18d. 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. Thus, BSAI sculpins will now be managed as an independent complex with its own harvest specifications.

Summary of Major Changes

1. Catch data are updated with partial data for 2010. In addition, all sculpin and Other Species catch data from 2003-2009 has been updated as a result of changes to the Catch Accounting System.
2. Biomass estimates and length compositions from the 2010 Bering Sea shelf and slope surveys, as well as the 2010 Aleutian Islands survey, have been added.
3. A new approach to harvest specifications is recommended. ABC and OFL have increased somewhat since the 2009 SAFE due to new survey data and the adoption of *M* estimates that are higher than those used in the 2009 SAFE.

Harvest recommendations

	last year		**this year**	
Quantity/Status	*2010*	*2011*	**2011**	2012
sculpin complex average mortality rate*			**0.28**	0.28
Specified/recommended Tier	*5*	*5*	**5**	5
Biomass	*225,825*	*225,825*	**208,181**	**208,181**
F_{OFL} (*F=complex mortality rate*)			**0.28**	0.28
max F_{ABC} (maximum allowable = 0.75 *x* F_{OFL})			**0.21**	0.21
Specified/recommended F_{ABC}			**0.21**	0.21
Specified/recommended OFL (t)	*51,272*	*51,272*	**58,291**	58,291
Specified/recommended ABC (t)	*30,174*	*30,174*	**43,718**	43,718
Is the stock 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, great, plain, threaded, warty, and yellow Irish lord. The complex mortality rate may change as new survey data become available. See "results" section for more detail.*

Responses to SSC Comments

There were no BSAI-specific comments from the SSC.

Introduction

Description, scientific names, and general distribution

Sculpins are relatively small, benthic-dwelling, teleost fish. This group is especially speciose; during cooperative U.S.-Japan trawl surveys, 41 species of sculpins were identified in the Eastern Bering Sea (EBS) and 22 species in the Aleutian Islands (AI) region. Sculpin diversity remains high in recent surveys of both areas (Table 20.1). 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 have begun to 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. However 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. Thus, BSAI sculpins will now be 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 5 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 to similar environmental changes (whether natural or fishing influenced) in different ways. Within each sculpin species, observed spatial differences in fecundity, egg size, and other life history characteristics suggest local population structure (Tokranov 1985), which is very different from wide ranging species such as sharks. 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.

Life history (BSAI-specific)

Information such as depth range, distribution, and maximum length has been collected for several years for many species during surveys. Recent 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

Directed 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 1998-2010 (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 4).

In 2002-2003, the observer program of the 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.* Several species of *Hemilepidotus* and *Myoxocephalus* have been identified from surveys. 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. 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 4). 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, although fishery observer data indicate that the retention rate increased to 13% in 2009 (Table 3).

Comparison of the species composition of observed fishery catches to the species composition of the 3-survey average sculpin biomass estimates reveals that sculpins are caught incidentally largely in proportion to their relative biomass (Table 5). Bigmouth sculpins are slightly overrepresented in the fishery catch, while relatively fewer Irish lords are caught considering their biomass, especially in the AI. These data are in contrast to a similar comparison in the Gulf of Alaska, where fishery catch composition varied considerably (see the 2010 GOA sculpin SAFE).

Data

Fishery Catch

Catch trend by genus is not available before 2004. Refer to Table 20.3 for total sculpin catch from 1998-2010. Fishery catch of sculpins is shelf-wide with the majority of the catch along the middle (50-100m) and outer shelf (100-200m) areas.

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 & Fig. 6). 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). Four trawl surveys have also been conducted on the EBS slope (in 2002, 2004, 2008, and 2010), but no biomass trends for sculpin were apparent in this short time series (Table 7). Based on the EBS slope surveys, abundance of sculpins appears to be relatively low in the deeper waters sampled by this survey. The slope contains a different sculpin community from the shelf and the AI, likely as a result of greater depths (Figure 6).

In the AI, yellow Irish lord account for the highest proportion of sculpin biomass, followed by darkfin sculpin, great sculpin, spectacled sculpin, bigmouth sculpin and scissortail sculpin (Table 8 & Figure 6). The spectacled and scissortail sculpins are two species not found on EBS surveys. The biomass estimate CVs are generally higher for the AI survey, perhaps reflecting a patchier distribution of sculpins. Due to varying rates of selectivity, the biomass estimates for the less abundant, smaller species of sculpin are probably not reliable (CV range from 0.31 to 1.00). 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 with an increase in yellow Irish lord biomass since 1991 (Figure 2).

In 2010, all three regions of the BSAI were sampled in the same year for the first time since 2004. Total BSAI sculpin biomass dropped slightly from 2004 to 2010 (239,174 t and 207,658 t, respectively; Table 9). In addition, the distribution of sculpins changed slightly: sculpin biomass increased in the AI and on the EBS slope, and decreased slightly on the EBS shelf (Table 9 & Fig. 7).

Length frequency and sample size

Eastern Bering Sea

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 2000: yellow Irish lord, plain sculpin, warty sculpin, great sculpin and bigmouth sculpin (Figure 3). The length composition by species is generally consistent, with few small sculpins caught by the survey. For all five species, a greater proportion of smaller individuals was observed in 2010.

Eastern Bering Sea Slope

Size compositions of the most abundant species on the slope are shown in Figure 4. 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 bigmouth sculpins consistently shows two size modes, which may indicate that two separate life stages of bigmouth inhabit the slope.

Aleutian Islands

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. Yellow Irish lords have 4 survey years of data and show a consistent size composition (Figure 5). Darkfin and spectacled sculpin only have length data collected from the 2002 survey. Specimens smaller than 70 mm have not been collected for many sculpins, which may be a factor of size selectivity of the survey gear.

Analytical Approach and Results

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 the aging studies for EBS sculpin (discussed in the previous section) were used to produce *M* estimates specific to this area (Table 10). These estimates vary widely. At the Plan Team meeting in September 2009, the authors were encouraged to use the best available science in selecting a value of *M* to be used for setting OFL, and that catch curves be used to estimate M wherever possible.

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 was calculated as the average of the last 3 surveys in each area (Table 6). In 2009, the BSAI Plan Team recommended that *M* values based on age-based catch-curve analysis be used wherever possible. In addition, separate ABC and OFL calculations were made for each species where recent *M* estimates were available and the individual values were aggregated to create sculpin-wide harvest recommendations. In effect, this means that 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. We have adopted the latter approach in this assessment, as we feel it more accurately represents how BSAI sculpins are managed (i.e., the previous approach implied that specifications were made for individual species).

2011-2012 sculpin complex harvest specifications						
species	3-survey average biomass				*M*	weighted contribution to mort. est.
	EBS shelf	EBS slope	AI	**BSAI**		
threaded	1,614	0	1	**1,615**	0.45	0.00
YIL	25,654	47	11,467	**37,168**	0.17	0.03
bigmouth	27,839	2,565	1,077	**31,481**	0.21	0.04
great sculpin	54,930	34	1,569	**56,532**	0.28	0.08
plain	53,131	0	0	**53,131**	0.40	0.11
warty	8,782	0	0	**8,782**	0.26	0.01
other	6,525	5,622	7,324	**19,471**		
total	**178,475**	**8,268**	**21,438**	**208,181**		

weighted-average mortality rate	0.28
F_{OFL}	0.28
max F_{ABC}	0.21
rec. F_{ABC}	0.21
OFL	58,291
max. ABC	43,718
rec. ABC	43,718

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 8). In the EBS the main predator of large sculpins (sculpins from the genera *Myoxocephalus*, *Hemitripterus* and *Hemilepidotus*) is Pacific cod (Figure 8). 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 4). Other sculpins (those sculpins not in the above genera) in the EBS feed mainly on shrimp and benthic amphipods (Figure 9). 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 9). 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 groundfish bottom trawl fishery (Figure 10). Diet of other sculpins in the AI consists of infauna such as polychaetes and benthic crustaceans (Figure 11). 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 11).

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. 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 to understand why only the 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 (mt) of sculpin complex compared to Other species catch (including squid), 1998-2009. *Data sources: catch data from the AKRO Catch Accounting System; retention rates from fishery observer data obtained from the AFSC Fishery Monitoring and Analysis division.*

Year	EBS sculpin catch	AI sculpin catch	BSAI sculpin catch	% retained	BSAI Other Species catch	Other Species TAC	% of sculpin in O. Species catch (BSAI)
1998	5,204	1,081	6,285		25,531	25,800	25%
1999	4,503	967	5,470		20,562	32,860	27%
2000	5,673	1,413	7,086		26,108	31,360	27%
2001	6,067	1,603	7,670		27,178	26,500	28%
2002	6,043	1,133	7,176		28,619	30,825	25%
2003	5,184	599	5,783	1%	25,728	32,309	22%
2004	5,242	894	6,136	1%	29,478	27,205	21%
2005	5,114	621	5,735	2%	29,575	29,000	19%
2006	4,907	911	5,818	3%	27,107	29,000	21%
2007	6,505	1,016	7,521	6%	26,648	37,355	28%
2008	6,682	935	7,618	7%	29,630	50,000	26%
2009	5,915	1,263	7,178	13%	27,992	50,000	26%
2010*	3,668	1,123	4,791	n/a	19,402	50,000	25%

* 2010 data are incomplete; retrieved October 10, 2010.

