# 20. Assessment of Sculpin stocks in the Bering Sea/Aleutian Islands

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November 2008

## Executive Summary

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

### a) Summary of Major Changes

1. Total fishery catch data from 2007 and 2008 to date are presented for the sculpin complex. Observer data are broken down for sculpins from the following genera: *Hemilepidotus, Myoxocephalus, Hemitripterus.* In 2008, observers identified to species sculpins in those three genera. 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 2007.
3. Biomass estimates from the 2008 Bering Sea Shelf and Slope Surveys are reported separately. There was no 2008 AI survey.
4. Size composition of the most abundant sculpin species are updated with 2008 survey data for the EBS Shelf and EBS slope. EBS slope species data are shown separate from the shelf.
5. Age and growth information for yellow Irish lord, great sculpin, plain sculpin and bigmouth sculpin are provided for the first time.
6. 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 ABCs and OFLs for each region.
7. Authors present updated estimates of natural mortality for five species from the EBS shelf. New ABC/OFL recommendations based on new estimates of M (conservative and average) are presented as an alternative to status quo calculations of ABC and OFL. Authors recommend using the alternative that uses the most conservative estimates of M.

Recommended ABC/OFL (based on conservative *M*) for Tier 5 Sculpin Complex 2009-10

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| $EBS_{Warty}$ | 0.16 | 13,985 | 0.12 | 1,678 | 0.16 | 2,238 |
| $EBS_{Great}$ | 0.24 | 61,127 | 0.18 | 11,003 | 0.24 | 14,670 |
| $EBS_{Bigmouth}$ | 0.21 | 30,641 | 0.1575 | 4,826 | 0.21 | 6,435 |
| $EBS_{Plain}$ | 0.17 | 71,023 | 0.1275 | 9,055 | 0.17 | 12,074 |
| $EBS_{Threaded}$ | 0.36 | 2,179 | 0.27 | 588 | 0.36 | 784 |
| $EBS_{YIL}$ | 0.04 | 27,178 | 0.03 | 815 | 0.04 | 1,087 |
| $EBS_{Other\ Sculpins}$ | 0.22 | 5,598 | 0.21 | 1,176 | 0.28 | 1,567 |
| **EBS slope** | 0.08 | 5,941 | 0.06 | 356 | 0.08 | 475 |
| **EBS total** | | 217,672 | | **29,246** | | **39,331** |
| $AI_{YIL}$ | 0.12 | 6,946 | 0.09 | 625 | 0.12 | 834 |
| $AI_{Other\ Sculpins}$ | 0.16 | 9,179 | 0.12 | 1,101 | 0.16 | 1,469 |
| **AI total** | | 16,125 | | **1,727** | | **2,302** |
| **BSAI** | | 233,797 | | **30,973** | | **41,633** |

Alternative ABC/OFL (based on average *M*) for Tier 5 Sculpin Complex 2009-2010

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| $EBS_{Warty}$ | 0.36 | 13,985 | 0.27 | 3,776 | 0.36 | 5,035 |
| $EBS_{Great}$ | 0.3 | 61,127 | 0.225 | 13,754 | 0.3 | 18,338 |
| $EBS_{Bigmouth}$ | 0.22 | 30,641 | 0.165 | 5,056 | 0.22 | 6,741 |
| $EBS_{Plain}$ | 0.32 | 71,023 | 0.24 | 17,046 | 0.32 | 22,727 |
| $EBS_{Threaded}$ | 0.48 | 2,179 | 0.36 | 784 | 0.48 | 1,046 |
| $EBS_{YIL}$ | 0.28 | 27,178 | 0.21 | 5,707 | 0.28 | 7,610 |
| $EBS_{Other\ Sculpins}$ | 0.28 | 5,598 | 0.21 | 1,176 | 0.28 | 1,567 |
| **EBS slope** | 0.08 | 5,941 | 0.06 | 356 | 0.08 | 475 |
| **EBS total** | | 217,672 | | **47,665** | | **63,540** |
| $AI_{YIL}$ | 0.22 | 6,946 | 0.16 | 1,146 | 0.22 | 1,528 |
| $AI_{Other\ Sculpins}$ | 0.16 | 9,179 | 0.12 | 1,101 | 0.16 | 1,469 |
| **AI total** | | 16,125 | | **2,248** | | **2,997** |
| **BSAI** | | 233,797 | | **49,902** | | **66,536** |

Status quo ABC/OFL (based on values of M used in the 2006 assessment of BSAI sculpins) for Tier 5 Sculpin Complex for 2009-2010

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| **BSAI** | 0.19 | 233,797 | 0.1425 | 33,316 | 0.19 | **44,538** |
| **EBS** | 0.19 | 217,672 | 0.1425 | **31,018** | 0.19 | 41,358 |
| **AI** | 0.19 | 16,125 | 0.1425 | **2,298** | 0.19 | 3,180 |

### b) Responses to SSC Comments

There were no directed comments from the SSC in 2007 for the BSAI sculpin complex.

