.26*
spinyhead	23	72	12	59	3	*0.49*
threaded	0	0	0	4	0	-
thorny	2	0	0	0	1	*0.46*
antlered	20	17	8	0	0	-
butterfly	0	0	0	0	0	-
crested	0	0	0	0	0	-
Pacific staghorn	0	9	0	0	0	-
plain	32	0	0	0	0	-
warty	0	0	0	0	0	-
total	**14,155**	**19,003**	**20,838**	**24,473**	**22,306**	

Table 9. Sculpin biomass estimates for 2010 and 2004 for all three subregions of the BSAI. YIL = yellow Irish lord. These are the two most recent years where all three surveys were conducted in the same year.

	EBS shelf			EBS slope			AI			total BSAI
species	**2004**	**2010**	**2012**	**2004**	**2010**	**2012**	**2004**	**2010**	**2012**	**2012**
antlered	-	-	-	-	-	-	17	0	0	0
armorhead	803	1,956	907	-	-	-	506	637	416	1,323
bigmouth	34,409	32,477	24,080	1,289	3,191	4,245	790	794	339	28,664
blacknose	-	-	-		17	21	-	-	-	21
blob	-	-	-		3,325	1,030	-	-	-	1,030
butterfly	1,173	965	2,426	-	-	-	-	-	-	2,426
crescent-tail	-	-	-	-	-	-	-	-	-	0
crested	-	-	-	-	-	-	-	-	-	0
darkfin	124	22	142	1,798	1,082	1,530	4,521	5,431	4,514	6,186
flabby	-	-	-	-	0.39	0.21				0
great sculpin	61,176	49,665	40,733	5	88	309	1,519	1,067	1,930	42,972
Pacific hookear	0.29	17	9	-	-	-	-	-	-	9
Pacific staghorn	-	-	-	-	-	-	9	0	0	0
plain	69,363	55,135	53,271	-	-	-	-	-	-	53,271
purplegray	0	14	21	-	-	-	-	-	-	21
red Irish lord	83	0	85	-	-	-	-	-	-	85
ribbed	558	474	291	-	-	-	-	-	-	291
roughspine	62	77	19	-	-	-	-	-	-	19
sailfin	0	1	0	-	-	-	-	-	-	0
scissortail	0	9	0	-	-	-	2,073	155	83	83
spatulate	13	60	49	-	-	-	-	-	-	49
spectacled	29	503	156	57	29	61.2	1,040	956	746	963
spinyhead	1,027	1,277	707	701	372	229	72	59	3	939
thorny	696	2,385	784	39	8	19	0.40	0.10	1	804
threaded	1,295	1,501	4,990	-	-	-	0	4	0	4,990
unidentfied	-	-	-	1,486	-	-	100	124	108	108
warty	10,230	6,998	6,477	-	-	-	-	-	-	6,477
wide-eye	-	-	-	-	0.14	2.35	-	-	-	2
YIL	33,639	21,518	22,154	113	20	29	8,357	15,247	14,166	36,349
total	**214,682**	**175,054**	**162,897**	**5,488**	**8,131**	**7,476**	**19,003**	**24,473**	**22,306**	**192,679**

Table 10. Natural mortality estimates from recent life history analyses of BSAI sculpins. All values are unpublished data from T. Tenbrink. “SAFE *M*” indicates the value used in the computation of harvest recommendations for the 2010 assessment.

species	area	sex	Hoenig	Jensen	Charnov	catch curve	SAFE *M*
yellow Irish lord	EBS	*M*	0.17	0.41	0.45	0.17	0.17
	EBS	*F*	0.15	0.47	0.51	0.17	
	AI	*M*	0.21	0.23	0.27	0.17	
	AI	*F*	0.16	0.27	0.31	0.17	
threaded sculpin	EBS	*M*	0.42	0.6	0.65	n/a	0.45
	EBS	*F*	0.47	0.36	0.4	n/a	
great sculpin	EBS	*M*	0.28	0.39	0.43	0.25	0.28
	EBS	*F*	0.25	0.27	0.3	0.31	
plain sculpin	EBS	*M*	0.28	0.38	0.42	0.39	0.40
	EBS	*F*	0.26	0.27	0.55	0.41	
warty sculpin	EBS	*M*	0.28	0.58	0.63	n/a	0.26
	EBS	*F*	0.23	0.41	0.47	n/a	
bigmouth sculpin	EBS	*both*	0.21	0.21	0.24	n/a	0.21

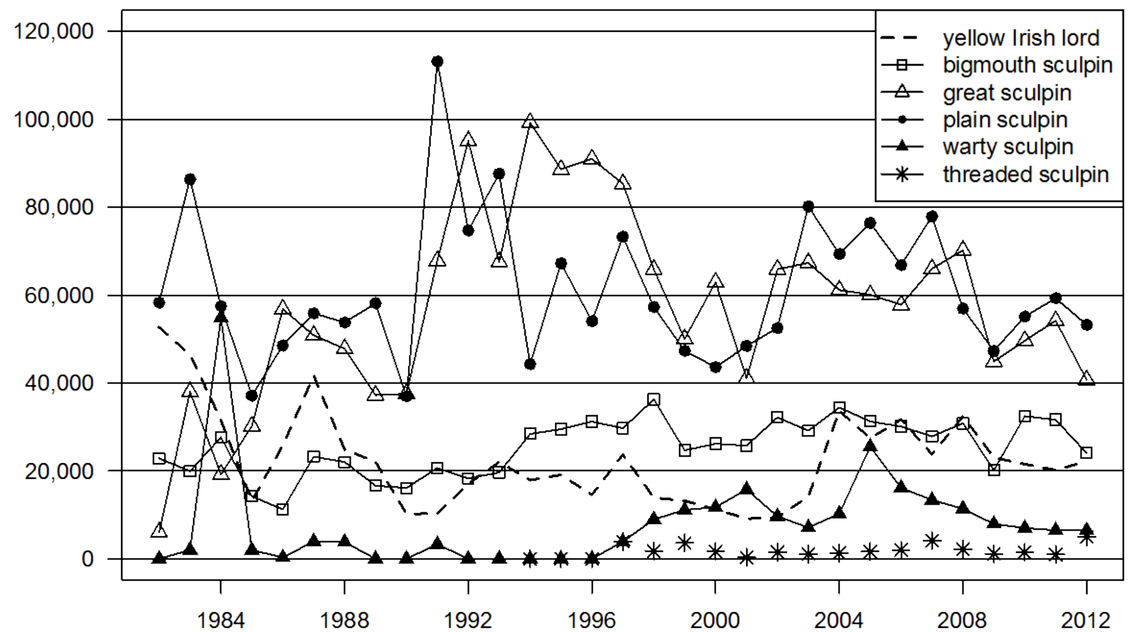


Figure 1. EBS shelf survey biomass estimates for the five most abundant sculpin species, from annual EBS shelf bottom trawl surveys for selected sculpin species, 1982-2012.

