20. 2006 BSAI Sculpins

Rebecca F. Reuter and Todd T. TenBrink

November 2006

20.0 Executive Summary

The following appendix of the Other species chapter summarizes the information currently known about sculpins (Families Cottidae, Hemitripteridae, Psychrolutidae, and Rhamphocottidae) in the Bering Sea/Aleutian Islands (BSAI) FMP.

a) 20.0.1 Summary of Major Changes

1. Total fishery catch data from 2005 and 2006 to date are presented for the sculpin complex. Data are broken down for sculpins from the following genera: *Hemilepidotus, Myoxocephalus, Hemitripterus.* Data for the rest of the sculpin species found in the BSAI are presented and reported as sculpin unidentified.
2. Information on total sculpin catch by target fishery and gear type for 2005.
3. Biomass estimates from the 2006 Aleutian Islands bottom trawl survey and the 2006 Eastern Bering Sea Shelf survey are presented.
4. Authors present information for recommending the splitting of the BSAI sculpin complex into a Bering Sea Shelf assemblage, a Bering Sea Slope assemblage and an Aleutian Island assemblage. Therefore, we suggest separate ABC and OFL for each region.
5. Authors used a 6 year average biomass to calculate ABC and OFL for the Sculpin Complex. For the EBS shelf average survey biomass estimate used 2001-2006, EBS slope average biomass estimate used 2002 and 2004 data, and AI average survey biomass estimates used 2000-2006 survey data.

Author recommended ABC/OFL for Tier 5 Sculpin Complex

Region	**M**	**Exploitable biomass (mt)**	**F_{ABC}**	**ABC (mt)**	**F_{OFL}**	**OFL (mt)**
BSAI	0.19	216,945	0.1425	30,915	0.19	41,220
EBS	0.19	200,208	0.1425	**28,530**	0.19	**38,040**
AI	0.19	16,737	0.1425	**2,385**	0.19	**3,180**

b) 20.0.2 Responses to SSC Comments

There were no directed comments from the SSC in 2005 for the BSAI sculpin complex.

20.1 Introduction

Description, scientific names, and general distribution

Sculpins are relatively small, benthic-dwelling predatory teleost fish, with many species in the North Pacific. During the cooperative U.S.-Japan 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 from recent surveys of both areas (Table 20.1). Considered as a species complex, sculpins are distributed throughout all benthic habitats from shallow to deep, rocky to flat in the Bering Sea and Aleutian Islands (BSAI), such that they would cover any map of the area completely. In this assessment, we focus on species from the genera *Myoxocephalus*, *Hemitripterus*, and *Hemilepidotus* where observers from the North Pacific Groundfish Observer Program have begun to identify sculpin catch to genus. According to observer catch totals for 2005, the aforementioned genera contributed nearly 90% of all sculpin catch in the BSAI.

Management units

Sculpins are managed as part of the BSAI Other species complex. This means that their catch is reported in aggregate as “other” along with the catch of sharks, skates, and octopi (BSAI) and squid (GOA). Because catch is officially reported within the Other species complex, estimates of sculpin catch must be made independently for each year using observer data. In the BSAI, catch of Other species is limited by a Total Allowable Catch (TAC) which is based on an Allowable Biological Catch (ABC) estimated by summing the TACs of all Other species groups (Gaichas et al., 2005). Sculpins are currently taken only as bycatch in fisheries directed at target species in the BSAI, so future catch of sculpins is more dependent on the distribution and limitations placed on target fisheries than on any harvest level established for this category. The Other species assessment is also presented in response to a draft revision to the National Standard Guidelines (NSG1, 70 FR 36240, June 22, 2005) of the Magnuson-Stevens Act that call for species assemblage management and the possibility of partitioning the Other species chapter into species assemblage management units.

Life history and stock structure (general)

Despite their abundance and diversity, sculpin life histories are not well known in Alaska. Much of the life history information comes from studies in the western North Pacific. In terms of life history, sculpins are different from many target groundfish species in that they 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 pollock, which are broadcast spawners with pelagic eggs. Some larger sculpin species such as the great sculpin, *Myoxocephalus polyacanthocephalus*, reach sizes of greater then 80 cm in the eastern Bering Sea. In the western Pacific, great sculpins are reported to have relatively late ages at maturity (5-8 years, Tokranov, 1985) despite being relatively short-lived (13-15 years), which suggests a limited reproductive portion of the lifespan relative to other groundfish species. Fecundity for the great sculpin off East Kamchatka waters ranged from 48,000 to 415,000 eggs (Tokranov, 1985). In addition, 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. There is limited BSAI-specific age and growth, maturity, or reproductive biology data for sculpins identified in this management region. To date, only the life history of the threaded sculpin, *Gymnocanthus pistilliger*, along the EBS shelf has been investigated beyond basic information in the BSAI (Hoff 2000). New age and growth information is now available for the great sculpin (*Myoxocephalus polyacanthocephalus*) based on samples collected from the 2005 EBS shelf survey. In addition, age and growth, maturity, and diet information are currently being collected for several species as part of a comprehensive study investigating large sculpins in the BSAI (great sculpin, plain sculpin, *Myoxocephalus jaok*, *M. verrucosus*, bigmouth sculpin, *Hemitripterus bolini*, and yellow Irish lord *Hemilepidotus jordani*). Known life history characteristics for the most abundant sculpin species along the EBS shelf are presented in Table 20.2.

20.2 Fishery

Directed fishery

There is no directed fishing for any sculpin species in the BSAI at this time although there has been anecdotal evidence or retention (A. Hollowed, personal communication). The authors are working on getting retention/discard rates for Large sculpins and Other sculpins of the BSAI.

Background on sculpin bycatch

Skates and sculpins constitute the bulk of the Other species catches, accounting for between 66-96% of the estimated totals in 1992-1997. Based on total catch estimates from 1997-2006 (Table 20.3), sculpins comprised an average of 20% 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, pollock, Atka mackerel and flathead sole, and Pacific cod hook-n-line fishery catch the most (Table 20.5).

It is likely that the larger sculpin species (Irish lords, *Hemilepidotus* spp., great sculpin and plain sculpins, *Myoxocephalus* spp., and bigmouth sculpin *Hemitripterus bolini*), which contribute to the majority of sculpin biomass on surveys, are the species commonly encountered incidentally in groundfish fisheries. It is unclear which sculpin species were commonly taken in BSAI groundfish fisheries up to 2004, because observers did not regularly identify animals in these groups to species. At least 80% (by weight) of the observed sculpin catch in past years was recorded as "sculpin unidentified", with the remainder of catch identified to the genus level (*Hemilepidotus, Myoxocephalus, Gymnocanthus, etc.*). Only small amounts (<2%) of sculpin catch in past years were identified to species, although observers were not specifically trained for this level of identification.

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 (*H. villosus*), 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.

20.3 Data

Fishery Catch

Catch trend by genus is not available before 2004. Refer to Table 20.3 for total sculpin catch from 1997-2006. Table 20.4 shows that *Myoxocephalus* spp. make up 50% of the sculpin total catch in the EBS. *Hemilepidotus* spp. make up 28% of the total sculpin catch in the EBS. *Hemitripterus* spp. (bigmouth sculpin) is primarily caught in the EBS. All other sculpin species, identified as "sculpin unidentified' contributed only 12% of the total EBS sculpin catch in 2005. It is reasonable to assume that more *Myoxocephalus* sculpins are caught because they constitute nearly 70% of the biomass along the continental shelf, where the majority of fishing occurs. Fishery catch of sculpins is shelf-wide with the majority of the catch along the middle (50-100m) and outer shelf (100-200m) areas. The catch to biomass ratio of the 2005 total catch of sculpin by genus group, relative to the 2006 biomass estimates from the surveys is shown in the following table:

Catch/Biomass ratio		
Genus	**EBS (shelf)**	**AI**
Myoxocephalus spp.	0.02	0.11
Hemitripterus spp.	0.02	0.04
Hemilepidotus spp.	0.04	0.03

Total sculpin catch by genus was calculated for each target fishery and gear types responsible for sculpin bycatch (Table 20.5). Looking at the catch data by target fishery and gear type shows that in the Aleutian Islands both the Pacific cod and Atka mackerel bottom trawl fisheries were the main fisheries that caught all three genera of sculpin. In the EBS the Pacific cod bottom trawl and longline fisheries were the main fisheries that caught all three genera of sculpin. In general, gear type rather than target fishery may be the main determinant for sculpin bycatch since bottom trawl gear accounted for much of the sculpin bycatch regardless of fishery.