## 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

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) (Gaichas et al., 2005). 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. The Other Species assessment is also presented in response to the North Pacific Fishery Management Council's interest in the possibility of partitioning the Other Species chapter into species assemblage management units.

Life history and stock structure (general)

Recent studies on the reproductive biology of top 5 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 comes 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), 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).

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. New age and growth information is now available for the great sculpin, yellow Irish lord, bigmouth, plain and Warty sculpin based on samples collected from the 2005-2008 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 which include: great sculpin (*Myoxocephalus polyacanthocephalus*), plain and warty sculpin (*Myoxocephalus jaok* and *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.

## 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, accounting for between 66-96% of the estimated totals in 1992-1997. Based on total catch estimates from 1998-2008 (Table 20.3), 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 Pacific cod hook-n-line fishery catch the most (Table 20.4).

Since 2005 observers have identified sculpins to the genus level of the most abundant sculpin species (i.e., *Hemilepidotus, Myoxocephalus, Hemitripterus*). 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. According to observer catch totals for 2007, these genera contributed nearly 87% of all sculpin catch in the BSAI (Table 20.4).

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 (*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. Beginning in 2008, all observers were required to identify to species all sculpins in the genera *Hemilepidotus, Myoxocephalus, and Hemitripterus.*

## Data

Fishery Catch

Catch trend by genus is not available before 2004. Refer to Table 20.3 for total sculpin catch from 1998-2008. Table 20.4 shows that in 2007 *Myoxocephalus* spp. EBS catch makes up 50% of the sculpin total catch in the BSAI. *Hemilepidotus* spp. Catch in the EBS makes up 16% of the total sculpin catch in the BSAI. *Hemitripterus* spp. (bigmouth sculpin) EBS catch is 8% of the total sculpin catch in the BSAI. All other sculpin species, identified as “sculpin unidentified’ contributed only 9% of the total BSAI sculpin catch in 2008. It is reasonable to assume that more *Myoxocephalus* sculpins are caught in trawl surveys because they constitute nearly 66% 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 three most abundant sculpin genera (Catch is from the 2007 total catch of sculpin by genus group, biomass is from the 2008 biomass estimates for the EBS and the 2006 biomass estimate for the AI):

| **2007 Catch/Biomass ratio:** | | |
|---|---|---|
| **Genus** | **EBS (shelf)** | **AI** |
| *Myoxocephalus* spp. | 0.02 | 0.03 |
| *Hemitripterus* spp. | 0.02 | 0.08 |
| *Hemilepidotus* spp. | 0.03 | 0.07 |

In 2008 fishery observers began collecting species data for the most abundant sculpin species in the BSAI. The following is the catch/biomass ratios for those species (catch is 2008catch, EBS shelf biomass is from the 2008 EBS shelf survey and AI biomass is from the 2006 AI. Survey)

| **2008* Catch/Biomass** | **EBS (shelf)** | **AI** |
|---|---|---|
| *Myoxocephalus jaok* | 0.03 | |
| *M. polyacanthocephalus* | 0.03 | 0.02 |
| *M. verrucocus* | 0.01 | |
| *Hemilepidotus jordani* | 0.01 | 0.02 |
| *Hemitripterus* spp. Bigmouth sculpin | 0.01 | 0.02 |

*Catch as of October 17th, 2008

Total sculpin catch, within the large sculpin group, was calculated by genus for each target fishery and gear type responsible for sculpin bycatch (Table 20.5). This analysis indicates that in the Aleutian Islands both the Pacific cod and Atka mackerel trawl fisheries were the main fisheries that caught all three genera of sculpin. In the EBS the Pacific cod trawl and other gear fisheries and the yellowfin sole trawl fishery 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 trawl gear accounted for much of the sculpin bycatch regardless of fishery. Sculpins, in general, are not retained by fisheries in the BSAI region, although retention rates have increased from 1% in 2003 to 6% in 2007 (Table 20.6).