Table 4. Total catch (mt) of all sculpins by target fishery in the eastern Bering Sea and Aleutian Islands, 2003-2010. *Source: NMFS AK regional office catch accounting system. * 2010 catch data are incomplete; retrieved October 10, 2010.*

eastern Bering Sea								
Target fishery	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010***
Alaska plaice	0	0	0	3	10	2	3	0
arrowtooth flounder	23	44	122	78	29	78	64	8
Atka mackerel	7	28	46	26	91	5	6	0
flathead sole	402	561	525	513	478	619	409	235
Greenland Turbot	6	5	1	1	1	1	1	1
IFQ halibut	3	1	0	3	0	7	0	1
other flat	53	37	47	11	28	1	1	2
other target	14	6	0	2	4	0	0	0
Pacific cod	2,740	3,177	2,587	2,302	2,448	1,663	1,281	815
rock sole	438	270	474	663	762	1,094	1,271	886
rockfish	1	1	0	2	0	0	0	2
sablefish	0	1	0	0	0	1	1	1
yellowfin sole	1,395	962	1,162	1,127	2,473	2,896	2,581	1,439
pollock	102	151	149	176	180	316	297	280
total	**5,184**	**5,242**	**5,114**	**4,907**	**6,505**	**6,682**	**5,915**	**3,668**

Aleutian Islands								
Target fishery	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010***
arrowtooth flounder	0	0	0	1	0	0	6	43
Atka mackerel	287	476	372	488	554	459	710	544
flathead sole	0	0	0	0	0	0	0	0
Greenland turbot	0	0	0	0	1	2	1	0
IFQ halibut	4	11	1	4	0	5	1	2
other target	0	0	0	0	0	0	1	0
Pacific cod	0	0	0	0	0	0	0	0
rock sole	0	0	0	0	0	0	0	0
rockfish	47	49	34	40	55	72	61	48
sablefish	260	358	214	376	404	396	479	486
pollock	0	0	0	1	2	1	4	0
total	**599**	**894**	**621**	**910**	**1,014**	**935**	**1,259**	**1,123**

Table 5. Composition of observed fishery catches, 2007-2009, 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.*

taxon	EBS (shelf and slope)				AI			
	fishery catch composition			proportion of average survey biomass	fishery catch composition			proportion of average survey biomass
	2007	2008	2009		2007	2008	2009	
Hemitripterus* spp.*	**10%**			**16%**	**12%**			**5%**
H. bolini		9%	8%	16%		14%	13%	5%
***Hemilepidotus* spp.**	**19%**			**14%**	**69%**			**53%**
Hemilepidotus unidentified		2%	2%	n/a		16%	13%	n/a
H. hemilepidotus		< 1%	< 1%	< 1%		< 1%	< 1%	< 1%
H. jordani		7%	8%	14%		35%	41%	53%
H. spinosus		< 1%	0%	< 1%		< 1%	< 1%	< 1%
***Myoxocephalus* spp.**	**58%**			**63%**	**6%**			**7%**
Myoxocephalus unidentified		4%	< 1%	n/a		< 1%	< 1%	n/a
M. verrucosus		2%	2%	5%		< 1%	< 1%	< 1%
M. jaok		27%	24%	28%		< 1%	< 1%	< 1%
M. polyacanthocephalus		44%	50%	29%		5%	5%	7%
Miscellaneous sculpins§	**13%**	**5%**	**2%**	**7%**	**13%**	**30%**	**17%**	**34%**

** *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.

	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	0	
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	41,635	0.48	23,262	0.18	50,845	0.13	55,852	0.11	3,976	0.24
1988	24,867	0.33	22,038	0.25	47,806	0.13	53,799	0.13	3,794	0.32
1989	22,049	0.39	16,636	0.22	37,244	0.16	58,136	0.15	0	
1990	10,212	0.18	16,123	0.24	37,573	0.26	36,991	0.26	0	
1991	10,296	0.17	20,669	0.23	67,848	0.23	113,188	0.08	3,306	0.45
1992	17,091	0.20	18,300	0.21	95,097	0.15	74,712	0.13	0	
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	0	
1995	19,112	0.28	29,492	0.18	88,622	0.18	67,240	0.13	0	
1996	14,581	0.19	31,250	0.22	90,999	0.13	54,096	0.10	0	
1997	23,727	0.28	29,722	0.17	85,371	0.24	73,288	0.08	3,915	0.48
1998	13,913	0.31	36,276	0.24	65,840	0.22	57,306	0.09	8,981	0.33
1999	13,229	0.20	24,681	0.18	50,039	0.14	47,333	0.12	11,104	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	15,781	0.15
2002	9,415	0.35	32,180	0.34	65,888	0.19	52,525	0.17	9,644	0.20
2003	14,205	0.25	29,161	0.14	67,357	0.19	80,187	0.09	7,109	0.17
2004	33,639	0.33	34,409	0.14	61,176	0.11	69,363	0.10	10,230	0.18
2005	27,451	0.26	31,289	0.13	60,100	0.09	76,428	0.10	25,522	0.51
2006	31,724	0.44	30,118	0.13	57,804	0.10	66,856	0.10	16,142	0.25
2007	23,765	0.34	27,859	0.18	66,000	0.11	77,934	0.11	13,370	0.27
2008	32,389	0.35	30,846	0.14	70,223	0.13	56,935	0.15	11,397	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	55,135	0.12	6,998	0.27

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
Pacific hookear	7	3	0	0	12	2	3	3	2
crested	0	0	0	0	0	4	4	2	2
spinyhead	1,384	1,245	684	874	958	1,462	1,816	1,380	1,194
purplegray	0	0	0	0	21	0	0	0	0
armorhead	5,313	606	523	1,252	916	254	347	237	1,708
threaded	0	0	0	3,867	1,801	3,572	1,697	349	1,560
red Irish lord	0	0	0	0	0	42	0	0	4
butterfly	19,094	13,419	2,890	6,572	1,413	4,013	4,829	4,158	3,257
spatulate	0	0	0	0	14	12	23	13	19
thorny	397	71	191	931	1,351	1,036	992	704	814
darkfin	0	0	16	45	0	123	49	180	529
sailfin	0	0	5	0	0	0	0	0	0
scissortail	0	14	10	0	3	3	1	7	2
roughspine	0	11	0	6	50	12	35	7	3
crescent-tail	0	0	0	0	0	0	0	0	0
ribbed	0	6	108	33	71	220	78	155	156
spectacled	0	0	9	652	168	200	491	142	255

species	2003	2004	2005	2006	2007	2008	2009	2010	*2010 CV*
Pacific hookear	0	0	3	1	4	3	8	17	*0.46*
crested	2	0	0	35	0	0	5	0	
spinyhead	1,272	1,027	3,710	2,035	1,949	870	1,586	1,277	*0.20*
purplegray	0	0	11	3	0	6	29	14	*0.61*
armorhead	730	803	1,273	1,424	990	2,113	1,859	1,956	*0.69*
threaded	1,154	1,295	1,629	1,976	4,126	2,174	1,167	1,501	*0.28*
red Irish lord	0	83	12	0	5	0	106	0	
butterfly	1,134	1,173	2,756	2,825	2,002	543	799	965	*0.19*
spatulate	4	13	19	39	53	23	60	60	*0.19*
thorny	748	696	515	547	558	940	1,159	2,385	*0.19*
darkfin	11	124	29	56	46	1	3	22	*0.76*
sailfin	0	0	0	0	0	0	0	1	*1.00*
scissortail	0	0	0	35	20	27	77	9	*0.79*
roughspine	10	62	91	138	57	176	64	77	*0.64*
crescent-tail	0	0	0	1	0	0	0	0	
ribbed	140	558	214	329	309	368	581	474	*0.53*
spectacled	298	29	93	300	217	184	224	503	*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 2010.

common name	**2002**	**2004**	**2008**	**2010**	***2010 CV***
armorhead	<1				
bigmouth	1,920	1,289	3,216	3,191	*0.14*
blacknose	122		40	16.5	*0.30*
blob	1,471		1,145	3,325	*0.21*
darkfin	1,525	1,798	1,109	1,082	*0.44*
flabby	<1		<1	0.39	*0.34*
great	44	5	9	88.1	*0.67*
roughskin	<1				
spatulate			<1		
spectacled	58	57	30	28.7	*0.56*
spinyhead	1,158	701	381	372	*0.18*
thorny	74	39	6	8.2	*0.22*
wide-eye	11		4	0.14	*0.57*
yellow Irish lord		113	7	20.0	*0.89*
sculpin unid (all others)		1,486			
total	**6,386**	**5,488**	**5,948**	**8,131**	

Table 8. Aleutian Islands (AI) sculpin biomass estimates (t) from 1980-2010 AI trawl surveys and the coefficient of variation (CV) for 2010.