Survey Biomass trend

Aggregate sculpin biomass in the BSAI shows no clear trend, and should probably not be used as an indicator of population status for a complex with so much species diversity. Trends in biomass are available for only a few sculpin species for the period 1982-2006 due to difficulties with species identification and survey priorities. 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 *Myoxocephalus* spp. being the most common, followed by bigmouth sculpins and yellow Irish lords (Table.20.6). A low coefficient of variation for the biomass estimates of these more abundant species reflects that the EBS shelf bottom trawl survey adequately estimates the biomass of these species. It is interesting to note that this year's butterfly sculpin (*H. papilio*) biomass estimate is the highest it's been in 5 years (Table 20.6). This may be in response to cooler waters observed in the Bering Sea in 2006 since it is thought that this species follows the cold pool north, to areas that aren't surveyed, during warmer years. Biomass estimates for the 5 most abundant sculpin species in the Eastern Bering Sea shelf seem to be stable (Figure 20.1). There are no biomass trends for the EBS slope, although there were two surveys (2002, 2004) the future of this survey is uncertain.

Sculpin species identification was only recently implemented in the AI survey. Each of the six most abundant species of sculpin in the AI have estimates at least since 1997, with the yellow Irish lord, bigmouth sculpin, and darkfin sculpin having reliable estimates since 1982. In the AI, yellow Irish lords account for the highest proportion of sculpin biomass, followed by darkfin sculpins, great sculpin, spectacled sculpin, bigmouth sculpin and scissortail sculpins (Table 20.7). The spectacled and scissortail sculpins are two species not found on EBS surveys. The AI survey adequately assesses the biomass of the 5 most abundant sculpin species, which are the larger species of sculpin. 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. Biomass trends of sculpin species in the AI seem to be stable with an increase in yellow Irish lord biomass. (Figure 20.2).

<u>Length frequency and sample size</u>

Eastern Bering Sea

Length measurements (fork length, FL) have been collected for a variety of sculpin species during AFSC 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 20.3). Year by year analysis shows that the length composition by species is consistent. One interesting observation is that the surveys tend to catch bigmouth sculpins on the higher side of the length range. Although little information is known about bigmouth sculpin life history, this may suggest that the younger or smaller bigmouth sculpins occur in areas not sampled well by the surveys or they are not fully selected by the gear. Fishery length data may be available for some sculpin species beginning in 2007 through a special project with the AFSC observer program.

Sample sizes for length frequency analysis for EBS

Species	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Yellow Irish Lord				369	516	604
Plain sculpin	1044	1263	997	1218	1736	1786
Warty sculpin	178	288	130	192	245	323
Great sculpin	338	327	346	635	681	786
Big mouth sculpin	50	157	231	179	342	187

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 3 survey years of data and show a consistent size composition (Figure 20.4). Darkfin and spectacled sculpin only have length data collected from the 2002 survey. Specimens smaller than 7 cm have not been collected for many sculpins, but this may be a factor of size selectivity of the survey gear. Spectacled sculpin population may have a bi-modal size distribution, with peaks at 13 cm and 19 cm.

Sample sizes for length frequency analysis for AI

Species	**2000**	**2002**	**2004**
Yellow Irish Lord	170	567	986
Darkfin sculpin	-	193	-
Spectacled sculpin	-	145	-
Great sculpin	12	23	58
Big mouth sculpin	8	29	27

Length at age and weight at age

At this time we do not have any age data for sculpins. The Age and Growth group at the AFSC is currently working up a small sample size of otoliths from the EBS shelf survey for spinyhead, thorny, great, plain, warty, spectacled and bigmouth sculpins. Ages will be available in 2007.

20.4 Analytical Approach and Results

The available data do not currently support population modeling for sculpins in the BSAI, although natural mortality (M) was estimated (refer to 2004 SAFE).

Parameters Estimated Independently

Natural Mortality

An analysis was undertaken to explore alternative methods to estimate natural mortality (M) for sculpin species found in the BSAI. Several methods were employed based on correlations of M with life history parameters including growth parameters (Alverson and Carney 1975, Pauly 1980, Charnov 1993), longevity (Hoenig 1983), and reproductive potential (Roff 1986, Rikhter and Efanov 1976). 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). Considering the uncertainty inherent in applying this method to sculpin species and stocks not found in the BSAI, we elected to use the lowest estimates of M derived from any of these methods (Table 20.8). Choosing the lowest estimate of M (0.19) is considered conservative because it will result in the lowest estimates of ABC and OFL under Tier 5. Until we find better information on sculpin productivity in the BSAI, this is still the best interim measure balancing sculpin conservation and allowing for historical levels of incidental catch in target groundfish fisheries. New data from an on-going sculpin study, however, in the BSAI will allow for more region-specific M estimates. Preliminary data exists for age and growth for the great sculpin (*Myoxocephalus polyacanthocephalus*) which does provide information necessary for an M estimate. This data is the result of analyzing only a single survey year (2005 EBS shelf survey), however, and may not be representative of the *Myoxocephalus* sculpins. We, therefore, continue to use the interim estimate of 0.19 until more data analyses are completed.

Assemblage analysis and recommendations

Currently all sculpin species from the BSAI are lumped into one complex. Analysis of species composition, abundance and occurrence of endemic species within the EBS and AI was done to determine if the complex should be split by region. Species composition in the EBS and AI are different. Although a few species such as *Myoxocephalus polyacanthocephalus*, *Hemilepidotus jordani*, and *Hemitripterus bolini* occur in both the EBS and AI regions, their biomass estimates vary greatly (Table 20.6 and 20.7). For example *Hemitripterus bolini* biomass in the EBS is an order of magnitude greater than in the AI. In both regions endemic species are also found. *Myoxocephalus jaok* and *M. verucosus* only occur on the EBS shelf. In the AI *Artediellus forficata* and *Enophrys diceraus* may be endemic. Lastly, there is evidence that the species composition of sculpins varies by region (Figure 20.5). Splitting the biomass to obtain separate ABC and OFL for each region will allow for adequate monitoring of those species in the AI.

20.5 ABC and OFL recommendations

Leaving sculpins within the larger aggregate of the Other species complex provides no benefit to the resource or to the fisheries that might wish to retain some other species but cannot when the aggregate TAC is exceeded, as it was in 2004. For 2005, the Other species TAC was set at 24,650 mt and was exceeded by 2,303 mt. Currently, as of 10/21/2006, 98% of the Other species TAC has been caught according to the NMFS Alaska Regional Office (http://www.fakr.noaa.gov/2006/car110_bsai_with_cdq.pdf). Because sculpins are such a diverse category themselves, and because their life history is so different from skates, sharks, and octopi as described above, we recommend that they be managed separately from the Other species complex. There is a reliable biomass time series for the sculpin complex as a whole, and recently reliable estimates of biomass for each species within the complex. We feel that our conservative estimate of M is the best available for managing this species complex until the research initiated in the Bering Sea is completed.

We recommend a Tier 5 approach be applied to the sculpin complex within the EBS and AI regions as long as the catch remains incidental and no target fishery develops. We further recommend using a 6 year average of aggregate biomass so that we may include multiple estimates from each of the EBS shelf, slope, and AI bottom trawl surveys, but can still capture recent biomass trends. In tier 5, F_{ABC} is defined to be <=0.75 x M and F_{OFL} is defined to be equal to M. Applying the M estimate of 0.19 to the 6 year (2001 – 2006 for EBS shelf; 2000-2006 AI; 2002, 2004 for EBS slope) average of bottom trawl survey biomass estimates by region, we calculate an ABC of (0.75 * 0.19) * (EBS shelf (194,255 mt)+ EBS slope (5,953 mt) = 200,208 mt) = 28,530 mt for the EBS and we calculate an ABC of 0.75 * 0.19 * (AI biomass; 16,737) = 2,385 mt. Using the same method to calculate OFL, 0.19 * (EBS shelf + EBS slope+ AI biomass = 216,945 mt) = 41,220 mt for the BSAI. Tier 6 options for sculpin management are not recommended.