Survey Biomass Estimates

Biomass estimates are available for all identified sculpin species in the BSAI. Trends in biomass are available for only a few sculpin species for the period 1982-2005 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.20.7). 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 the 2006 and 2007 biomass estimates for butterfly sculpin (*H. papilio*) were substantially higher than in previous years (Table 20.7). This may be in response to cooler waters observed in the Bering Sea in 2006 and 2007 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 relatively stable (Figure 20.1). Three trawl surveys have also been conducted on the EBS slope (in 2002, 2004 and 2008), but no biomass trends for sculpin were apparent in this short time series (Table 20.8).

In the AI, biomass estimates of the six most abundant species of sculpin have been calculated since 1997. The yellow Irish lord, bigmouth sculpin, and darkfin sculpin having reliable estimates since 1982. 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 20.9). 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 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 20.2).

Length frequency and sample size

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 generally consistent. However, yellow Irish lord showed more small fish in the earlier years, and there was a conspicuous absence of fish <300 mm in 2007, but they returned in 2008. 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 are still not available.

| **Sample sizes for length frequency analysis for EBS shelf:** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** |
| Yellow Irish Lord | | | 369 | 516 | 604 | 492 | 272 | 627 |
| Plain sculpin | 1263 | 997 | 1218 | 1736 | 1786 | 1778 | 1541 | 2892 |
| Warty sculpin | 288 | 130 | 192 | 245 | 323 | 383 | 224 | 468 |
| Great sculpin | 327 | 346 | 635 | 681 | 786 | 845 | 749 | 1449 |
| Bigmouth sculpin | 157 | 231 | 179 | 342 | 187 | 207 | 125 | 342 |

Eastern Bering Sea Slope

Size compositions of the most abundant species on the slope are shown in Figure 20.4. These data will be presented separately from the EBS shelf data, to show any size differences by species and the difference species composition of sculpins on the slope.

Sample sizes for length frequency analysis for EBS Slope in 2008:

| **Species** | **2008** |
|---|---|
| Darkfin Sculpin | 220 |
| Spinyhead sculpin | 138 |
| Blob Sculpin | 123 |
| Bigmouth sculpin | 178 |

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 5 survey years of data and show a consistent size composition (Figure 20.5). 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.

| Sample sizes for length frequency analysis for AI | | | | |
|---|---|---|---|---|
| **Species** | **2000** | **2002** | **2004** | **2006** |
| Yellow Irish Lord | 170 | 567 | 986 | 1,099 |
| Great sculpin | 12 | 23 | 58 | 65 |
| Big mouth sculpin | 8 | 29 | 27 | 41 |

Length at age and weight at age

In 2007 and 2008 as part of a grant from the North Pacific Research Board, the Age and Growth group at the AFSC aged the following species of sculpin from the Eastern Bering Sea shelf survey:

| **Species** | **Max. Age** | **# samples aged** |
|---|---|---|
| Yellow Irish Lord | 28 | 784 |
| Great sculpin | 17 | 578 |
| Big mouth sculpin | 20 | 88 |
| Warty | 18 | 683 |
| Plain | 16 | 777 |

Figure 20.6 shows the von Bertalanffy growth curves for yellow Irish lords in the Bering Sea and Aleutian Islands. Below are estimates of the von Bertalanffy growth parameters for yellow Irish lord in the eastern Bering Sea and Aleutian Islands. Age is the maximum age estimated, $r^2$ is the coefficient of determination, and *n* is the sample size. Asymptotic standard errors are shown in parentheses next to each parameter, $r^2$ is the coefficient of determination, and *n* is the sample size. The analysis of residual sum of squares (ARSS) found that growth was significantly different between sexes in the eastern Bering Sea ($P < 0.05$). The ARSS found that growth was significantly different between sexes in the Aleutian Islands ($P = 0.002$), that growth was significantly different between males between regions ($P < 0.05$) and that growth was significantly different between females between regions ($P = 0.001$).