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

	biomass estimate (t)					
species	**2000**	**2002**	**2004**	**2006**	**2010**	***2010 CV***
yellow Irish lord	6,711	4,240	8,357	10,797	15,247	*0.30*
darkfin	2,533	3,971	4,521	4,520	5,431	*0.16*
great	1,168	1,494	1,519	2,121	1,067	*0.30*
spectacled	1,122	2,393	1,040	993	956	*0.32*
bigmouth	1,005	1,191	790	1,647	794	*0.41*
armorhead	288	208	506	424	637	*0.26*
scissortail	67	442	2,073	136	155	*0.48*
unidentified sculpins	49	138	100	181	124	*0.26*
spinyhead	19	23	72	12	59	*1.00*
threaded	0	0	0	0	4	*0.87*
thorny	1	2	0	0	0	*0.86*
antlered	0	20	17	8	0	-
butterfly	0	0	0	0	0	-
crested	0	0	0	0	0	-
Pacific staghorn	0	0	9	0	0	-
plain	0	32	0	0	0	-
warty	0	0	0	0	0	-
total	**12,963**	**14,155**	**19,003**	**20,838**	**24,473**	

Table 9. Sculpin biomass estimates for 2004 and 2010 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.

species	EBS shelf		EBS slope		AI		total BSAI	
	2004	**2010**	**2004**	**2010**	**2004**	**2010**	**2004**	**2010**
antlered	-	-	-	-	17	0	17	0
armorhead	803	1,956	-	-	506	637	1,309	2,593
bigmouth	34,409	32,477	1,289	3,191	790	794	36,488	36,461
blacknose	-	-		17	-	-	0	17
blob	-	-		3,325	-	-	0	3,325
butterfly	1,173	965	-	-	-	-	1,173	965
crescent-tail	-	-	-	-	-	-	-	-
crested	-	-	-	-	-	-	-	-
darkfin	124	22	1,798	1,082	4,521	5,431	6,443	6,534
flabby	-	-	-	0.39			0	0.39
great sculpin	61,176	49,665	5	88	1,519	1,067	62,700	50,820
Pacific hookear	0.29	17	-	-	-	-	0.29	17
Pacific staghorn	-	-	-	-	9	0	9	0
plain	69,363	55,135	-	-	-	-	69,363	55,135
purplegray	0	14	-	-	-	-	0	14
red Irish lord	83	0.00	-	-	-	-	83	0
ribbed	558	474	-	-	-	-	558	474
roughspine	62	77	-	-	-	-	62	77
sailfin	0	1	-	-	-	-	0	1
scissortail	0	9	-	-	2,073	155	2,073	164
spatulate	13	60	-	-	-	-	13	60
spectacled	29	503	57	29	1,040	956	1,126	1,487
spinyhead	1,027	1,277	701	372	72	59	1,800	1,707
thorny	696	2,385	39	8	0.40	0.10	736	2,393
threaded	1,295	1,501	-	-	0	4	1,295	1,505
unidentfied	-	-	1,486	-	100	124	1,586	124
warty	10,230	6,998	-	-	-	-	10,230	6,998
wide-eye	-	-	-	0.14	-	-	0	0.14
YIL	33,639	21,518	113	20	8,357	15,247	42,109	36,785
total	**214,682**	**175,054**	**5,488**	**8,131**	**19,003**	**24,473**	**239,174**	**207,658**

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

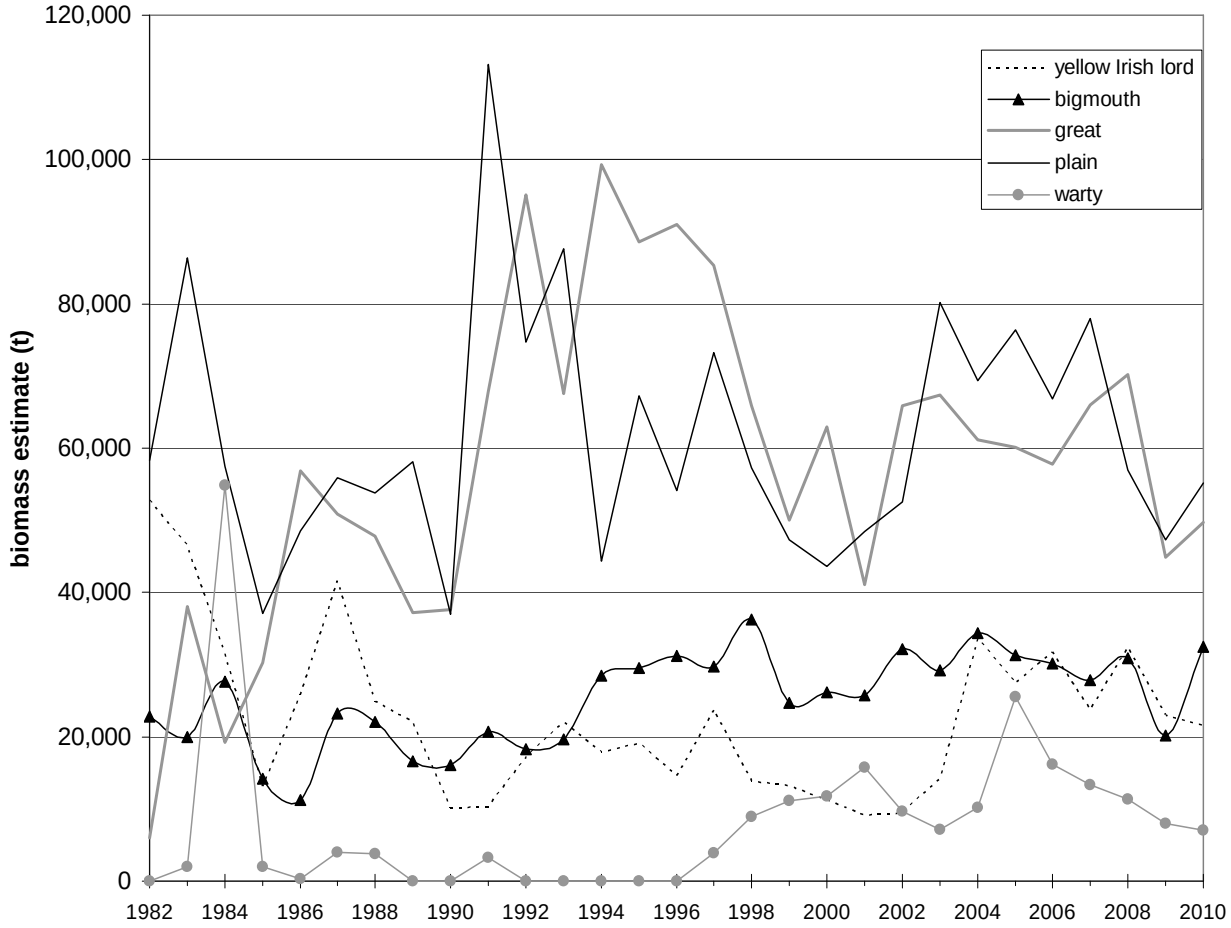

Figure 1. EBS shelf survey biomass estimates for the five most abundant sculpin species, from annual EBS shelf bottom trawl surveys for selected sculpin species, 1982-2010.