In the unlikely event that target fisheries develop for some sculpin species, we recommend that each targeted sculpin species be managed separately, and that directed fishing only be allowed when sufficient life history information becomes available to make reasonable species specfic estimates of productivity. Given that the most probable targeted sculpin species would be the most abundant, managing as single species may not be problematic under the current TAC setting regime, assuming the species was being identified to species level by the observer program. If a targeted species of sculpin is one with a low abundance thus low TACs, then alternative management strategies such as closed areas should be considered.

20.6 Ecosystem Considerations

20.6.1 Ecosystem Effects on Stock

Little is known about sculpin food habits in the BSAI, especially during fall and winter months. Aydin et al. (In review) has 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 20.6). In the EBS the main predator of large sculpins are Pacific cod, but the greatest mortality of large sculpins is due to the flatfish bottom trawl fishery (Figure 20.6). Other sculpins in the EBS feed mainly on shrimp and benthic amphipods (Figure 20.7). 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 20.7). In the AI large sculpin have a different diet than in the EBS, consisting of crabs, Atka mackerel and miscellaneous shallow water fish (Figure 20.8). Large sculpin in the AI are preyed upon mainly by Pacific halibut, but the main source of their mortality is from “other” groundfish bottom trawl fishery (Figure 20.8). Diet of other sculpins in the AI consists of polychaetes and benthic amphipods (Figure 20.9). 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 20.9).

20.6.2 Fishery Effects on the Ecosystem

Analysis of ecosystem considerations for those fisheries that affect the stocks within this complex (see Table 20.5) is given in the respective fisheries SAFE chapter. 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 affect	Probably no concern
a. Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	No affect	Probably no concern
Birds	Stable, some increasing some decreasing	No affect	Probably no concern
Fish (Pollock, Pacific cod, halibut)	Stable to increasing	Affects not known	Probably no concern
b. Changes in habitat quality			
Temperature regime	None	Affects not known	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)**			

20.6.3 Data gaps and research priorities

Sculpin life history has been studied more extensively in the western Bering Sea and associated waters. Several life history data gaps continue to persist in the eastern Bering Sea and Aleutian Island regions. These data are necessary in improving management strategies and stock assessments for this non-target species group. A newly funded study concentrating on large sculpins (great sculpin *Myoxocephalus polyacanthocephalus*, plain sculpin, *M. jaok*, *M. verrucosus*, bigmouth sculpin, *Hemitripterus bolini*, and yellow Irish lord *Hemilepidotus jordani*) addresses some of these data gaps. Age and growth, maturity, and diet information is being investigated for populations inhabiting both the eastern Bering Sea shelf and the Aleutian Islands. Data collection began in 2006 and will continue through the end of 2007. Age and growth analysis of some of these species will also include prior years. Some preliminary results from this study should be available for use in the 2007 SAFE.

20.7 Summary

Below are the recommendations for ABC and OFL for an EBS sculpin complex and AI sculpin complex. BSAI numbers are there for reference.

Summary Table for Tier 5 Sculpin Complex

Region	**M**	**Exploitable biomass (mt)**	**F_{ABC}**	**ABC (mt)**	**F_{OFL}**	**OFL (mt)**
BSAI	0.19	216,945	0.1425	30,915	0.19	41,220
EBS	0.19	200,208	0.1425	**28,530**	0.19	**38,040**
AI	0.19	16,737	0.1425	**2,385**	0.19	**3,180**

20.8 Literature Cited

Alverson, D.L., and M.J. Carney. 1975. A graphic review of the growth and decay of population cohorts. J. Cons. Int. Explor. Mer 36:133-143.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. *In review*. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA Tech Memo.

Charnov, E.L. 1993. Life history invariants some explorations of symmetry in evolutionary ecology. Oxford University Press Inc., New York. 167p.

Eschmeyer, W.N., E.S. Herald, and H. Hammann, 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Co., Boston: 336 pp.

Fritz, L. W. 1997. Squid and other species. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Gaichas, S.K., L.W. Fritz, and J.N, Ianelli. 1999. Other species considerations for the Gulf of Alaska. Appendix D. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska Region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Gaichas, S.K., D. Courtney, R. Reuter, L. Conners, C. Tribuzio, K. Goldman, T. TenBrink, D. Stevenson, B. Matta, J. Hoff, and E. Jorgenson. 2005. Bering Sea and Aleutian Islands Squids and Other Species. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea and Aleutian Islands Region. North Pacific Fishery Management Council, Anchorage AK.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82: 898-903.

Hoff, G.R. 2000. Biology and ecology of threaded sculpin, *Gymnocanthus pistilliger*, in the eastern Bering Sea. Fishery Bulletin 98:711-722.

Markevich, A. 2000. Spawning of the sea raven *Hemitripterus villosus* in Peter the Great Bay, Sea of Japan. Russian Journal of Marine Biology 26(4): 283-285.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer 39(2):175-192.

Rikhter, V.A., and V.N. Efanov. 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res. Doc. 76/VI/8. Serial N. 3777. 13p.

Roff, D.A. 1986. The evolution of life history parameters in teleosts. Can. J. Fish. Aquat. Sci. 41:989-1000.

Stevenson, D.E. 2004. Identification of skates, sculpins, and smelts by observers in North Pacific groundfish fisheries (2002-2003). U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-142, 67p.

Tokranov, A.M. 1985. Reproduction of great sculpin, *Myoxocephalus polyacanthocephalus* (Cottidae) in Kamchatka waters. J. Ichthyol. 24(4):119-127.

Table 20.1. 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 20.2. Life history information available for selected BSAI sculpin species.

Species	Common Name	Maximum Length (cm)			Maximum Age		Fecundity (x1000)	Age at 50% Maturity
		Other	AI	EBS	Other	BSAI		
Myoxocephalus joak	Plain sculpin	75	NA	63	15		25.4 - 147	5 - 8
M. polyacanthocephalus	Great sculpin	82	76	82	13	16	48 - 415	6 - 8
M. verrucosus	Warty sculpin	78	NA	78			2.7	
Hemitripterus bolini	Bigmouth sculpin	83	83	78				
Hemilepidotus jordani	Yellow Irish lord	65	65	50	13		25 - 241	6 - 7
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 2002; Panchenko 2003; Tokranov 1985; Andriyashev 1954; Tokranov 1988a; Tokranov 1988b; Tokranov 1995; Hoff 2000; Tokranov and Orlov 2001.

Table 20.3. Total catch (mt) of sculpin complex compared to Other species catch (including squid), 1997-2006.

Year	Other species ABC	Other species TAC	Other species OFL	Other species catch	EBS Sculpin catch	AI Sculpin Catch	% of Sculpin in Other spp. catch (EBS)	% of Sculpin in Other spp. catch (AI)
1997	25,800	25,800		25,176	6,707	771	27%	3%
1998	25,800	25,800	134,000	25,531	5,204	1,081	20%	4%
1999	32,860	32,860	129,000	20,562	4,503	967	22%	5%
2000	31,360	31,360	71,500	26,108	5,673	1,413	22%	5%
2001	33,600	26,500	69,000	27,178	6,067	1,603	22%	6%
2002	39,100	30,825	78,900	28,619	6,043	1,133	21%	4%
2003*	43,300	32,309	81,100	27,356	5,350	598	19%	2%
2004*	46,810	27,205	81,150	30,361	5,258	887	17%	3%
2005*	53,860	29,000	87,920	30,690	5,094	676	17%	2%
2006**	58,882	29,000	89,404	25,597	3,180	512	20%	3%

Data sources: Other species ABC, TAC, OFL, and catch from AKRO website 2006
Other species catch updated October 21, 2006
, * 2003-2005 Sculpin catch data revised in 2006. Source is Catch Accounting System at NMFS AK Regional Office
**2006 sculpin data complete as of August 10, 2006

Table 20.4. Extrapolated total catch (mt) of Large sculpins (*Hemilepidotus* spp.*, Hemitripterus* spp*. and Myoxocephalus* spp.) based on proportion of observed catch*. Source: NMFS AK regional office catch accounting system.*

2006*	**Eastern Bering Sea**	**Aleutian Islands**
Hemitripterus spp. Bigmouth sculpin	341	26
Hemilepidotus spp.	634	320
Myoxocephalus spp.	1,749	46
Sculpin unidentified	455	118
Total	**3,179**	**510**

*As of August 11, 2006

2005	**Eastern Bering Sea**	**Aleutian Islands**
Hemitripterus spp. Bigmouth sculpin	487	75
Hemilepidotus spp.	1,445	346
Myoxocephalus spp.	2,563	228
Sculpin unidentified	598	75
Total	**5,093**	**674**