| **Yellow Irish lord** | | | | | | |
|---|---|---|---|---|---|---|
| | Eastern Bering Sea | | | Aleutian Islands | | |
| | Combined | Males | Females | Combined | Males | Females |
| $n$ | 386 | 140 | 246 | 398 | 160 | 238 |
| $L_\infty$ (cm) | 43.0 (4.28) | 46.8 (10.86) | 42.1 (4.35) | 45.8 (6.99) | 52.2 (16.99) | 44.2 (7.60) |
| $k$ | 0.299 (0.018) | 0.257 (0.029) | 0.295 (0.019) | 0.179 (0.013) | 0.147 (0.018) | 0.171 (0.015) |
| $t_0$ | 0.056 (0.172) | -0.071 (0.311) | -0.022 (0.198) | -0.808 (0.291) | -0.851 (0.429) | -1.258 (0.393) |
| $r^2$ | 0.80 | 0.81 | 0.83 | 0.78 | 0.84 | 0.80 |
| $t_{max}$ | 28 | 24 | 28 | 26 | 20 | 26 |
| $t_{min}$ | 2 | 2 | 2 | 1 | 2 | 1 |
| $t_{mean}$ | 7.4 | 6.2 | 8.1 | 8.6 | 7.8 | 9.1 |

Figure 20.7 shows the von Bertalanffy growth curves for great sculpins in the Bering Sea and parameters of the von Bertalanffy growth curves for males and females are listed below. Ages (*t*) provided are the mean, minimum and maximum estimates. Asymptotic standard errors are shown in parentheses next to each parameter, $r^2$ is the coefficient of determination, and *n* is the sample size. The ARSS found that growth was significantly different between sexes ($P < 0.001$)

| **Great sculpin** | | |
|---|---|---|
| Parameters | Males | Females |
| $n$ | 241 | 330 |
| $L_\infty$ | 60.8 (2.03) | 80.0 (2.82) |
| $k$ | 0.245 (0.033) | 0.169 (0.018) |
| $t_0$ | 0.540 (0.319) | 0.351 (0.257) |
| $r^2$ | 0.73 | 0.83 |
| $t_{mean}$ | 6.45 | 7.08 |
| $t_{min}$ | 2 | 3 |
| $t_{max}$ | 15 | 17 |

Figure 20.8 shows the von Bertalanffy growth curves for bigmouth sculpins in the Bering Sea. Below are the parameters of the von Bertalanffy growth curves for sexes combined for Bigmouth sculpin. Ages (*t*) provided are the mean, minimum and maximum estimates. Asymptotic standard errors are shown in parentheses next to each parameter, $r^2$ is the coefficient of determination, and *n* is the sample size. Comparisons of male and female growth were not conducted due to small sample size.

| **Bigmouth sculpin** | |
|---|---|
| Parameters | Combined |
| $n$ | 88 |
| $L_\infty$ | 78.4 (6.00) |
| $k$ | 0.132 (0.027) |
| $t_0$ | 0.555 (0.531) |
| $r^2$ | 0.77 |
| $t_{mean}$ | 8.61 |
| $t_{min}$ | 2 |
| $t_{max}$ | 20 |

Figure 20.9 shows the von Bertalanffy growth curves for warty sculpins in the Bering Sea, and parameters of the von Bertalanffy growth curves for males and females are listed below. Ages (*t*) provided are the mean, minimum and maximum estimates. Asymptotic standard errors are shown in parentheses next to each parameter, $r^2$ is the coefficient of determination, and *n* is the sample size. The ARSS found that growth was significantly different between sexes ($P < 0.01$)

| **Warty sculpin** | | |
|---|---|---|
| Parameters | Males | Females |
| $n$ | 267 | 415 |
| $L_\infty$ | 43.4 (1.10) | 53.7 (0.74) |
| $k$ | 0.362 (0.059) | 0.259 (0.022) |
| $t_0$ | 0.039 (0.455) | -0.089 (0.283) |
| $r^2$ | 0.50 | 0.76 |
| $t_{mean}$ | 5.43 | 7.47 |
| $t_{min}$ | 2 | 2 |
| $t_{max}$ | 15 | 18 |

Figure 20.10 shows the von Bertalanffy growth curves for plain sculpins in the Bering Sea and parameters of the von Bertalanffy growth curves for males and females are listed below. Ages (*t*) provided are the mean, minimum and maximum estimates. Asymptotic standard errors are shown in parentheses next to each parameter, $r^2$ is the coefficient of determination, and *n* is the sample size. The ARSS found that growth was significantly different between sexes ($P = 0.001$)

| **Plain sculpin** | | |
|---|---|---|
| Parameters | Males | Females |
| $n$ | 300 | 477 |
| $L_\infty$ | 43.4 (1.70) | 54.8 (0.92) |
| $k$ | 0.240 (0.035) | 0.312 (0.022) |
| $t_0$ | -0.547 (0.372) | 1.030 (0.141) |
| $r^2$ | 0.57 | 0.74 |
| $t_{mean}$ | 4.94 | 5.83 |
| $t_{min}$ | 1 | 1 |
| $t_{max}$ | 15 | 16 |