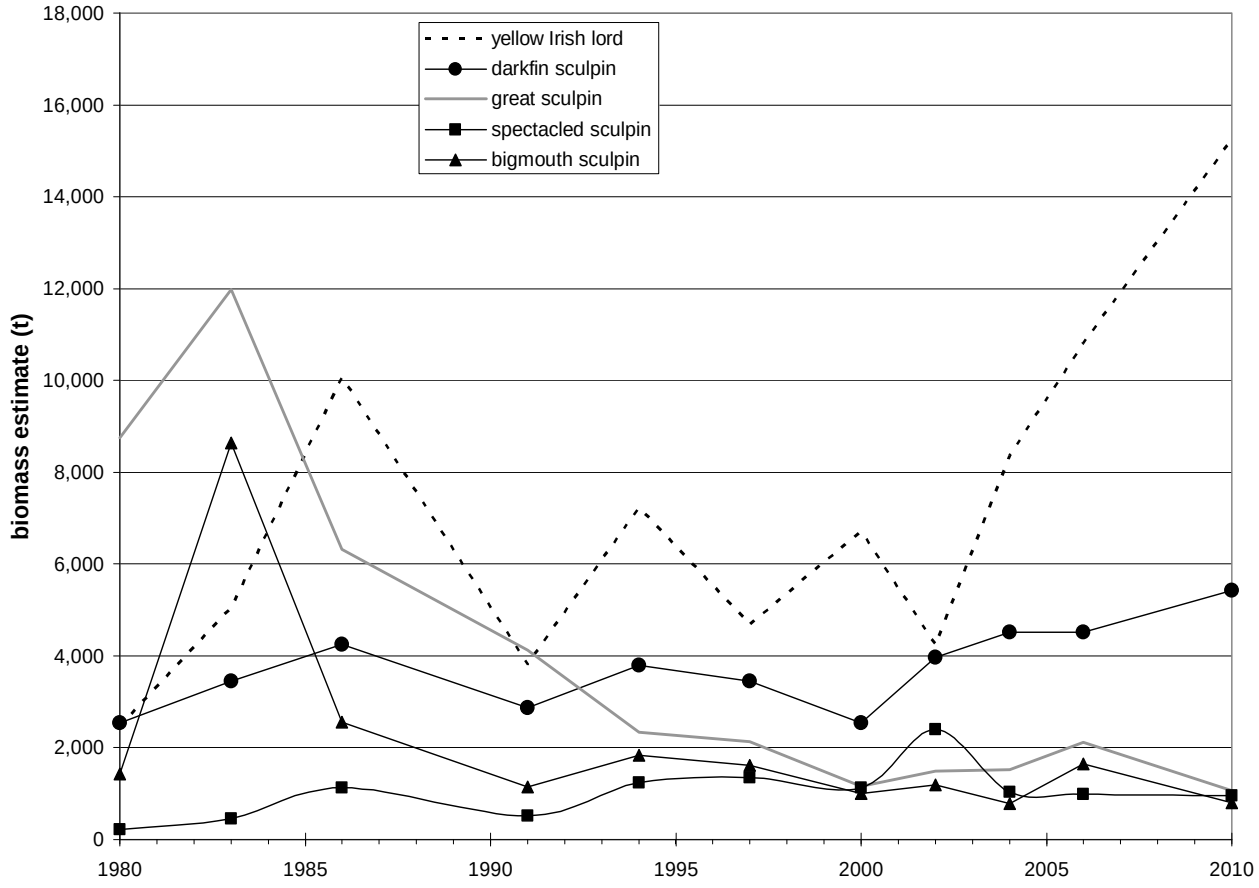

Figure 2. Aleutian Islands (AI) survey biomass estimates for the five most abundant sculpin species, from AI trawl surveys 1980-2010. Note: Some sculpin species were not regularly identified to species-level until recent surveys.

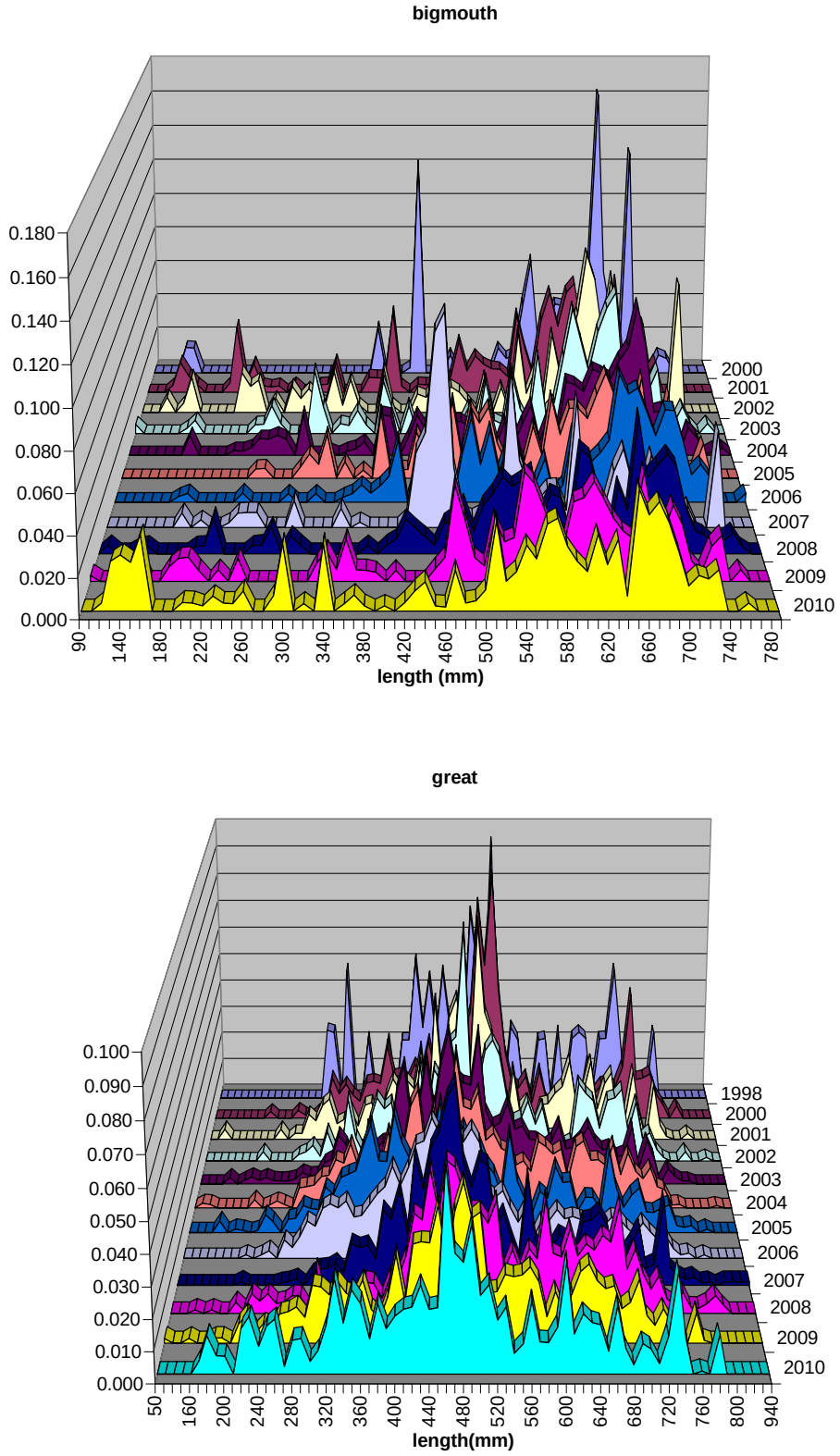

Figure 3. Length frequencies (fork length, FL in mm) from EBS shelf survey data for the five most abundant sculpin species in EBS, 2002-2010. Length scale differs among plots.