Table 20.5. Total catch (mt) of Large sculpins (*Hemilepidotus* spp., *Hemitripterus* spp. *and Myoxocephalus* spp.) by target fishery and gear, from 2005 for Aleutian Islands and Eastern Bering Sea. *Source: NMFS AK regional office catch accounting system. Note: Amounts below do not add up to the total catch of the Sculpin complex.*

2005
Aleutian Islands

Large Sculpins

Target fishery	Gear type: Bottom Trawl	Pelagic Trawl	Pot	Longline
Atka Mackerel	372	>1	-	-
Pacific Cod	92	-	-	178
Flatfish	-	-	-	1
Rockfish	34	-	-	-
Sablefish	-	-	>1	>1
Pollock	-	>1	-	-

2005
Eastern Bering Sea

Large sculpins

Target fishery	Gear type: Bottom Trawl	Pelagic Trawl	Pot	Longline
Pacific Cod	899	0	113	1,225
Flatfish	2,074	-	-	>1
Pollock	3	135	-	-
Sablefish	-	-	>1	>1
Rockfish	-	-	-	-
Atka Mackerel	44	-	-	-

Table 20.6. Sculpin complex biomass (mt) from the 2001-2006 Bering Sea shelf survey.

		Biomass						CV
Sculpin species	**common**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2006**
Myoxocephalus jaok	plain	48,400	52,525	79,337	68,671	76,540	66,819	0.10
Myoxocephalus polyacanthocephalus	great	39,815	64,881	64,486	58,505	55,957	54,456	0.10
Hemitripterus bolini	bigmouth	25,751	32,178	29,274	34,748	31,002	30,116	0.13
Hemilepidotus jordani	yellow Irish lord	9,109	9,430	14,220	33,630	27,380	31,684	0.44
Myoxocephalus verrucosus	warty	15,023	10,801	7,058	10,089	25,897	16,099	0.25
Gymnocanthus pistilliger	threaded	423	1,560	1,137	1,275	1,977	2,385	0.24
Dasycottus setiger	spinyhead	1,681	1,194	1,274	1,019	4,469	2,479	0.16
Gymnocanthus galeatus	armorhead	289	1,708	720	785	1,551	1,732	0.55
Icelus spiniger	thorny	793	767	715	616	543	596	0.20
Triglops pingeli	ribbed	186	155	142	556	264	400	0.36
Hemilepidotus papilio	butterfly	1,649	686	628	379	370	1,491	0.52
Malacocottus zonurus	darkfin	220	529	11	122	35	69	0.79
Triglops macellus	roughspine	8	3	10	62	111	168	0.75
Triglops scepticus	spectacled	174	255	298	29	112	365	0.79
Icelus spatula	spatulate	16	19	3	13	20	46	0.24
sculpin unid (all others)		10	2	0	10	0	0	0.70
Artediellus pacificus	hookear	4	2	0	trace	3	1	0.60
Triglops forficata	scissortail	0	0	0	0	0	0	
Leptocottus armatus	staghorn	0	0	0	0	210	91	0.70
Enophrys diceraus	antlered	0	0	0	0	0	0	
Blepsias bilobus	crested						23	0.62
Total		**143,551**	**176,695**	**199,313**	**210,509**	**226,441**	**209,020**	

Table 20.7. Sculpin complex biomass (mt) from the 1997-2006 Aleutian Islands trawl survey.

Species	**Common Name**			**Biomass**			**CV**
		1997	**2000**	**2002**	**2004**	**2006**	**2006**
Hemilepidotus jordani	Yellow Irish lord	4,667	6,624	4,282	8,361	10,797	0.16
Malacocottus zonurus	Darkfin sculpin	3,442	2,533	3,971	4,493	4,520	0.17
Myoxocephalus polyacanthocephalus	Great sculpin	2,138	1,161	1,547	1,519	2,121	0.20
Triglops scepticus	Spectacled sculpin	1,344	1,121	2,393	1,038	993	0.29
Hemitripterus bolini	Bigmouth sculpin	1,617	1,026	1,191	790	1,647	0.32
T. forficata	Scissortail sculpin	219	66	442	2,073	136	0.43
Gymnocanthus galeatus	Armorhead sculpin	105	287	207	506	424	0.34
Sculpin unid. (all others)		75	49	137	101	181	0.31
Dasycottus setiger	Spinyhead sculpin	71	19	23	72	12	0.62
Enophrys diceraus	Antlered sculpin	0	0	20	17	8	1.00
Myoxocephalus jaok	Plain sculpin	0	0	32	0	0	
Leptocottus armatus	Pacific staghorn sculpin	0	0	0	9	0	
Total		**13,678**	**12,886**	**14,245**	**18,979**	**20,839**	

Table 20.8. List of available natural mortality information for sculpins.

Species	Area	Sex	Hoenig	Rikhter & Efanov	Alverson & Carney	Charnov	Roff
Arctic staghorn sculpin	W. Bering Sea	*M*	0.53				
	W. Bering Sea	*F*	0.47				
				0.41			
Common staghorn sculpin	Kamchatka	*M*	0.32	0.32			
	Kamchatka	*F*	0.25	0.26			
Red Irish lord	Puget Sound		0.70				
Longfin Irish lord	Kuril Islands	*F*	0.47		0.70	0.22	
Yellow Irish lord	Kamchatka	*M*	0.32	0.24			
	Kamchatka	*F*	0.35	0.24			
Pacific staghorn sculpin	California	*F*	0.42				
Threaded sculpin	E. Bering Sea	*M*	0.42		0.36	0.65	
	E. Bering Sea	*F*	0.47		0.58	0.40	
Armorhead sculpin	Kamchatka	*M*	0.38				
	Kamchatka	*F*	0.32				
Great sculpin	Kamchatka	*M*	0.47	0.26			
	Kamchatka	*F*	0.32	0.19			
	E. Bering Sea	*M*	0.28				
	E. Bering Sea	*F*	0.26		0.29	0.30	
Plain sculpin	Sea of Japan	*M*	0.35	0.29			
	Sea of Japan	*F*	0.28	0.22	0.38	0.20	
	Kamchatka	*M*	0.47	0.32			
	Kamchatka	*F*	0.35	0.22			

References: AFSC; Panchenko 2002; Panchenko 2003; Tokranov 1985; Tokranov 1988a; Tokranov 1988b; Tokranov 1995; Hoff 2000; Tokranov and Orlov 2001, Tokranov et al. 2003; Weiss 1969