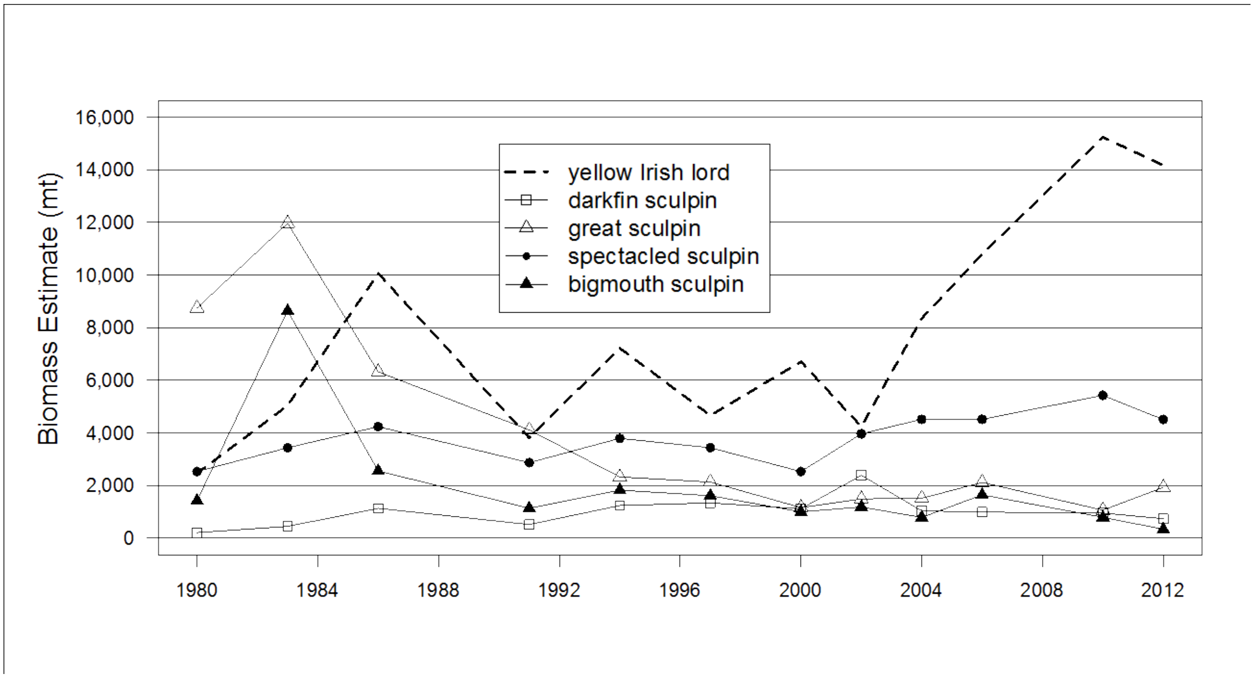


Figure 2. Aleutian Islands (AI) survey biomass estimates for the five most abundant sculpin species, from AI trawl surveys 1980-2012.

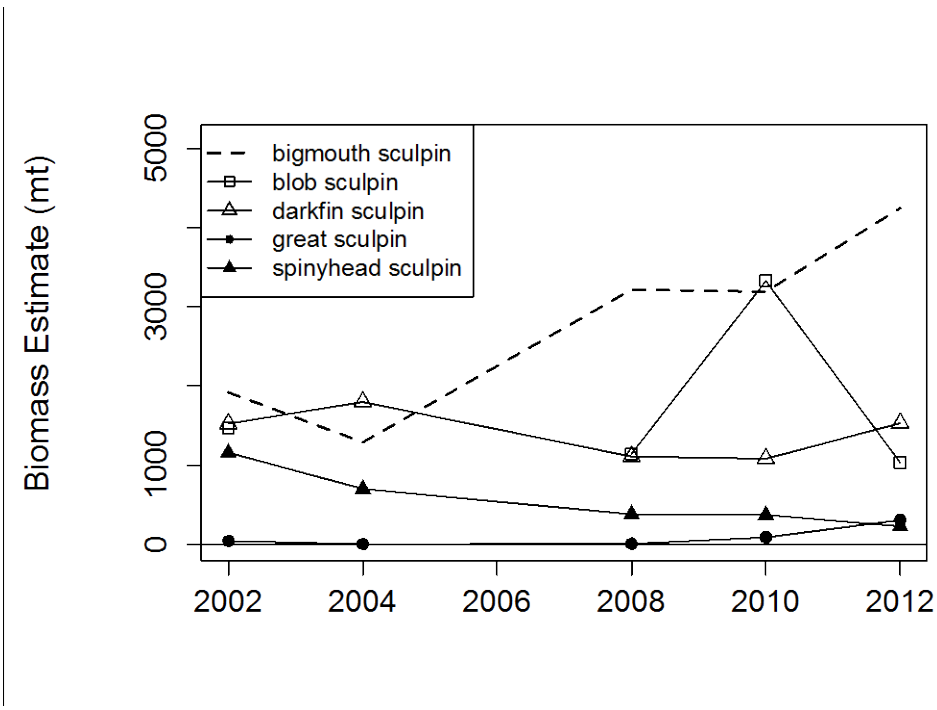
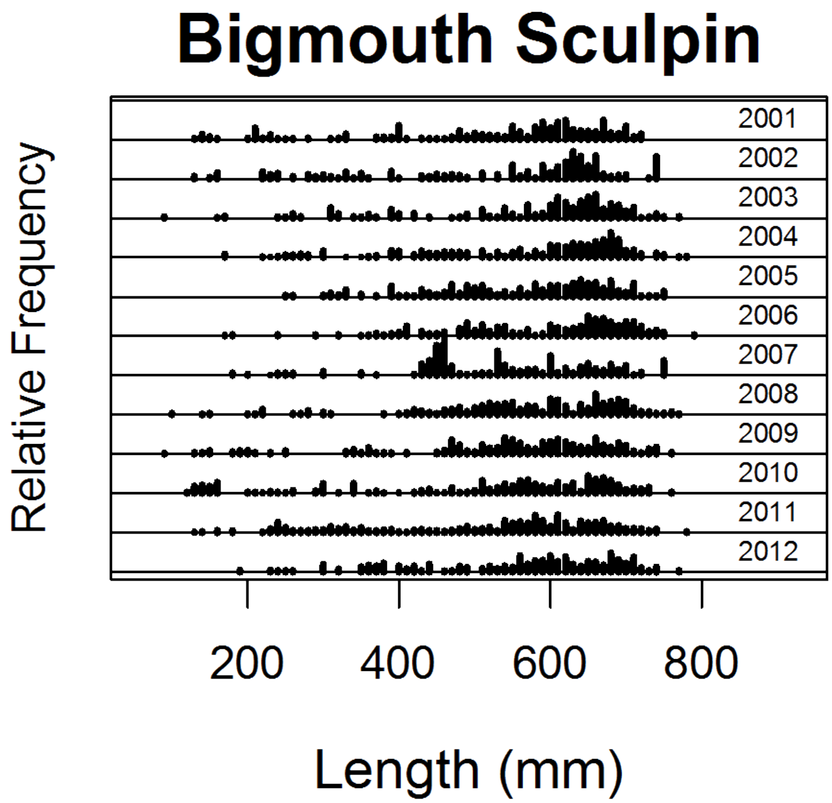