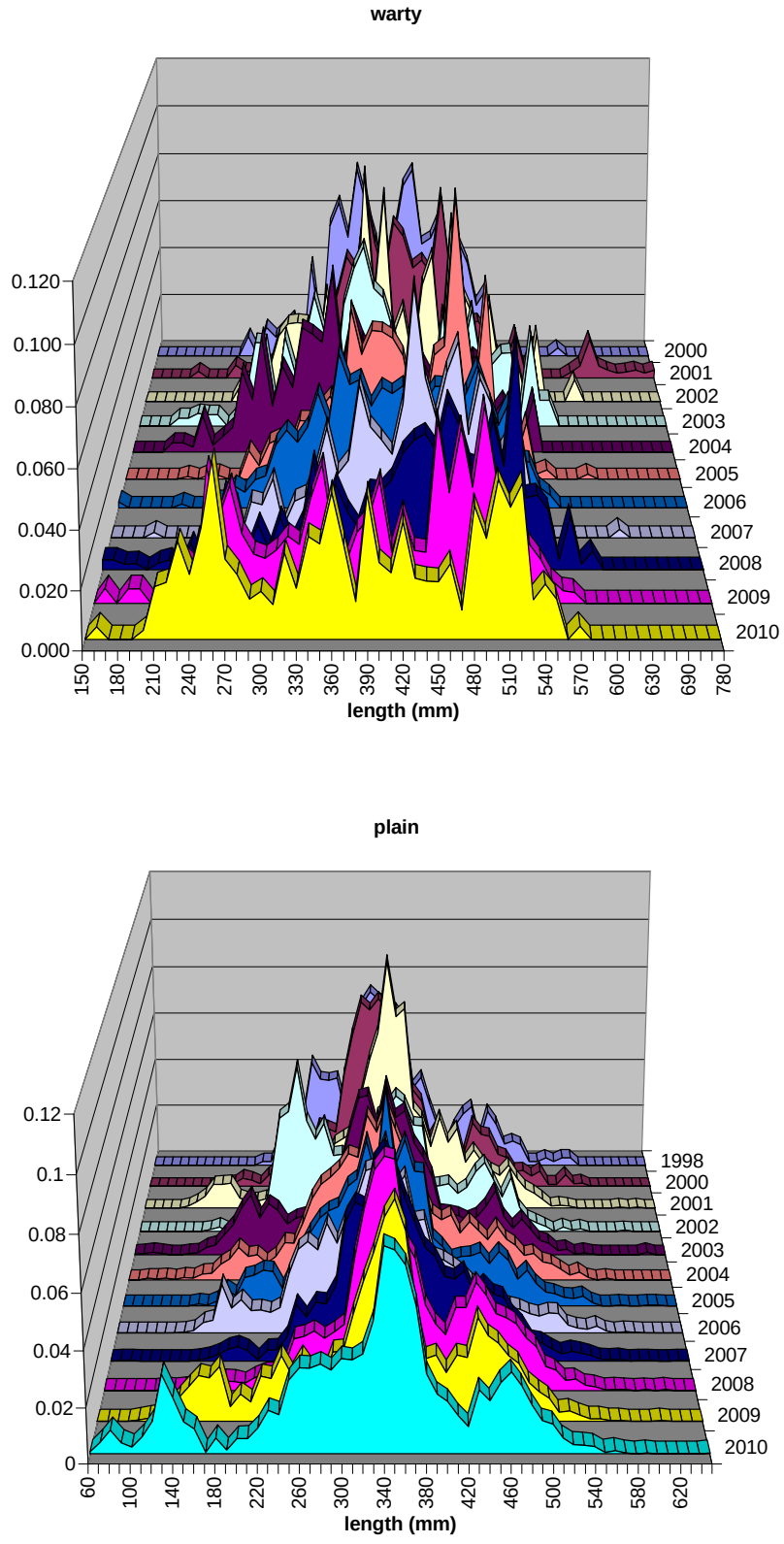

Figure 3 (continued). Length frequencies (fork length, FL in mm) from EBS shelf survey data for the five most abundant sculpin species in EBS, 2002-2010. Length scale differs among plots.

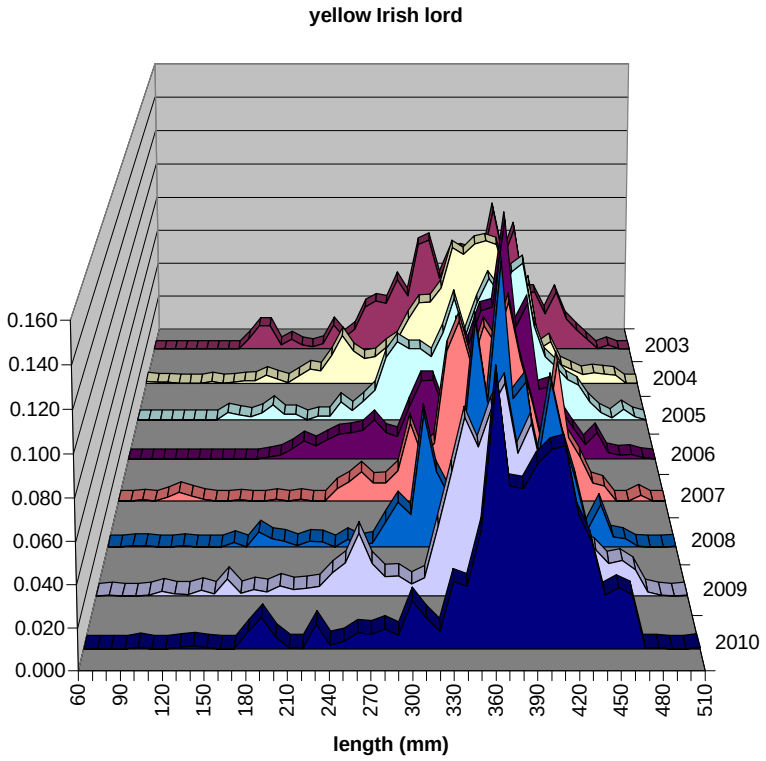

Figure 3 (continued). Length frequencies (fork length, FL in mm) from EBS shelf survey data for the five most abundant sculpin species in EBS, 2002-2010. Length scale differs among plots.

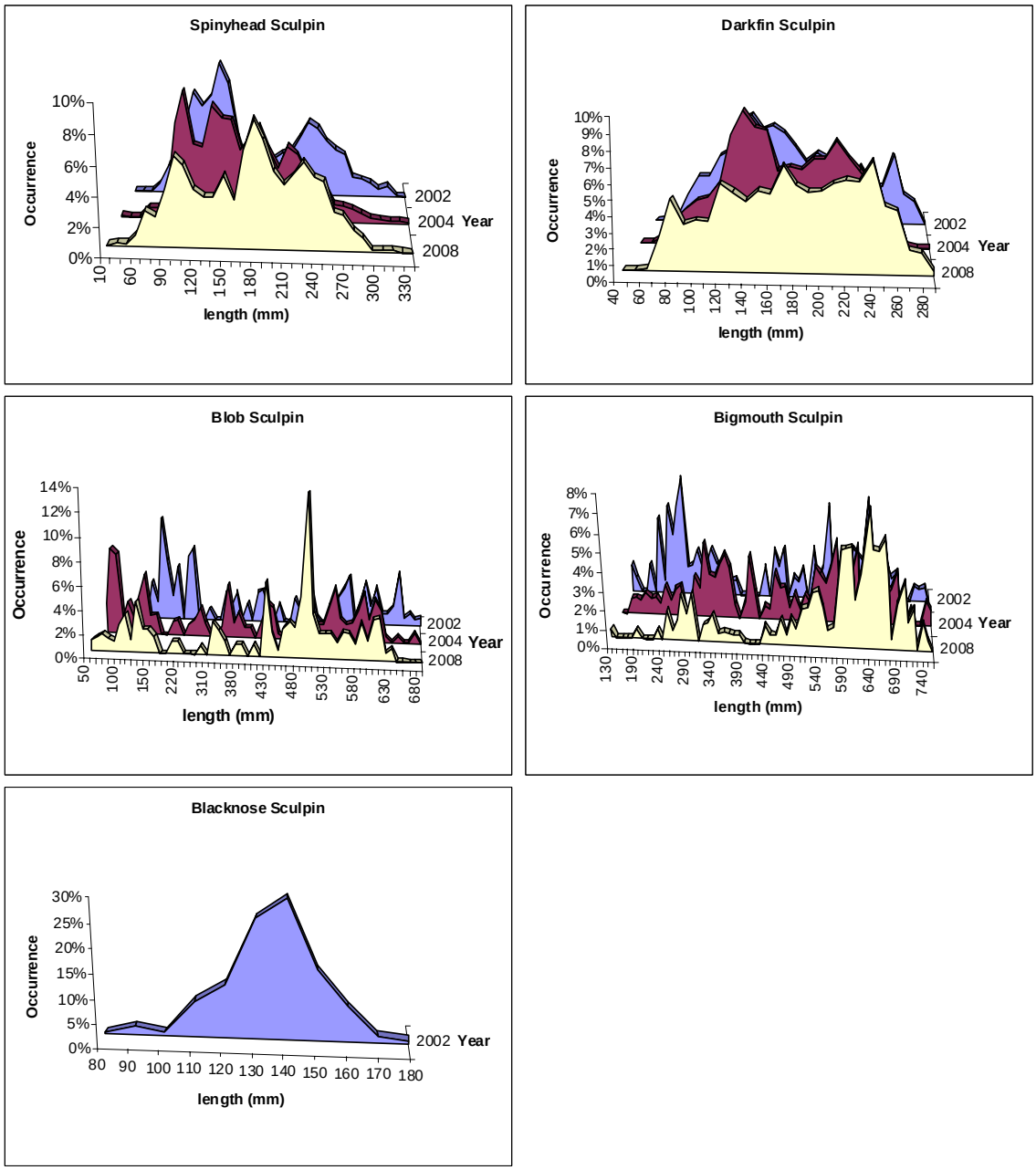

Figure 4. Length frequencies (fork length, FL in mm) from EBS slope survey data for the five most abundant sculpin species in these surveys.