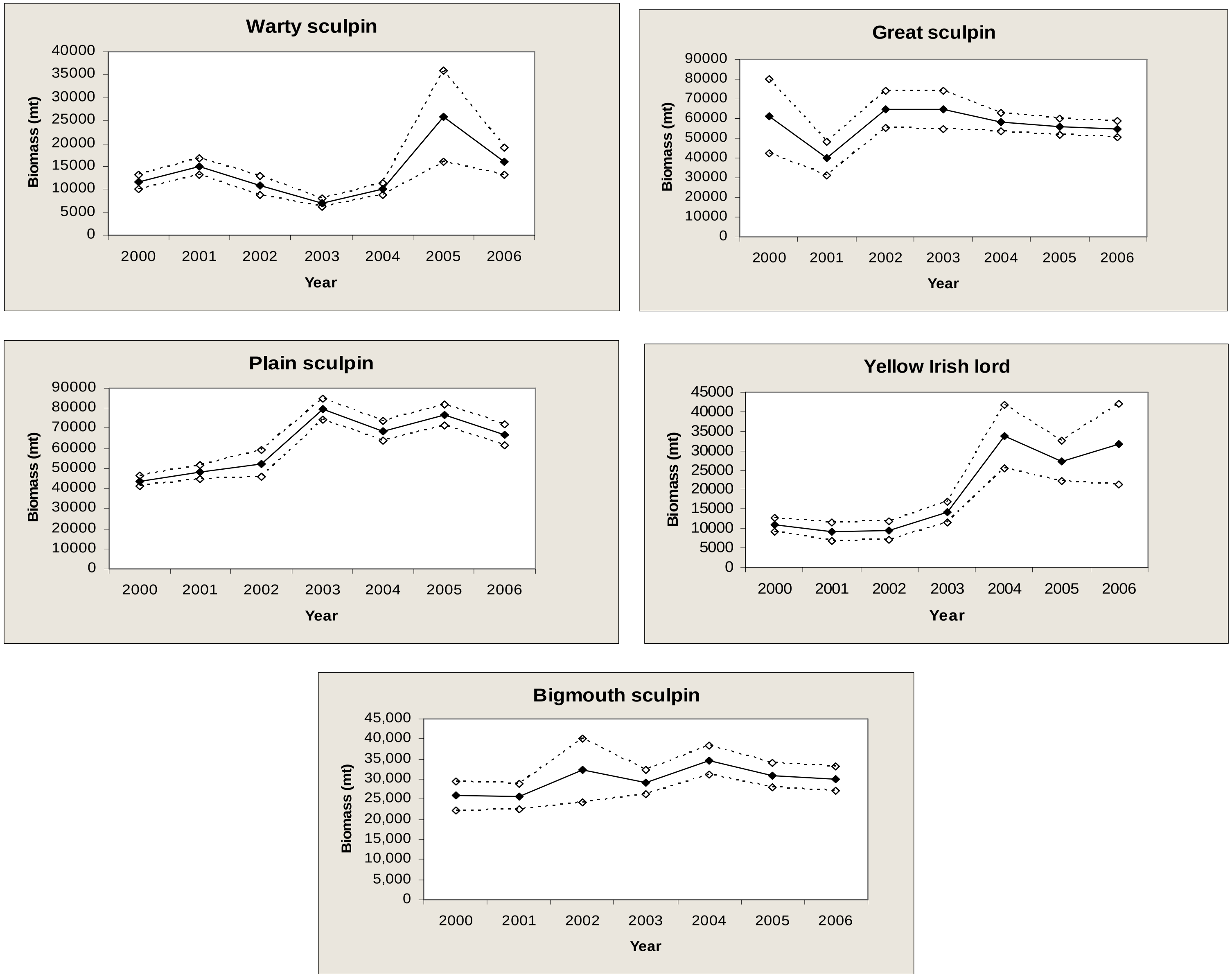

Figure 20.1. Biomass time series (with 95% Confidence Intervals) from annual EBS shelf bottom trawl surveys for selected sculpin species, 2000-2006.

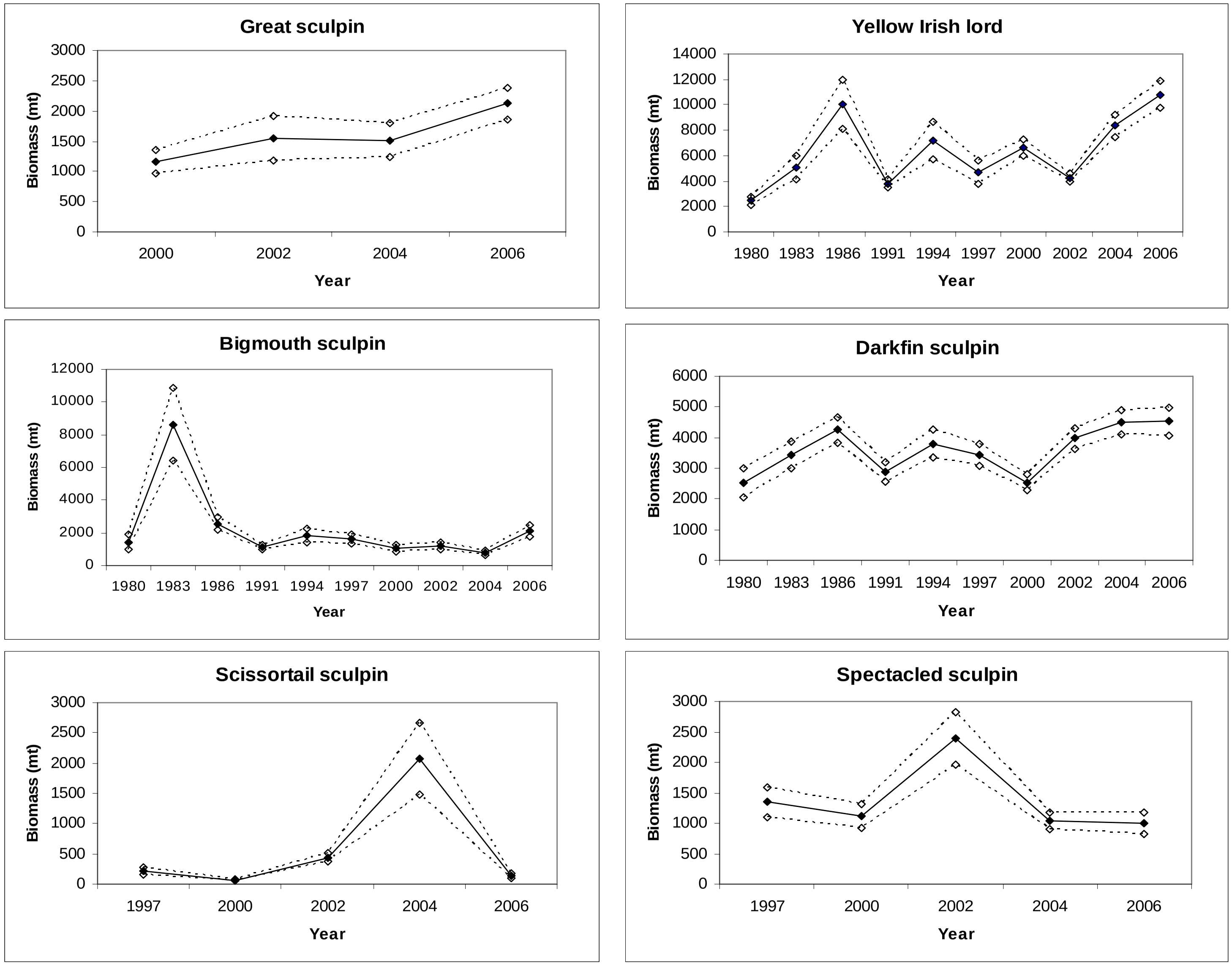

Figure 20.2. Biomass time series (with 95% Confidence Intervals) for the six most abundant sculpin species in Aleutian Islands trawl survey 1980-2006. Note: Some sculpin species were not regularly identified to species-level until recent surveys.