Figure 3. Bering sea slope survey biomass estimates for the five most abundant sculpin species, from slope trawl surveys 2002-2012.



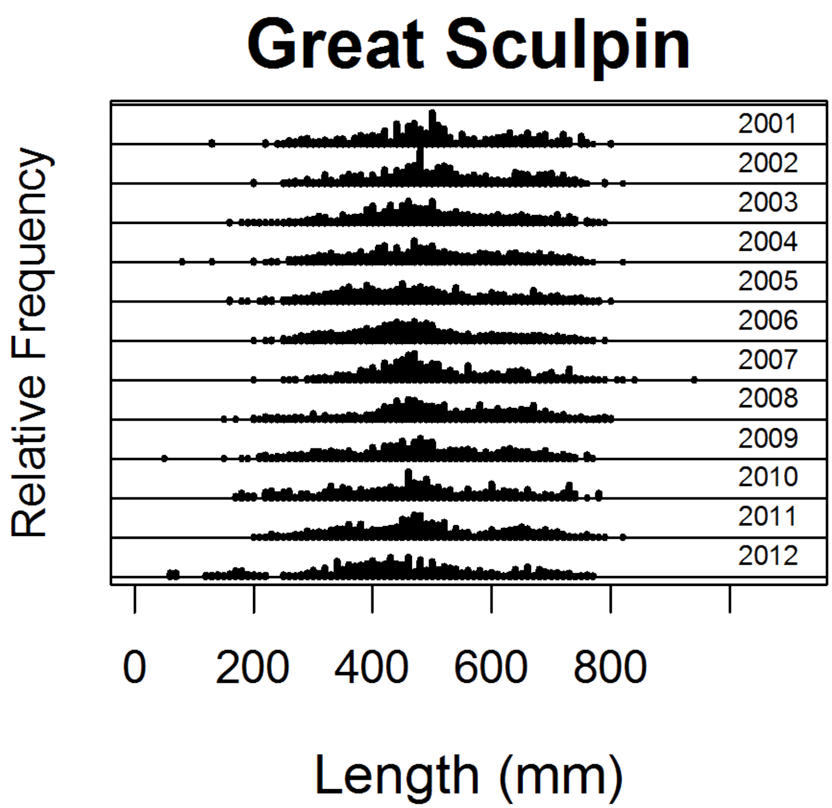


Figure 4. Length frequencies (fork length, FL in mm) from EBS shelf survey data for the five most abundant sculpin species in EBS, 2001-2012 (2003-2012 for Yellow Irish Lord). Length scale differs among plots.