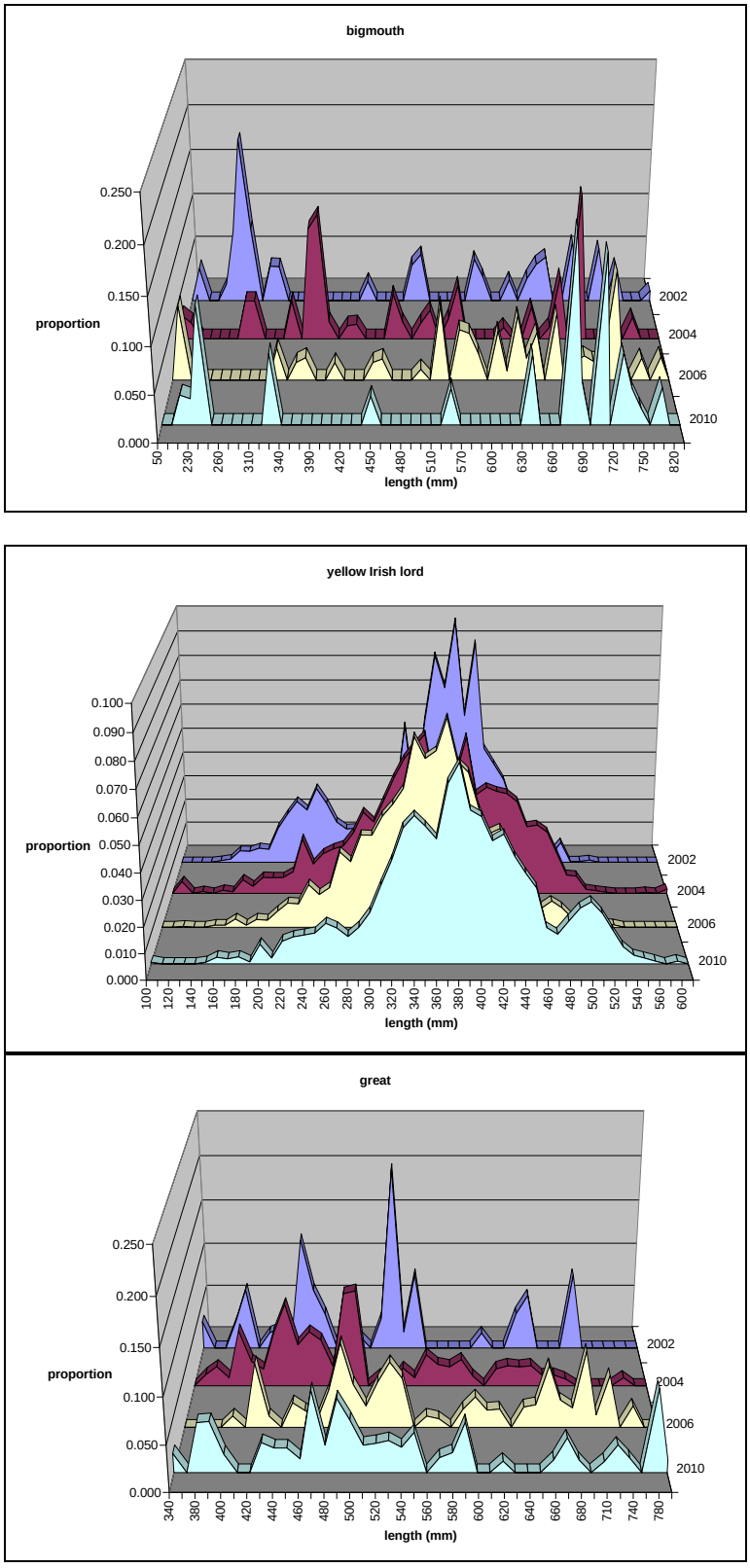

Figure 5. Survey length composition for the 3 most abundant sculpin species in the AI, 2002-2010.

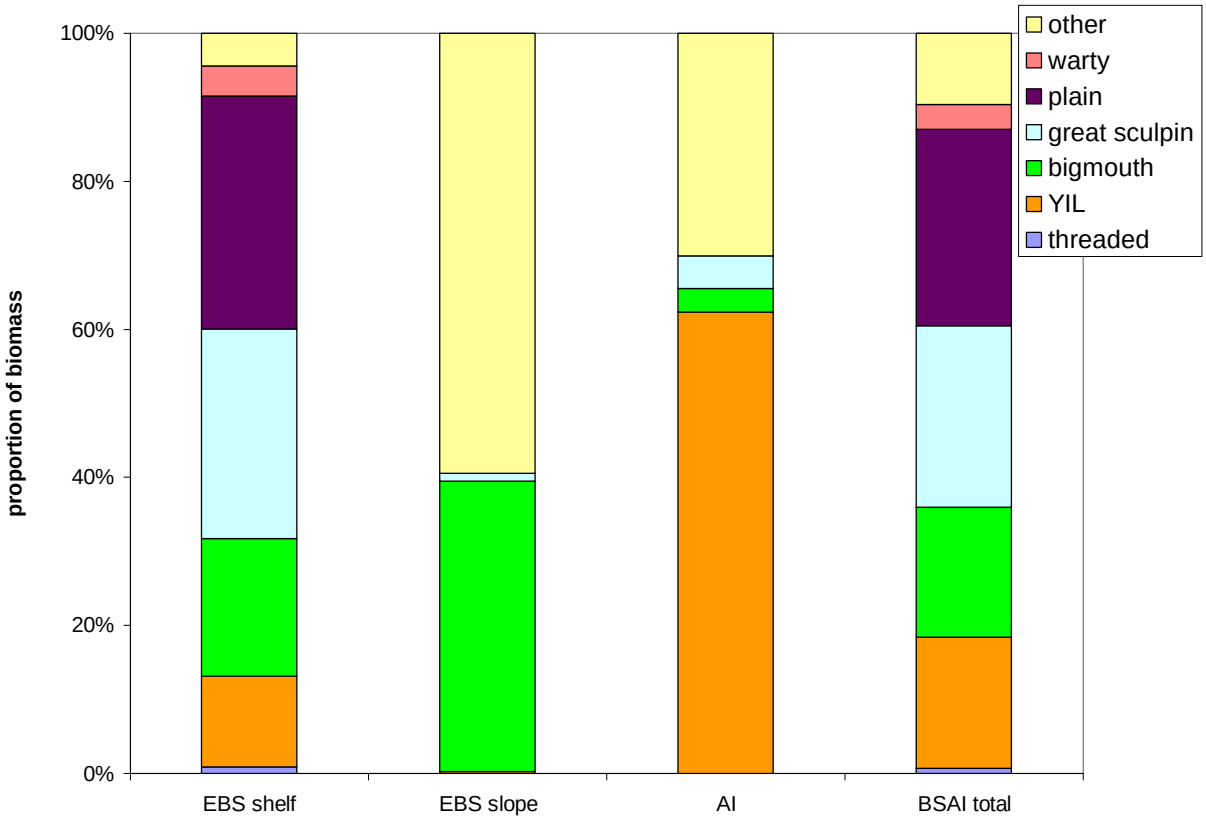

Figure 6. Species composition of the sculpin complex in the three subregions of the BSAI as well as the BSAI as a whole. "Other" sculpins contains a variety of species; see table for more detail.