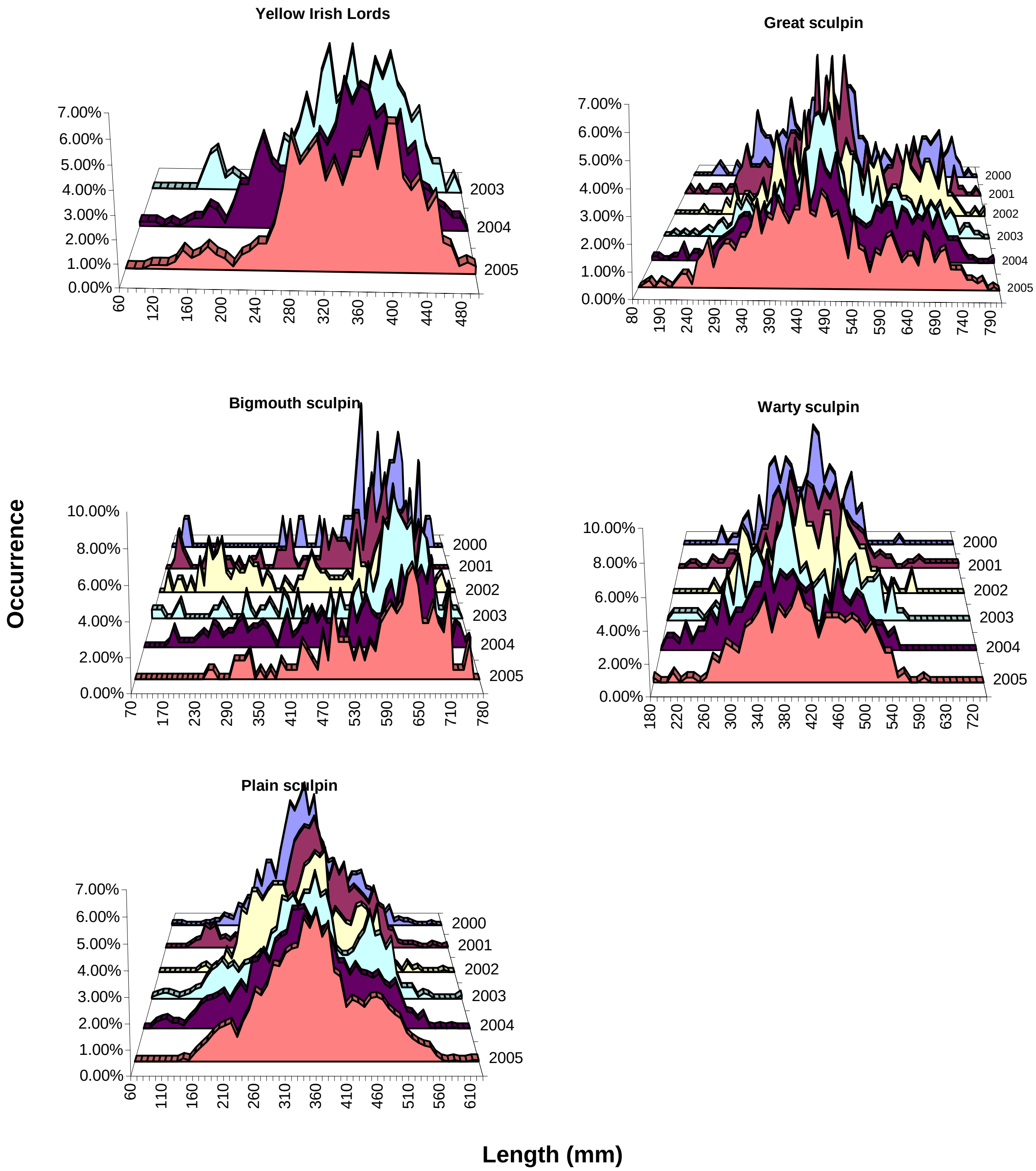

Figure 20.3. Length frequencies (fork length, FL in mm) from survey data for the five most abundant sculpin species in EBS. Note: Plain and warty sculpins found only on EBS shelf.

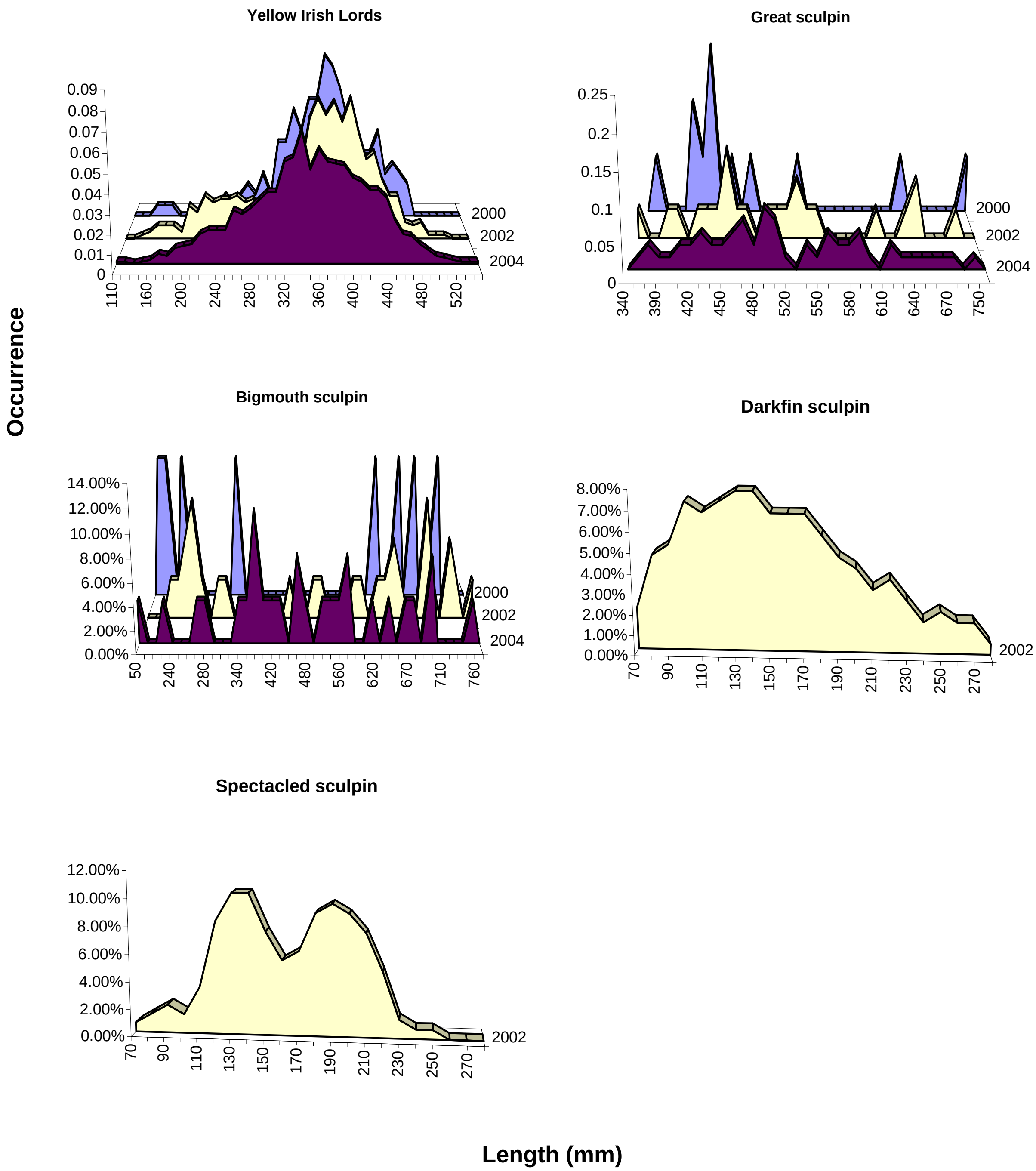

Figure 20.4. Length frequencies (fork length, FL in mm) from survey data for the 5 most abundant sculpin species in AI.