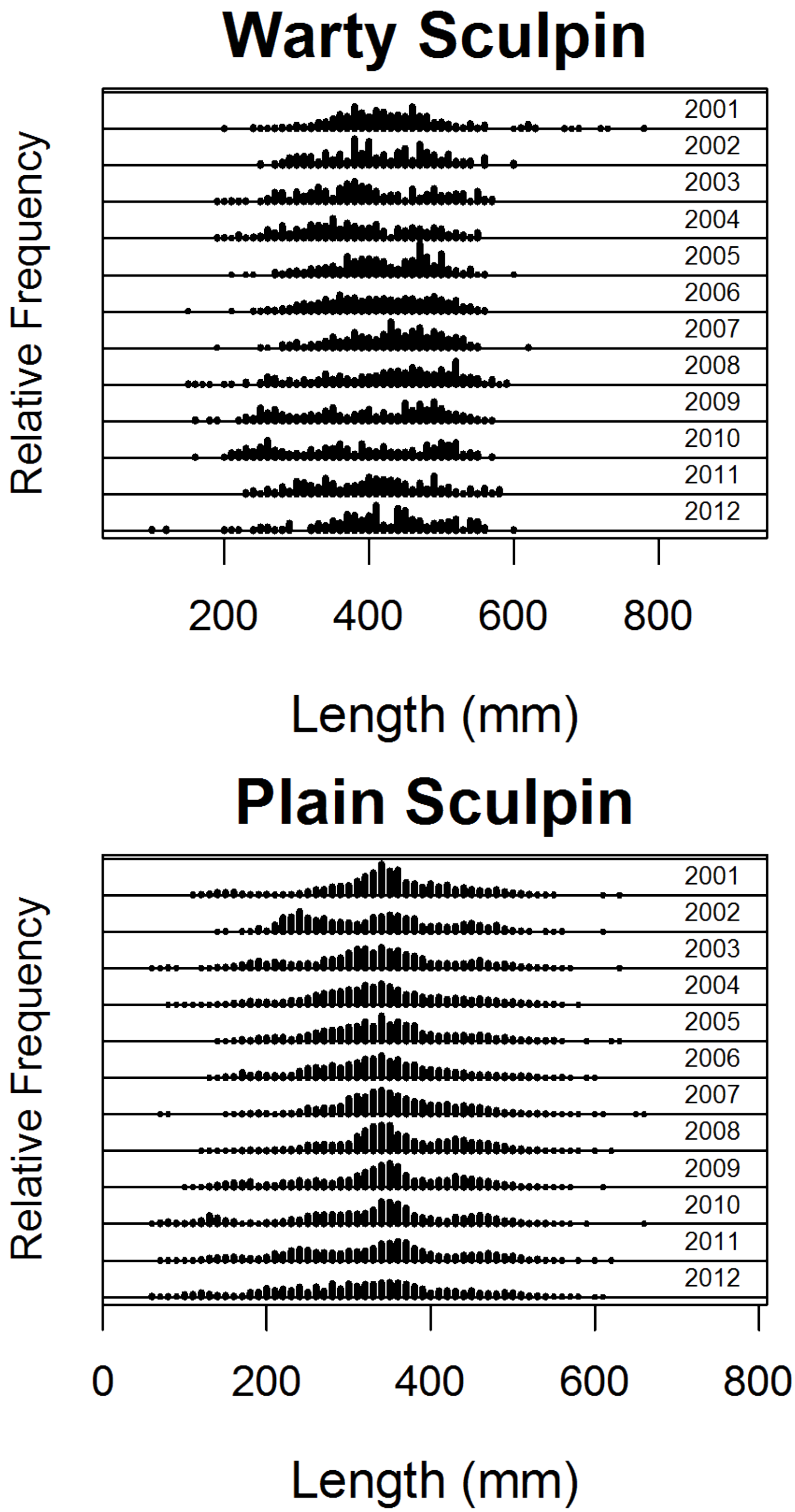


Figure 4 (continued). Length frequencies (fork length, FL in mm) from EBS shelf survey data for the five most abundant sculpin species in EBS, 2001-2012 (2003-2012 for Yellow Irish Lord). Length scale differs among plots.

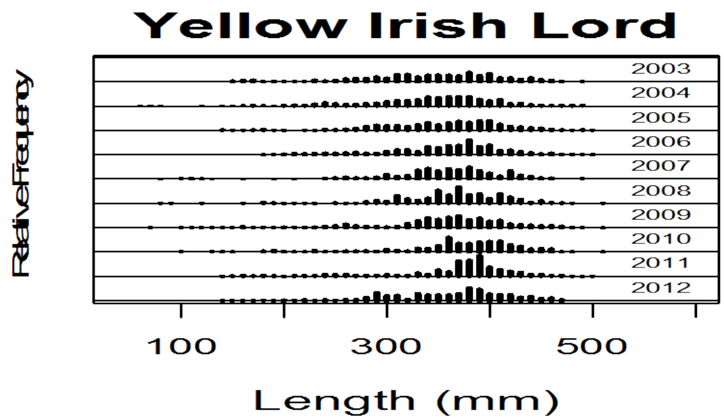


Figure 4 (continued). Length frequencies (fork length, FL in mm) from EBS shelf survey data for the five most abundant sculpin species in EBS, 2001-2012 (2003-2012 for Yellow Irish Lord). Length scale differs among plots.

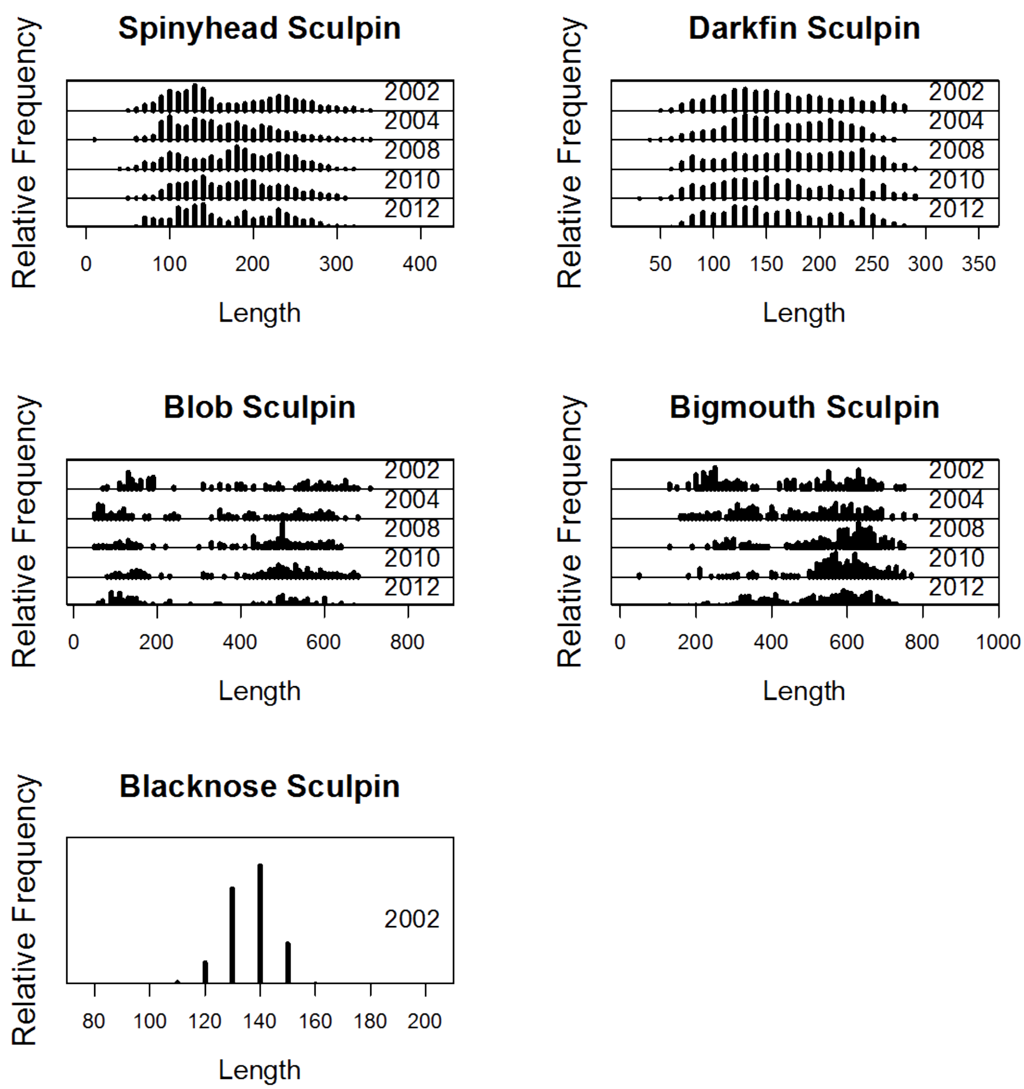


Figure 5. Length frequencies (fork length, FL in mm) from EBS slope survey data for the five most abundant sculpin species in these surveys.