**Analytical Approach and Results**

The available data do not currently support population modeling for sculpins in the BSAI, therefore, this stock is managed as a tier 5 stock where ABC is estimated as a function of biomass and the natural mortality. Natural mortality (M) was estimated for several species of sculpin in various regions including the Eastern Bering Sea.

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 continuing in 2008, the results of the aging studies for EBS sculpin (discussed in the previous section) have been used to estimate natural mortality estimates specific to this area (Table 20.10). Due to this new information, the most conservative estimates of M, with respect to species, will be used for the determination of OFL and ABC in this report. An exception was made in the case of yellow Irish lord, where the most conservative M is 0.02, which the authors believe is too conservative given the other values, thus the next conservative value of M is used. For the others the estimates are: warty sculpin, 0.16, greatsculpin, 0.24, threaded sculpin, 0.36. However, we also provide an alternative using average M's for comparison of ABC/OFL values for 2009-2010. For other sculpin species that may not have an estimate of M for the BSAI, we elected to use a proxy for M from the resultant most abundant species (plain sculpin in the EBS shelf (0.28), Yellow Irish Lord for the EBS slope (0.04) and a preliminary M for Yellow Irish Lord in the AI (0.16)) (Table 20.10). Choosing the lowest estimate of M is considered conservative because it will result in the lowest estimates of ABC and OFL under Tier 5 of the NPFMC's overfishing definitions. 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

Assemblage analysis and recommendations

Currently all sculpin species from the BSAI are lumped into one complex. Analysis of species composition, abundance and occurrence of sculpin species within the EBS and AI was done to determine if the complex should be split by region. Results of this analysis indicated that species composition in the EBS and AI is different (Figure 20.11). Although a few species such as *great sculpin, yellow Irish lord and bigmouth sculpin* occur in the EBS shelf, EBS slope and AI regions, their proportion of biomass relative to the complex varies greatly (Table 20.7, 20.8 and 20.9). *Myoxocephalus jaok* and *M. verucosus* only occur on the EBS shelf, and are not found in the AI or EBS slope. In the AI *Artediellus forficata* and *Enophrys diceraus* may be endemic. Splitting the biomass to obtain separate ABC and OFL for each region will allow for adequate monitoring of those species in the AI.

**ABC and OFL recommendations**

Leaving sculpins within the larger aggregate of the Other Species complex provides limited conservation to the resource or and does not benefit 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 2007, the Other Species TAC was set at 31,752 mt and 83% of the TAC was caught. Currently, as of 10/11/2008, 59% of the Other Species TAC (42,500 mt) has been caught according to the NMFS Alaska Regional Office (http://www.fakr.noaa.gov/2008/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 believe that our conservative estimates of M are the best available for managing this species complex.

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.

This year the authors would like to suggest an alternative method, to previous years, for calculating the ABC and OFL of the BSAI sculpin complex. Since estimates of M for a few sculpin species from the EBS shelf have been estimated in 2007, then we suggest that the average EBS shelf biomass and their respective estimate of M be used to calculate their respective ABC and OFL. Therefore, Sculpin EBS $_{ABC}$ is defined as (warty$_{ABC}$ + great$_{ABC}$ + threaded$_{ABC}$ + yellow Irish lord $_{ABC}$ + Other Sculpins$_{ABC}$ + EBS slope $_{ABC}$), with an analogous procedure for EBS $_{OFL}$. 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 for those sculpins in the EBS with an estimate to their respective 6 year (2003 – 2008 for EBS shelf; 2000-2006 AI; 2002, 2004 and 2008 for EBS slope) average of bottom trawl survey biomass estimates by region, we calculate a sculpin EBS ABC using the following information:

Calculation of ABC/OFL using most conservative value of M (see table 20.10):