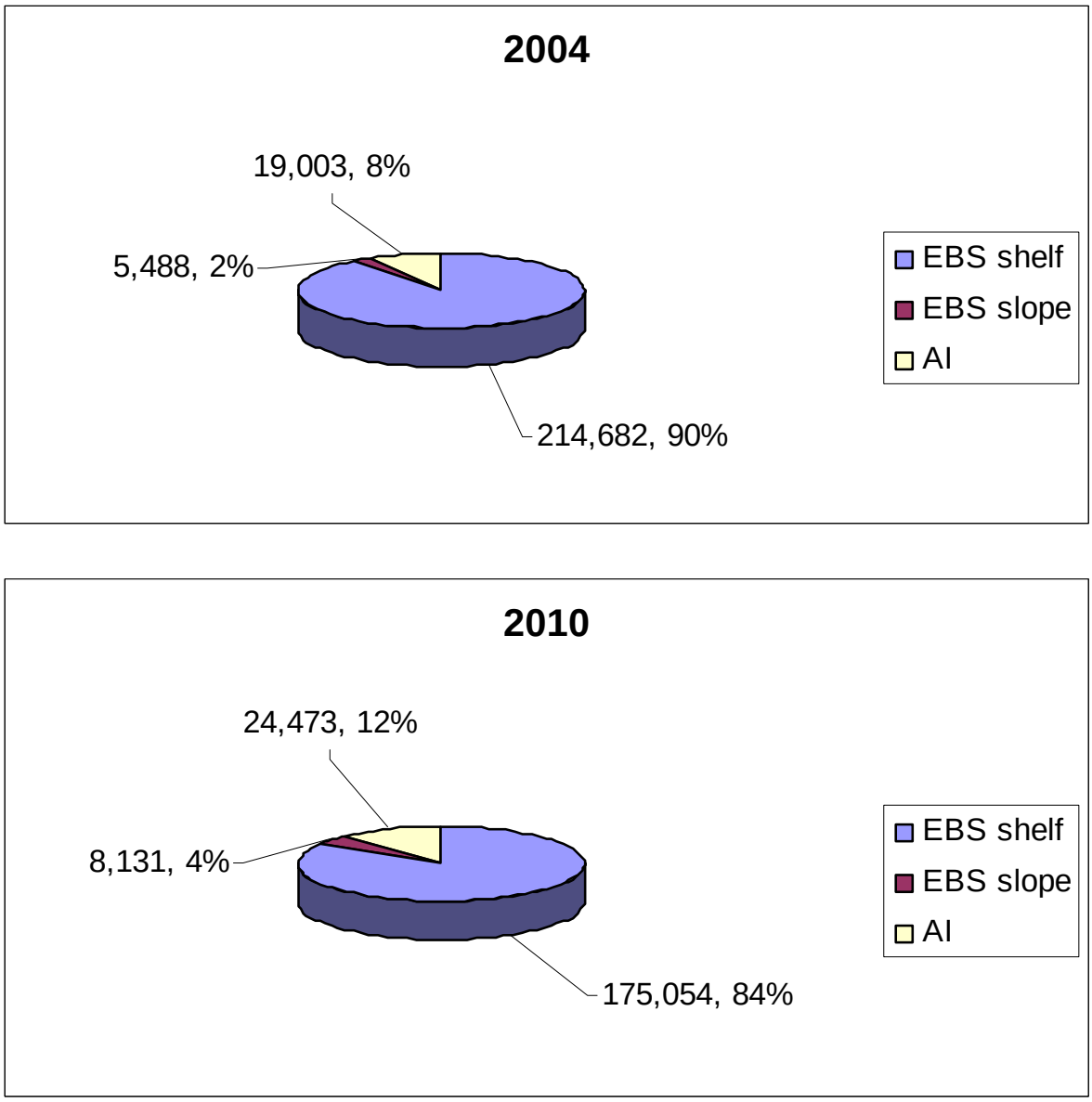

Figure 7. Relative abundance of sculpins in three subregions of the BSAI for the two most recent years where surveys were conducted in all three regions in the same year. Data shown in plot are biomass (t).

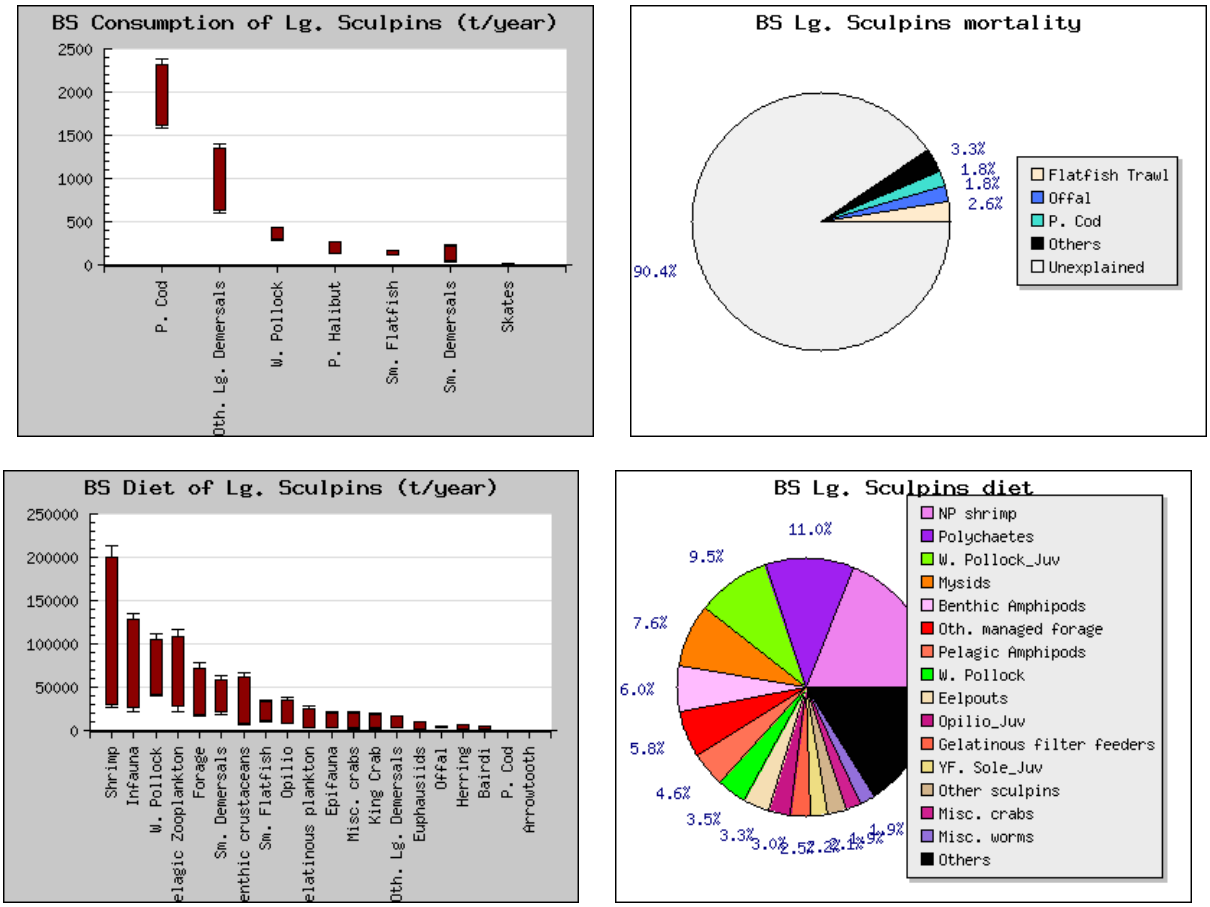

Figure 8. Figures showing Consumption, mortality, and diet of large sculpins from the eastern Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

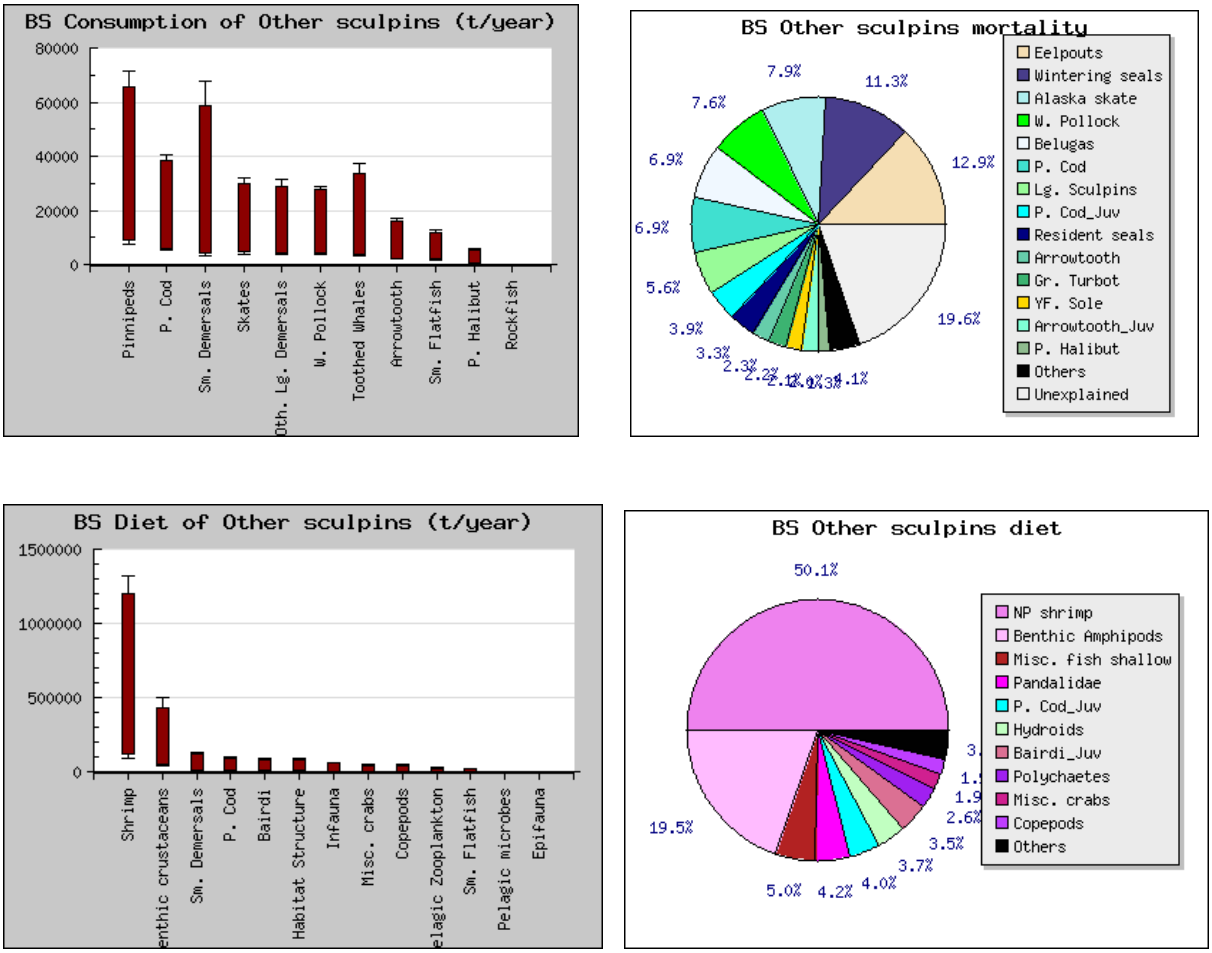

Figure 9. Figures showing Consumption, mortality, and diet of other sculpins from the eastern Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