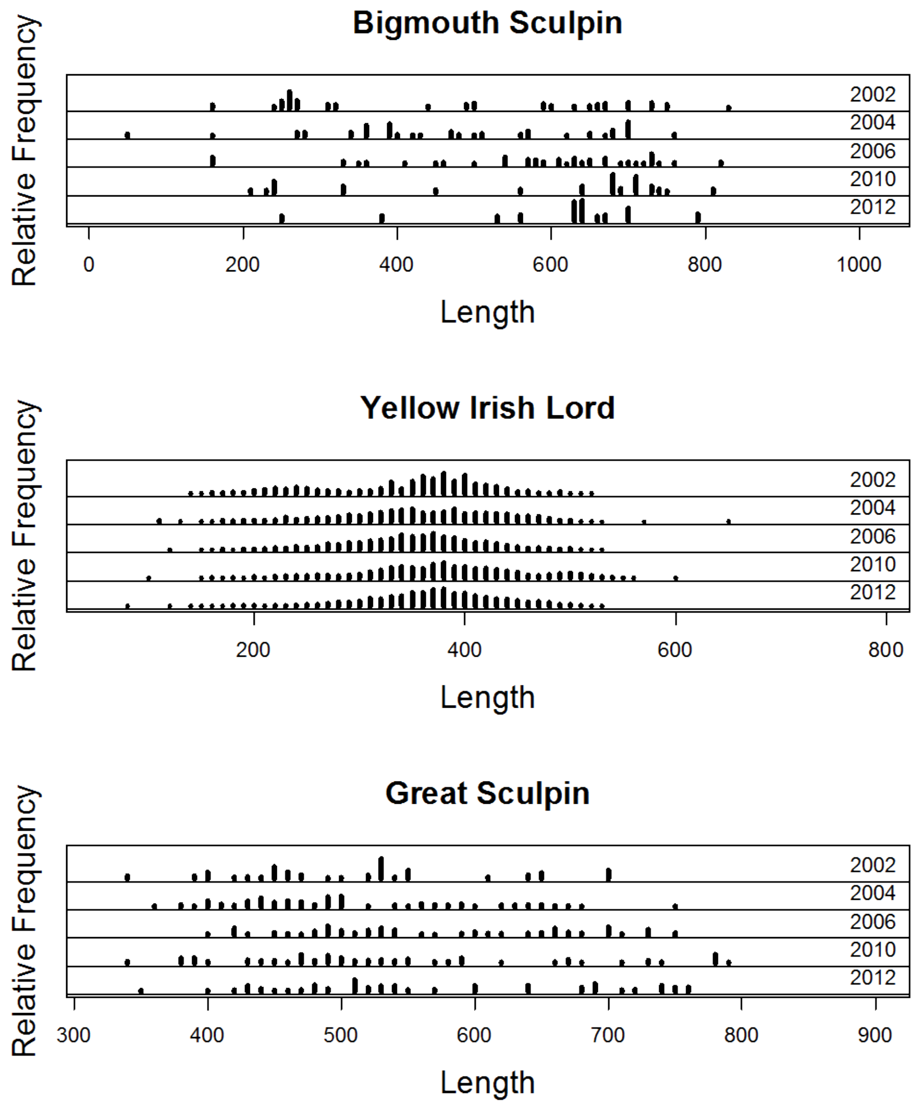


Figure 6. Survey length composition for the 3 most abundant sculpin species in the AI, 2004-2012.

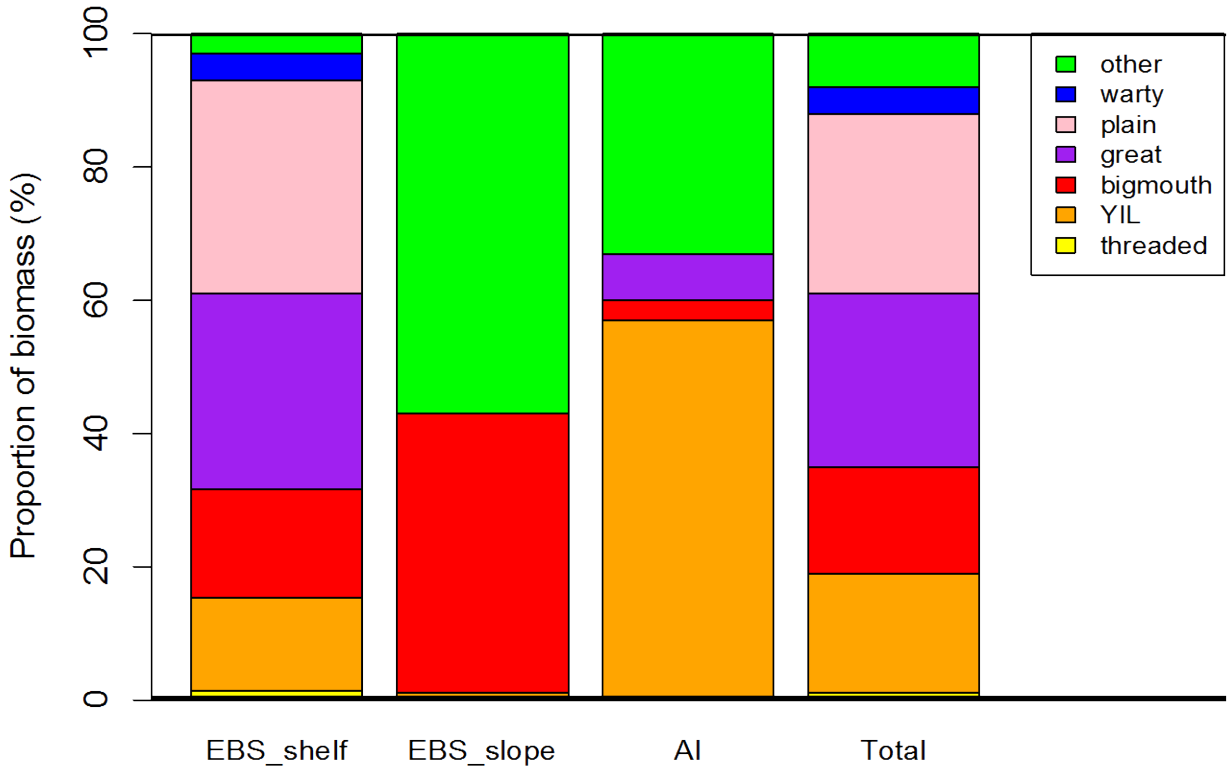


Figure 7. Species composition of the sculpin complex in the three subregions of the BSAI as well as the BSAI as a whole. "Other" sculpins contains a variety of species; see table for more detail.