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| $EBS_{Warty}$ | 0.16 | 13,985 | 0.12 | 1,678 | 0.16 | 2,238 |
| $EBS_{Great}$ | 0.24 | 61,127 | 0.18 | 11,003 | 0.24 | 14,670 |
| $EBS_{Bigmouth}$ | 0.21 | 30,641 | 0.1575 | 4,826 | 0.21 | 6,435 |
| $EBS_{Plain}$ | 0.17 | 71,023 | 0.1275 | 9,055 | 0.17 | 12,074 |
| $EBS_{Threaded}$ | 0.36 | 2,179 | 0.27 | 588 | 0.36 | 784 |
| $EBS_{YIL}$ | 0.04 | 27,178 | 0.03 | 815 | 0.04 | 1,087 |
| $EBS_{Other\ Sculpins}$ | 0.22 | 5,598 | 0.21 | 1,176 | 0.28 | 1,567 |
| **EBS slope** | 0.08 | 5,941 | 0.06 | 356 | 0.08 | 475 |
| **EBS total** | | 217,672 | | **29,246** | | **39,331** |
| $AI_{YIL}$ | 0.12 | 6,946 | 0.09 | 625 | 0.12 | 834 |
| $AI_{Other\ Sculpins}$ | 0.16 | 9,179 | 0.12 | 1,101 | 0.16 | 1,469 |
| **AI total** | | 16,125 | | **1,727** | | **2,302** |
| **BSAI** | | 233,797 | | **30,973** | | **41,633** |

ABC/OFL calculations using average M values (see table 20.10 for values used):

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| $EBS_{Warty}$ | 0.36 | 13,985 | 0.27 | 3,776 | 0.36 | 5,035 |
| $EBS_{Great}$ | 0.3 | 61,127 | 0.225 | 13,754 | 0.3 | 18,338 |
| $EBS_{Bigmouth}$ | 0.22 | 30,641 | 0.165 | 5,056 | 0.22 | 6,741 |
| $EBS_{Plain}$ | 0.32 | 71,023 | 0.24 | 17,046 | 0.32 | 22,727 |
| $EBS_{Threaded}$ | 0.48 | 2,179 | 0.36 | 784 | 0.48 | 1,046 |
| $EBS_{YIL}$ | 0.28 | 27,178 | 0.21 | 5,707 | 0.28 | 7,610 |
| $EBS_{Other\ Sculpins}$ | 0.28 | 5,598 | 0.21 | 1,176 | 0.28 | 1,567 |
| **EBS slope** | 0.08 | 5,941 | 0.06 | 356 | 0.08 | 475 |
| **EBS total** | | 217,672 | | **47,665** | | **63,540** |
| $AI_{YIL}$ | 0.22 | 6,946 | 0.16 | 1,146 | 0.22 | 1,528 |
| $AI_{Other\ Sculpins}$ | 0.16 | 9,179 | 0.12 | 1,101 | 0.16 | 1,469 |
| **AI total** | | 16,125 | | **2,248** | | **2,997** |
| **BSAI** | | 233,797 | | **49,902** | | **66,536** |

The status quo method would apply the M estimate of 0.19 (the most conservative estimate of M prior to 2008) to the 6 year (2003 – 2008 for EBS shelf; 2000-2006 AI; 2002, 2004, 2008 for EBS slope) average of bottom trawl survey biomass estimates by region, we calculate an ABC of (0.75 * 0.19) * (EBS shelf + EBS slope = 217,672 mt) = 31,018mt for the EBS and we calculate an ABC of 0.75 * 0.19 * (AI biomass; 16,125) = 2,298 mt. Using the same method to calculate OFL, 0.19 * (EBS shelf + EBS slope+ AI biomass = 233,797 mt) = 44,421 mt for the BSAI.

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| **BSAI** | 0.19 | 233,797 | 0.1425 | 33,316 | 0.19 | **44,538** |
| **EBS** | 0.19 | 217,672 | 0.1425 | **31,018** | 0.19 | 41,358 |
| **AI** | 0.19 | 16,125 | 0.1425 | **2,298** | 0.19 | 3,180 |

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 and thus low TACs, then alternative management strategies should be considered.

## 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. (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 20.12). In the EBS the main predator of large sculpins (sculpins from the genera: *Myoxocephalus*, *Hemitripterus* and *Hemilepidotus*) are Pacific cod (Figure 20.8). Although the greatest mortality of large sculpins is unexplained, their fishing mortality is due to the flatfish bottom trawl fishery and Pacific Cod longline, trawl and pot fisheries as supported by data in Table 20.4. Other sculpins (those sculpins not in the above genera) in the EBS feed mainly on shrimp and benthic amphipods (Figure 20.13). 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 20.13). In the AI large sculpin have a different diet than in the EBS, consisting of crabs, Atka mackerel and miscellaneous shallow water fish (Figure 20.14). 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 20.14). Diet of other sculpins in the AI consists of infauna such as polychaetes and benthic crustaceans (Figure 20.15). 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 20.15).