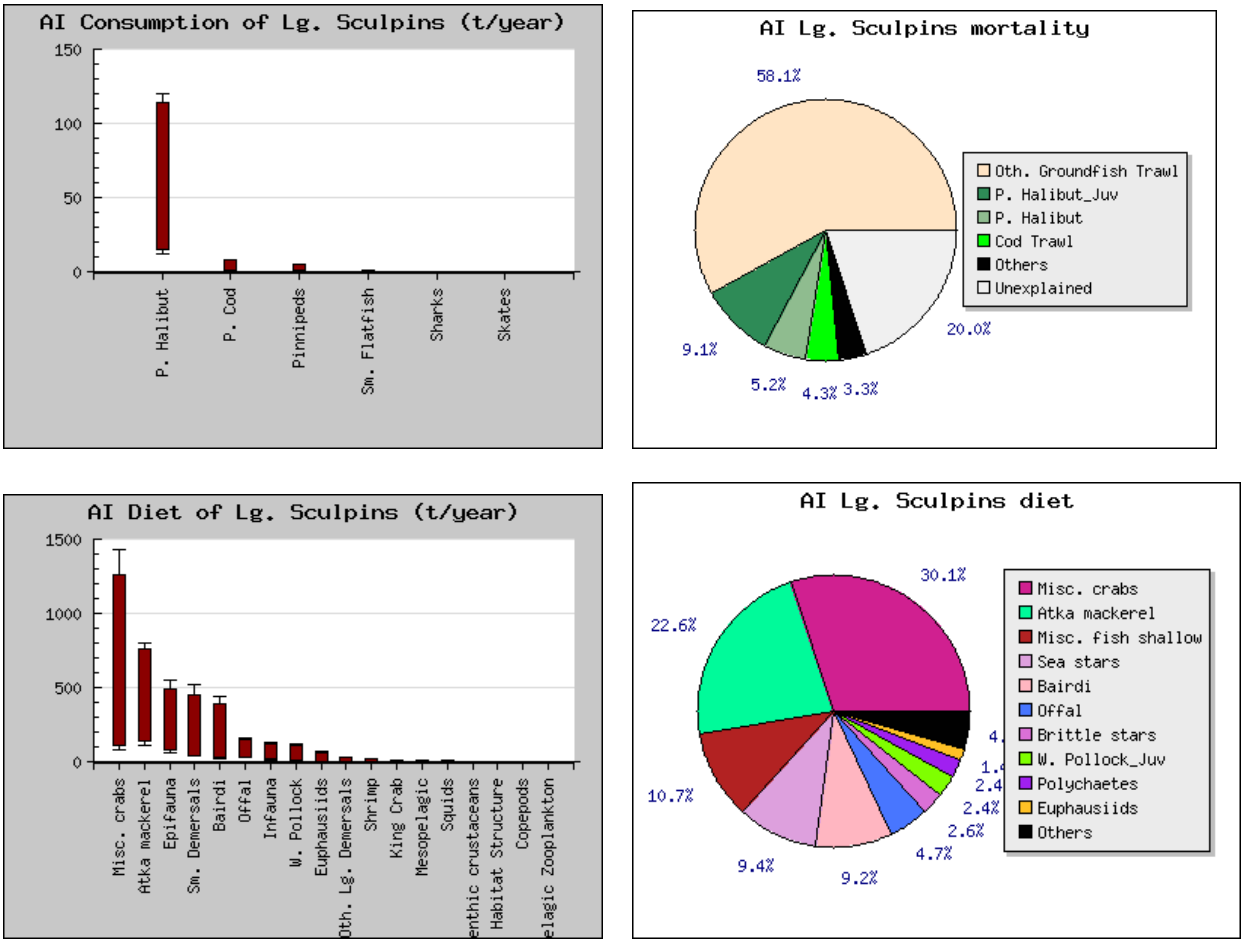

Figure 10. Figures showing Consumption, mortality, and diet of large sculpins from the Aleutian Islands. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

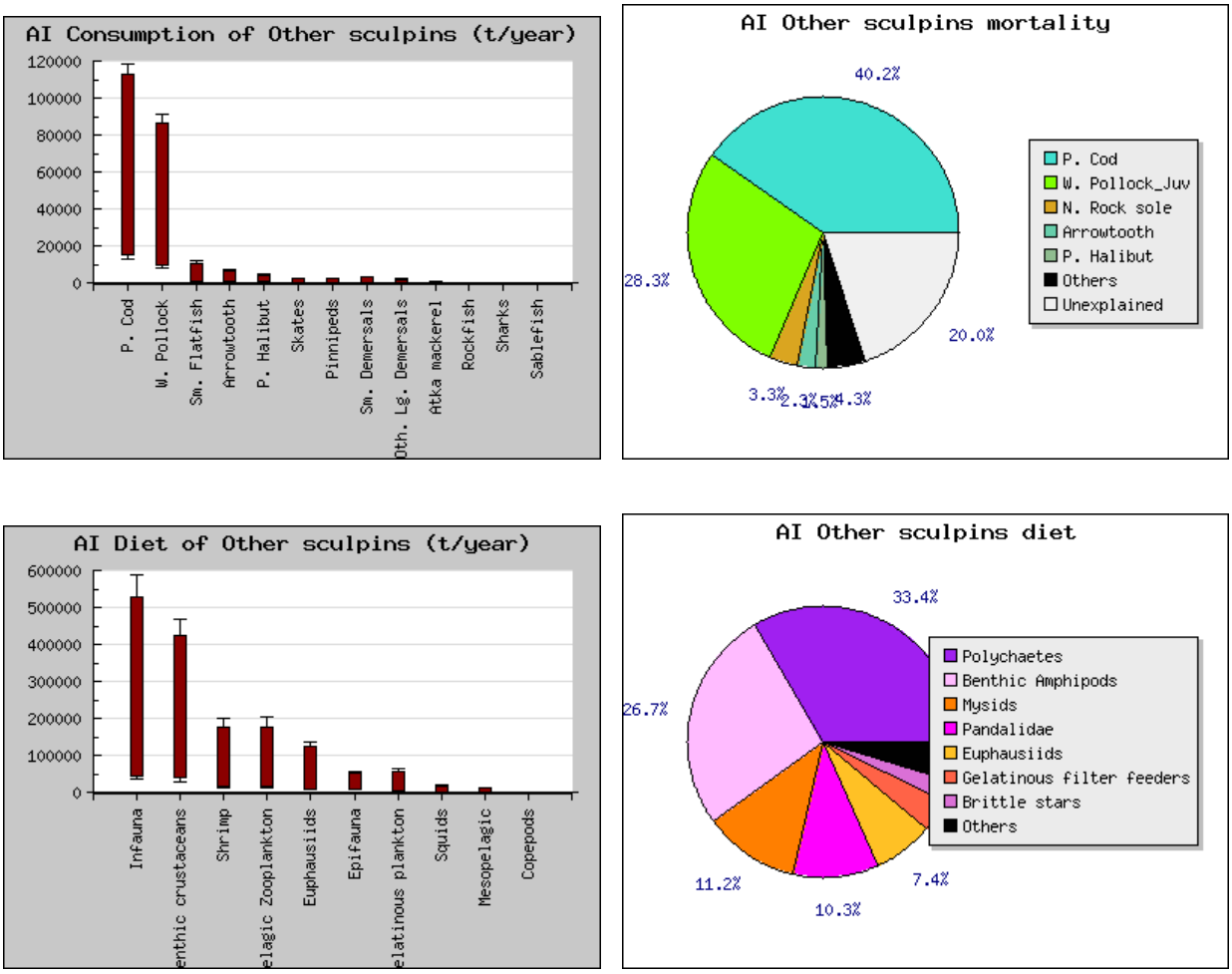

Figure 11. Figures showing Consumption, mortality, and diet of other sculpins from the Aleutian Islands. Source: REEM ecosystem website.

*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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