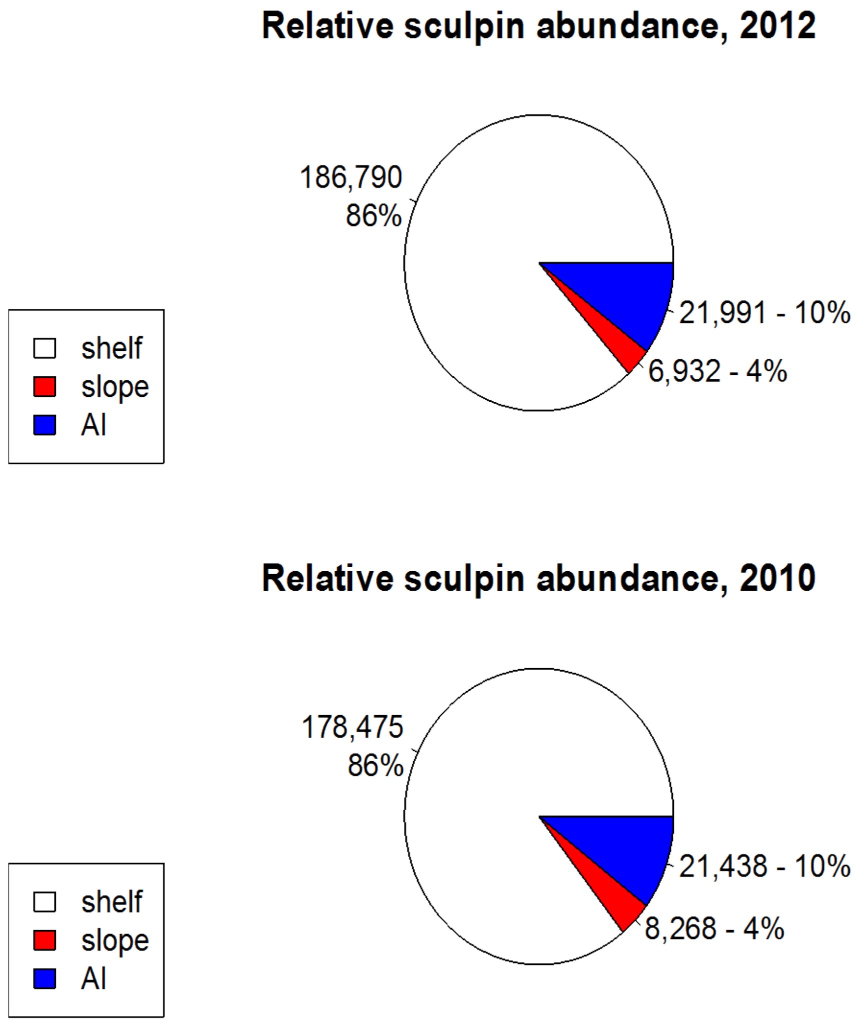


Figure 8. Relative abundance of sculpins in three subregions of the BSAI for the two most recent years where surveys were conducted in all three regions in the same year. Data shown in plot are biomass (t).