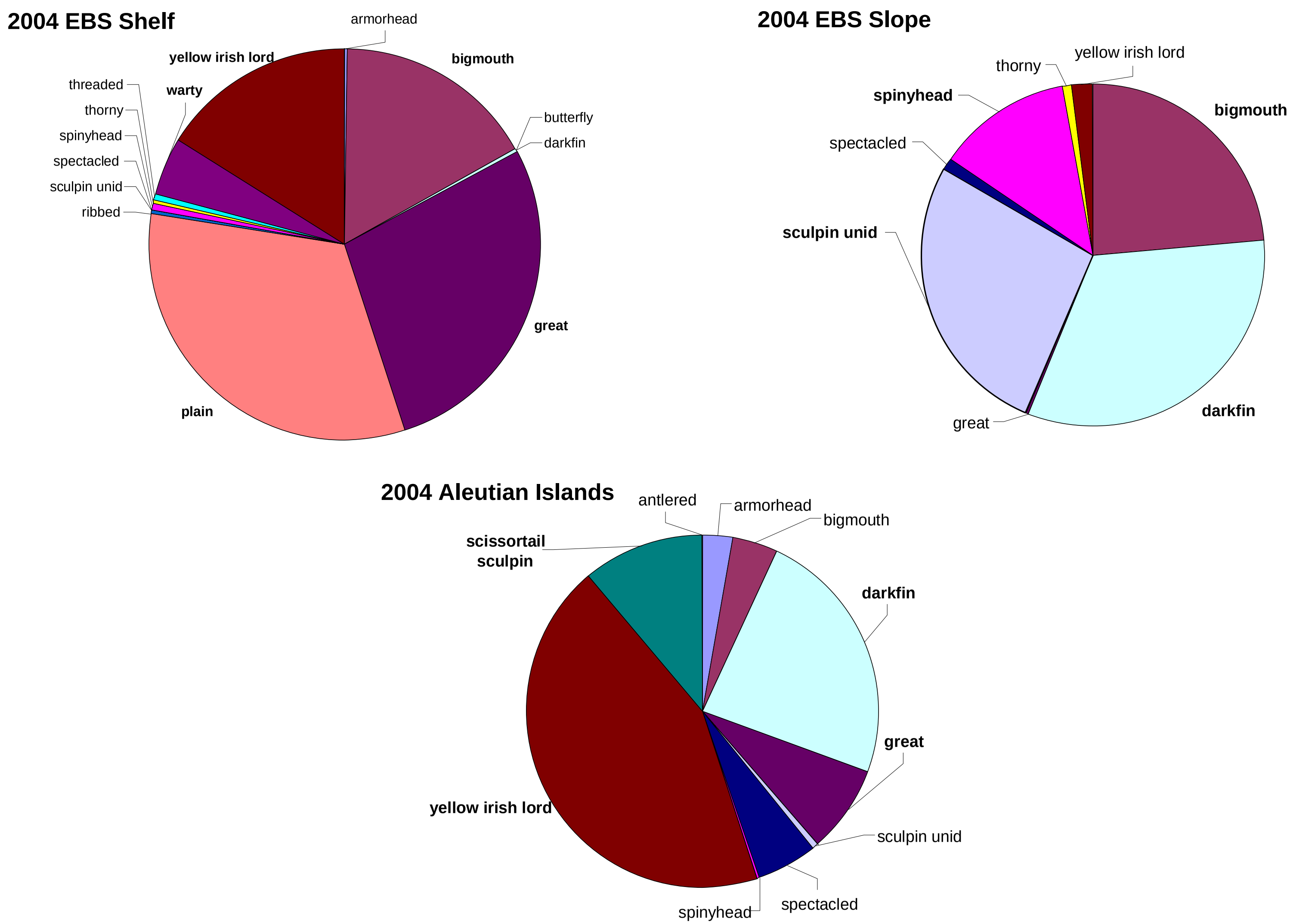

Figure 20.5. 2004 Sculpin Biomass estimates from the EBS shelf, EBS slope and AI surveys to show differences in species composition.

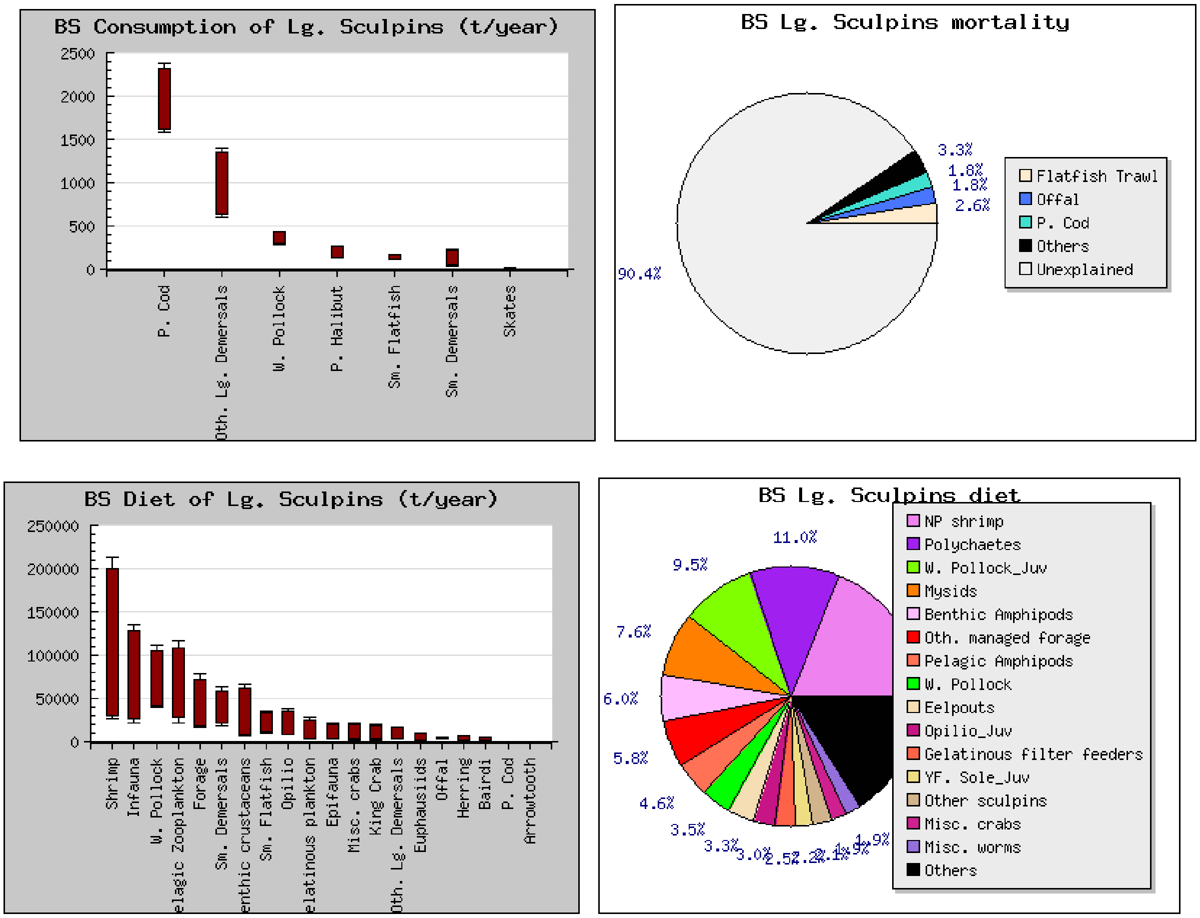

Figure 20.6. Figures showing Consumption, mortality, and diet of large sculpins from the Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

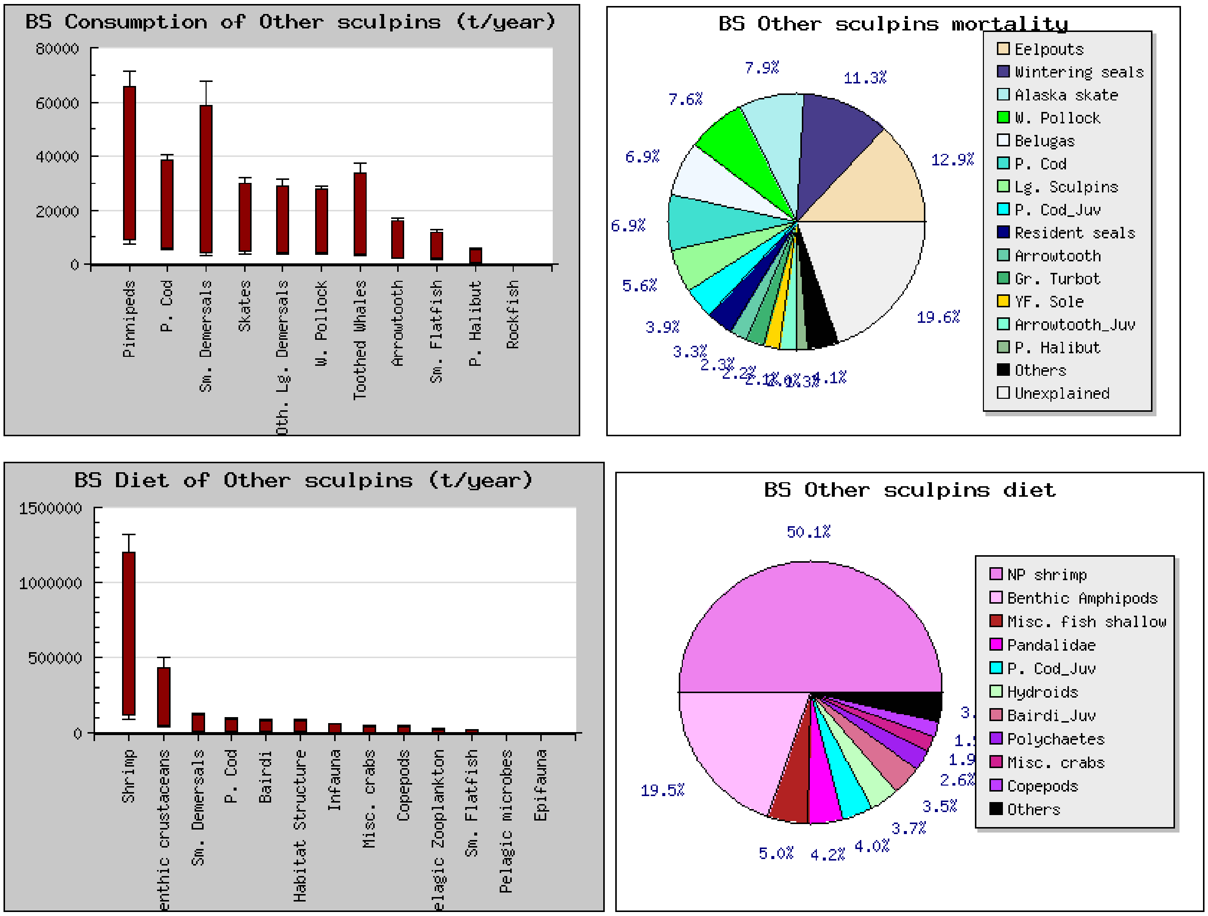

Figure 20.7. Figures showing Consumption, mortality, and diet of other sculpins from the Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