### *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 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.

**Summary**

Below are a alternative recommendations for ABC and OFL for the EBS sculpin complex and AI sculpin complex. BSAI total numbers are shown for reference.

Recommended ABC/OFL (based on conservative *M*) for Tier 5 Sculpin Complex 2009-10

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| $EBS_{Warty}$ | 0.16 | 13,985 | 0.12 | 1,678 | 0.16 | 2,238 |
| $EBS_{Great}$ | 0.24 | 61,127 | 0.18 | 11,003 | 0.24 | 14,670 |
| $EBS_{Bigmouth}$ | 0.21 | 30,641 | 0.1575 | 4,826 | 0.21 | 6,435 |
| $EBS_{Plain}$ | 0.17 | 71,023 | 0.1275 | 9,055 | 0.17 | 12,074 |
| $EBS_{Threaded}$ | 0.36 | 2,179 | 0.27 | 588 | 0.36 | 784 |
| $EBS_{YIL}$ | 0.04 | 27,178 | 0.03 | 815 | 0.04 | 1,087 |
| $EBS_{Other\ Sculpins}$ | 0.22 | 5,598 | 0.21 | 1,176 | 0.28 | 1,567 |
| **EBS slope** | 0.08 | 5,941 | 0.06 | 356 | 0.08 | 475 |
| **EBS total** | | 217,672 | | **29,246** | | **39,331** |
| $AI_{YIL}$ | 0.12 | 6,946 | 0.09 | 625 | 0.12 | 834 |
| $AI_{Other\ Sculpins}$ | 0.16 | 9,179 | 0.12 | 1,101 | 0.16 | 1,469 |
| **AI total** | | 16,125 | | **1,727** | | **2,302** |
| **BSAI** | | 233,797 | | **30,973** | | **41,633** |

Alternative ABC/OFL (based on average *M*) for Tier 5 Sculpin Complex 2009-2010

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| $EBS_{Warty}$ | 0.36 | 13,985 | 0.27 | 3,776 | 0.36 | 5,035 |
| $EBS_{Great}$ | 0.3 | 61,127 | 0.225 | 13,754 | 0.3 | 18,338 |
| $EBS_{Bigmouth}$ | 0.22 | 30,641 | 0.165 | 5,056 | 0.22 | 6,741 |
| $EBS_{Plain}$ | 0.32 | 71,023 | 0.24 | 17,046 | 0.32 | 22,727 |
| $EBS_{Threaded}$ | 0.48 | 2,179 | 0.36 | 784 | 0.48 | 1,046 |
| $EBS_{YIL}$ | 0.28 | 27,178 | 0.21 | 5,707 | 0.28 | 7,610 |
| $EBS_{Other\ Sculpins}$ | 0.28 | 5,598 | 0.21 | 1,176 | 0.28 | 1,567 |
| **EBS slope** | 0.08 | 5,941 | 0.06 | 356 | 0.08 | 475 |
| **EBS total** | | 217,672 | | **47,665** | | **63,540** |
| $AI_{YIL}$ | 0.22 | 6,946 | 0.16 | 1,146 | 0.22 | 1,528 |
| $AI_{Other\ Sculpins}$ | 0.16 | 9,179 | 0.12 | 1,101 | 0.16 | 1,469 |
| **AI total** | | 16,125 | | **2,248** | | **2,997** |
| **BSAI** | | 233,797 | | **49,902** | | **66,536** |

Status quo ABC/OFL (based on values of *M* used in previous assessment of BSAI sculpins) for Tier 5 Sculpin Complex for 2009-2010

| Region | M | Exploitable biomass (mt) | $F_{ABC}$ | ABC (mt) | $F_{OFL}$ | OFL (mt) |
|---|---|---|---|---|---|---|
| **BSAI** | 0.19 | 233,797 | 0.1425 | 33,316 | 0.19 | **44,538** |
| **EBS** | 0.19 | 217,672 | 0.1425 | **31,018** | 0.19 | 41,358 |
| **AI** | 0.19 | 16,125 | 0.1425 | **2,298** | 0.19 | 3,180 |