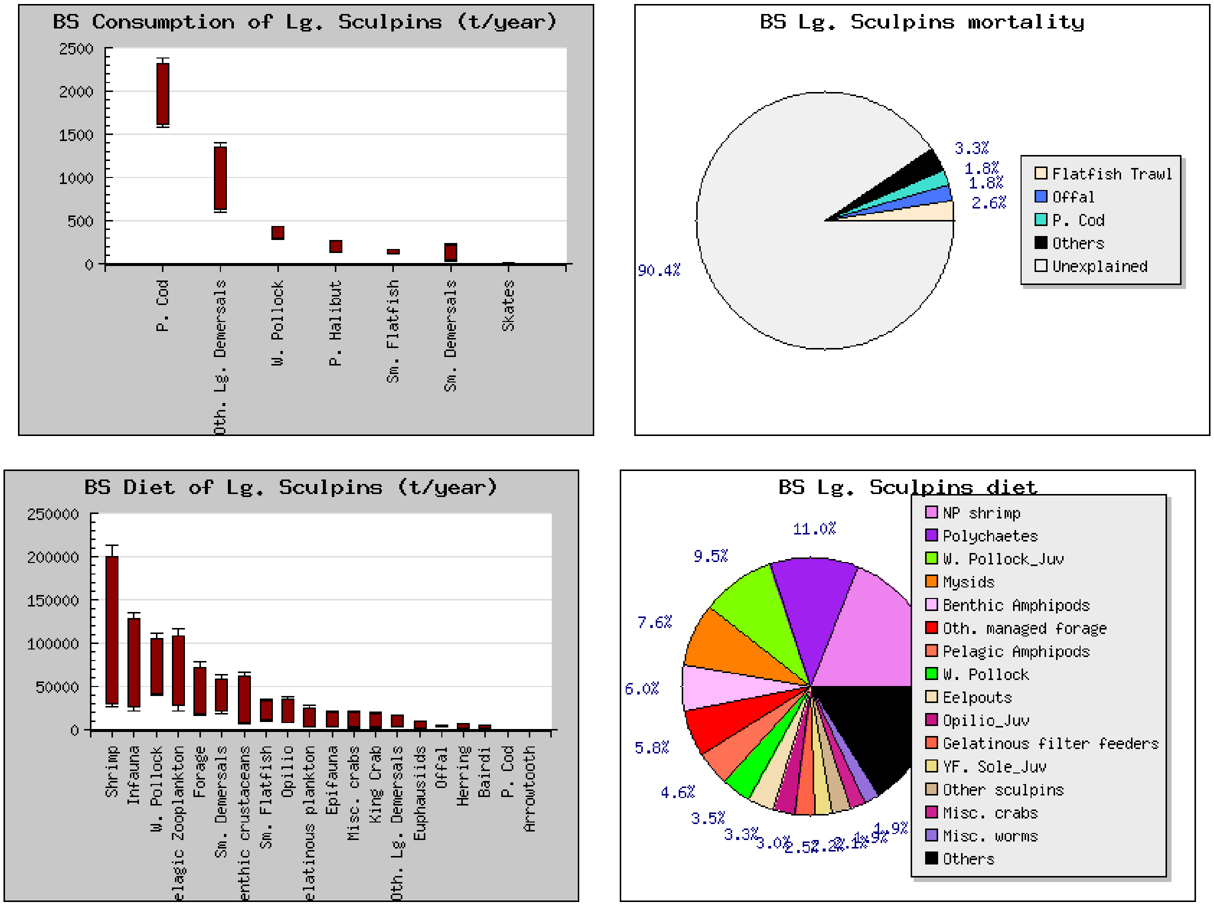


Figure 9. Figures showing Consumption, mortality, and diet of large sculpins from the eastern Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

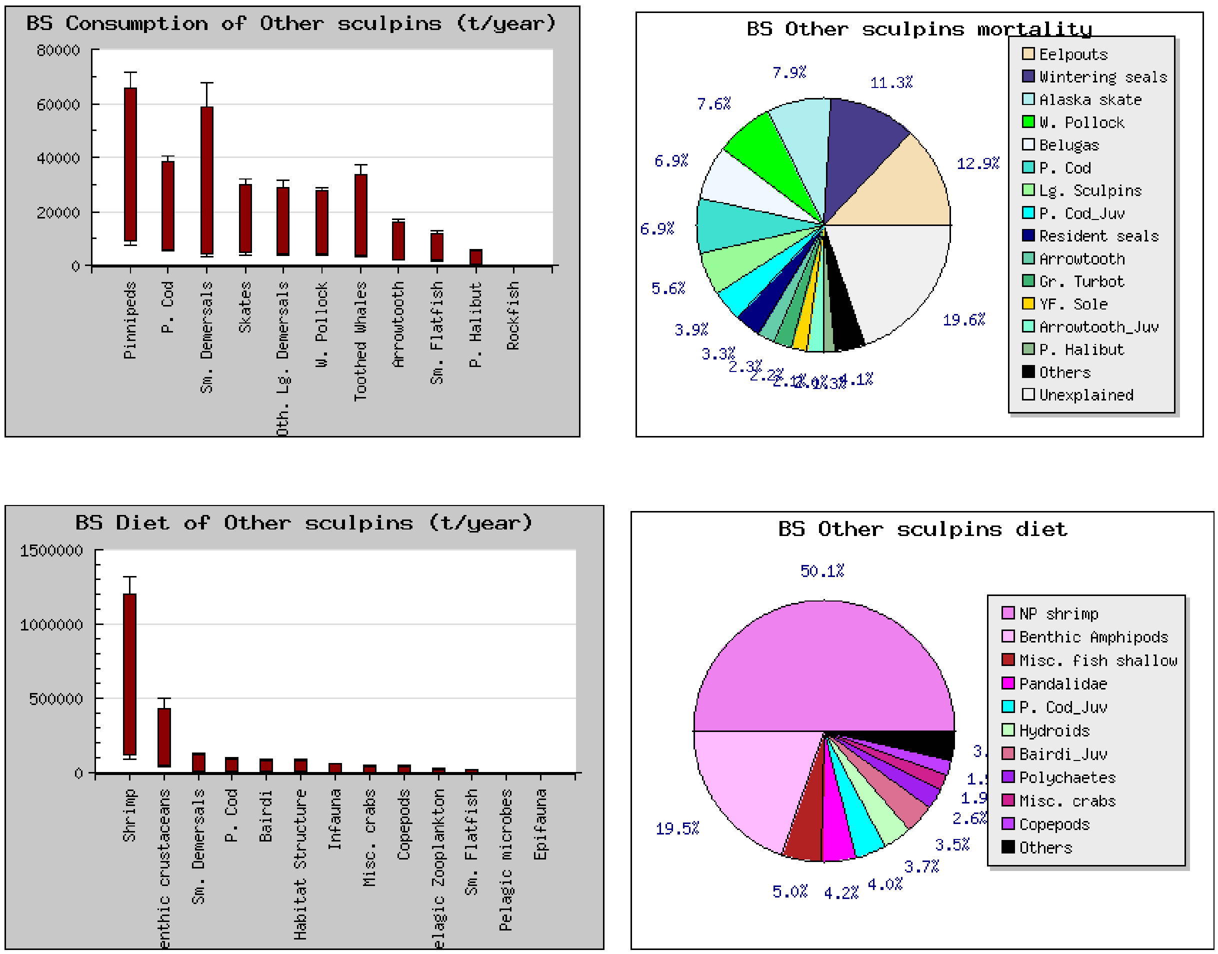


Figure 10. Figures showing Consumption, mortality, and diet of other sculpins from the eastern Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