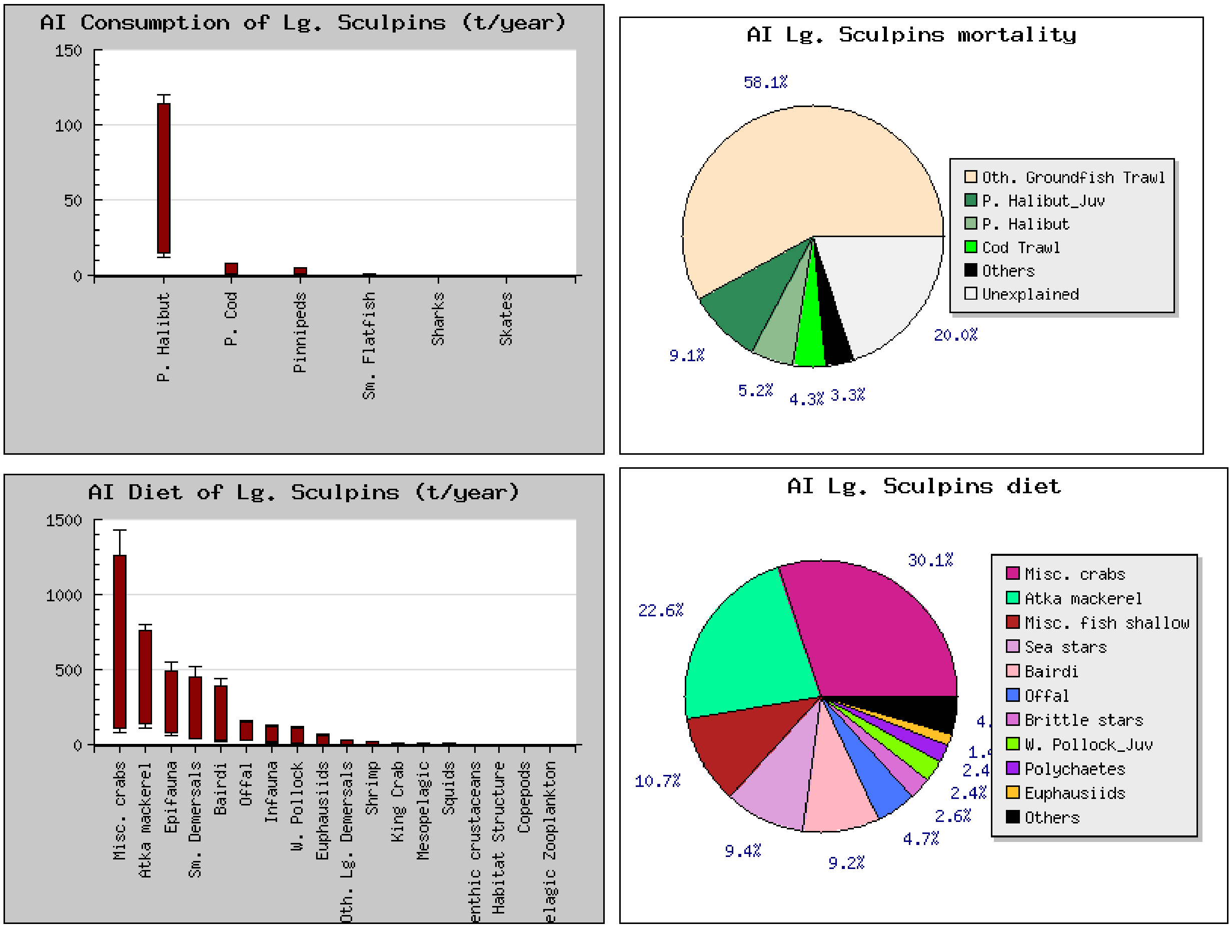

Figure 20.8. Figures showing Consumption, mortality, and diet of large sculpins from the Aleutian Islands. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

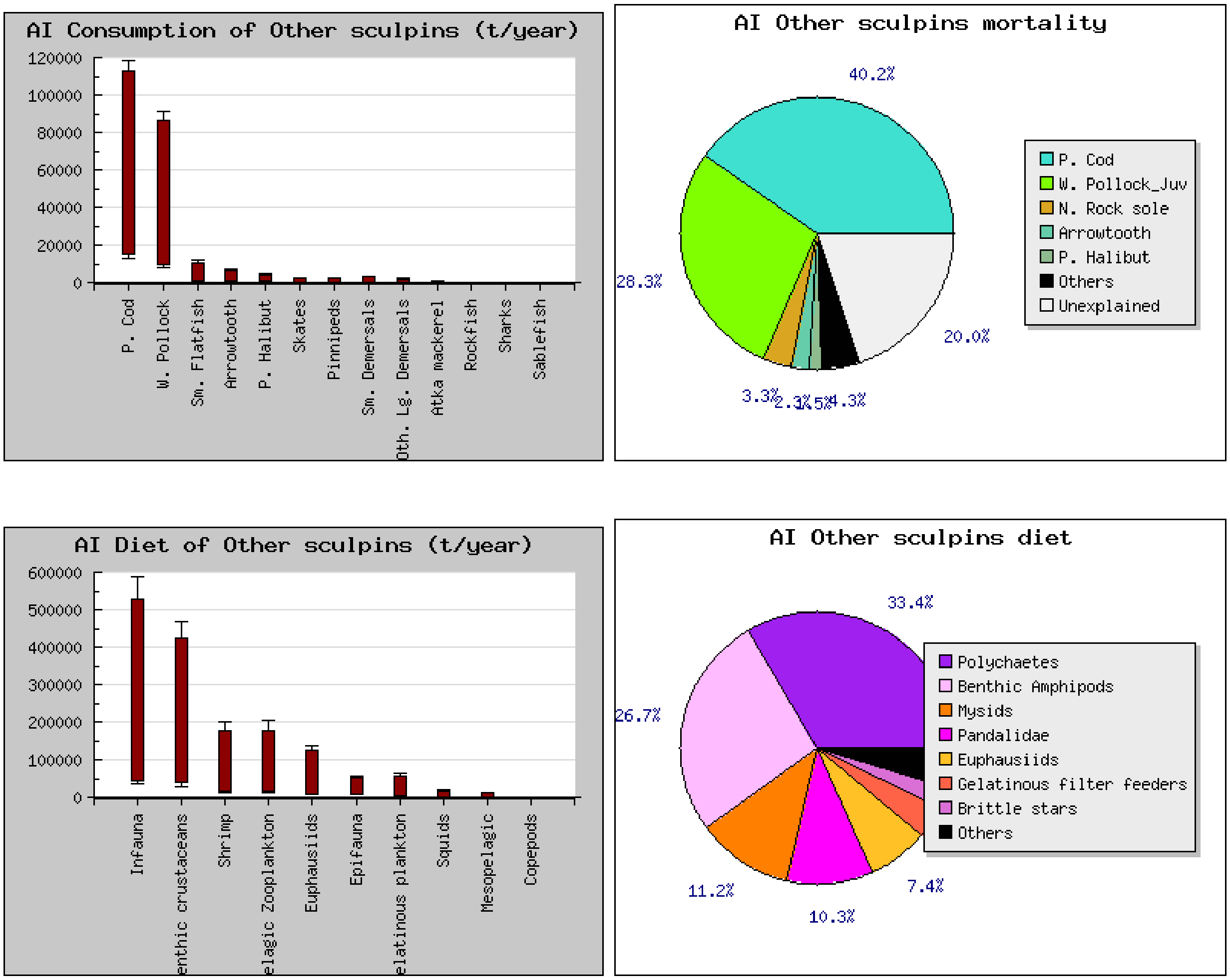

Figure 20.9. Figures showing Consumption, mortality, and diet of other sculpins from the Aleutian Islands. Source: REEM ecosystem website.

*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.