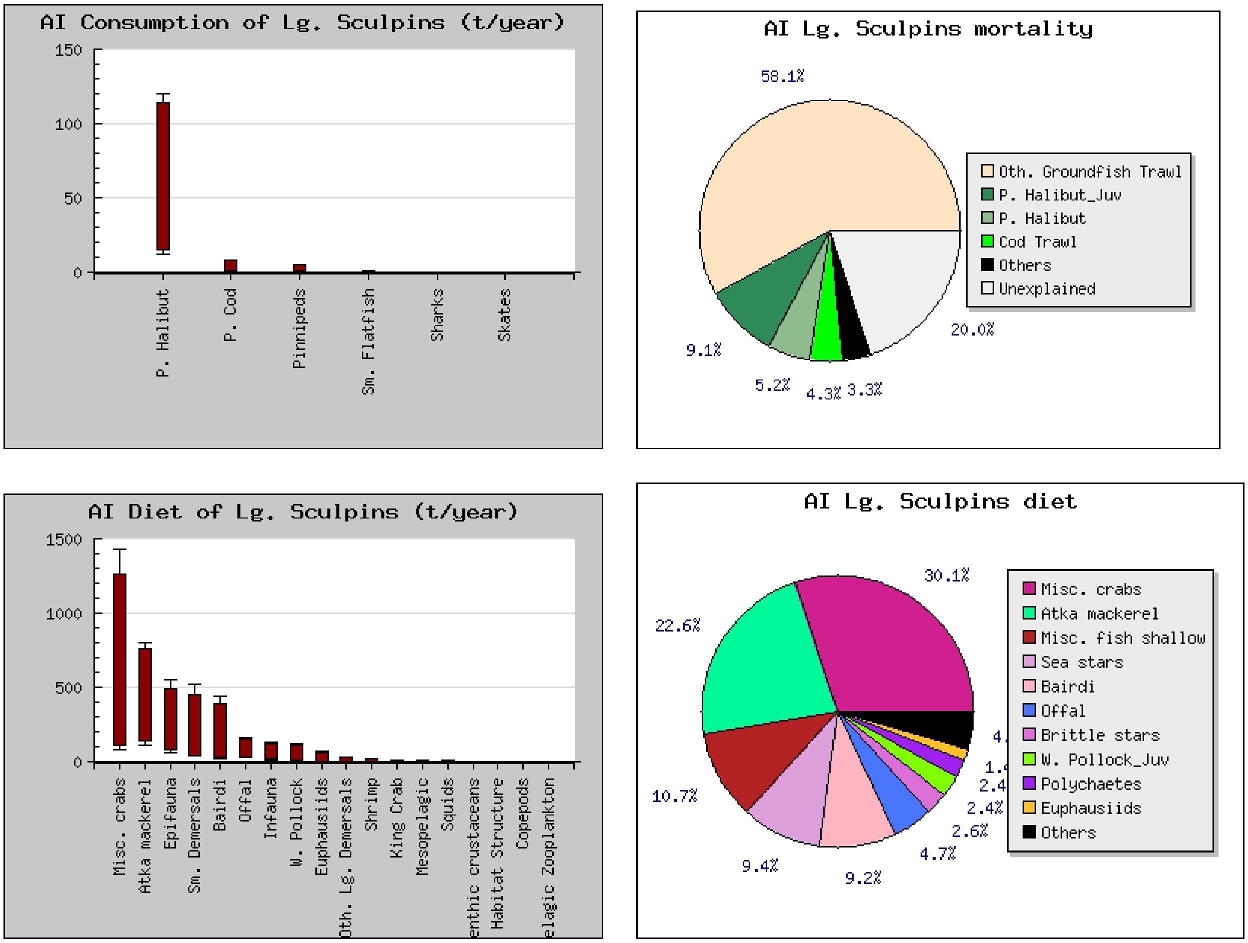


Figure 11. Figures showing Consumption, mortality, and diet of large sculpins from the Aleutian Islands. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

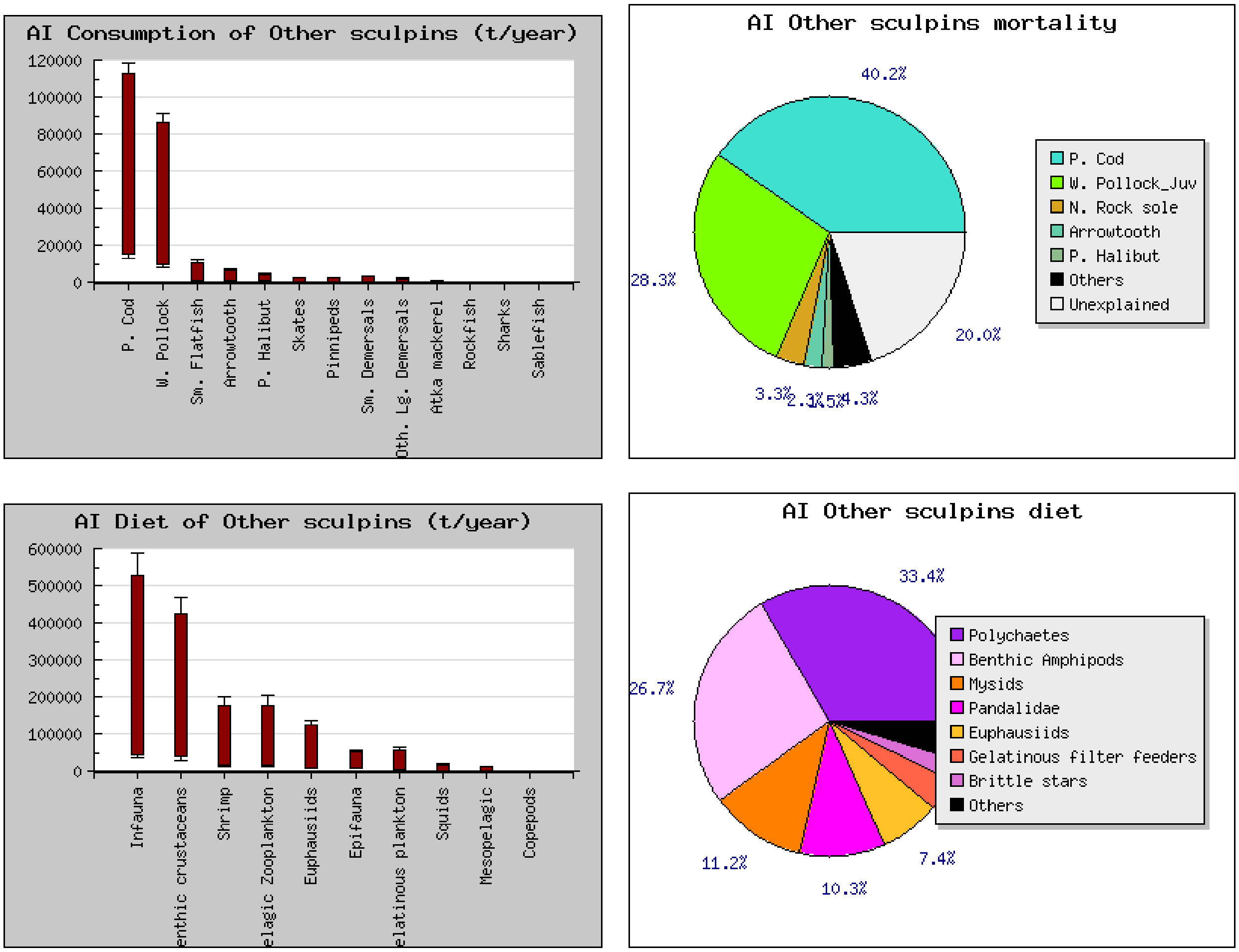


Figure 12. Figures showing Consumption, mortality, and diet of other sculpins from the Aleutian Islands. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

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