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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 | 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 20.3. Total catch (mt) of sculpin complex compared to Other species catch (including squid), 1998-2008.

| Year | Other species ABC | Other species TAC | Other species OFL | BSAI Other species catch | EBS Sculpin catch | AI Sculpi n Catch | BSAI Sculpin Catch | % of Sculpin in Other spp. catch (BSAI) |
|---|---|---|---|---|---|---|---|---|
| 1998 | 25,800 | 25,800 | 134,000 | 25,531 | 5,204 | 1,081 | 6,285 | 25% |
| 1999 | 32,860 | 32,860 | 129,000 | 20,562 | 4,503 | 967 | 5,470 | 27% |
| 2000 | 31,360 | 31,360 | 71,500 | 26,108 | 5,673 | 1,413 | 7,086 | 27% |
| 2001 | 33,600 | 26,500 | 69,000 | 27,178 | 6,067 | 1,603 | 7,670 | 28% |
| 2002 | 39,100 | 30,825 | 78,900 | 28,619 | 6,043 | 1,133 | 7,176 | 25% |
| 2003 | 43,300 | 32,309 | 81,100 | 27,356 | 5,350 | 598 | 5,948 | 22% |
| 2004 | 46,810 | 27,205 | 81,150 | 30,530 | 5,258 | 887 | 6,145 | 20% |
| 2005 | 53,860 | 29,000 | 87,920 | 30,609 | 5,094 | 676 | 5,770 | 19% |
| 2006 | 58,882 | 29,000 | 89,404 | 28,202 | 4,887 | 912 | 5,799 | 21% |
| 2007* | 68,800 | 37,355 | 91,700 | 27,852 | 6,601 | 999 | 7,600 | 27% |
| 2008** | 78,100 | 50,000 | 104,000 | 22,809 | 5,346 | 567 | 5,913 | 26% |

Data sources: Other species ABC, TAC, OFL, and catch from AKRO website 2008 Other species catch updated October 6, 2007

* 2007 data updated and is now complete

**2008 sculpin data complete as of October 3, 2008

Table 20.4. Extrapolated total catch (mt) of Large sculpins (*Hemilepidotus* spp., *Hemitripterus* spp. *and Myoxocephalus* spp.).Based on observer data. *Source: NMFS AFSC FMA program and NMFS AK regional office catch accounting system.*

| **2008*** | **Eastern Bering Sea** | **% BSAI Sculpins** | **Aleutian Islands** | **% BSAI Sculpins** |
|---|---|---|---|---|
| *Myoxocephalus* spp. | 224 | 4% | | |
| *Myoxocephalus jaok* | 1,873 | 32% | <1 | - |
| *Myoxocephalus polyacanthocephalus* | 2,143 | 36% | 34 | <1% |
| *Myoxocephalus verrucocus* | 143 | 2% | <1 | - |
| *Hemilepidotus* spp. | | | | |
| *Hemilepidotus hemilepidotus* | <1 | - | <1 | - |
| *Hemilepidotus jordani* | 398 | 7% | 229 | 4% |
| *Hemilepidotus spinosus* | <1 | - | | |
| *Hemitripterus* spp. Bigmouth sculpin | 494 | 8% | 34 | <1% |
| Sculpin unidentified** | 370 | 6% | 114 | 2% |

*As of October 17, 2008

| **2007** | **Eastern Bering Sea** | **% BSAI Sculpins** | **Aleutian Islands** | **%BSAI Sculpins** |
|---|---|---|---|---|
| *Myoxocephalus* spp. | 3,698 | 49% | 77 | 1% |
| *Hemilepidotus* spp. | 1,200 | 16% | 868 | 11% |
| *Hemitripterus* spp. Bigmouth sculpin | 609 | 8% | 157 | 2% |
| Sculpin unidentified** | 827 | 11% | 164 | 1% |

** Sculpin unidentified is analogous to the Other sculpin category in the catch accounting system. Therefore percentages that were used to get total sculpin catch from sculpins in the Large Sculpin category are different than above.

Table 20.5. Total catch (mt) of Large sculpins (*Hemilepidotus* spp., *Hemitripterus* spp. *and Myoxocephalus* spp.) by target fishery and gear, from 2007 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.*

**2007**
**Aleutian Islands**

**Large Sculpins**

| Target fishery | Gear type | | | |
|---|---|---|---|---|
| | **Bottom Trawl** | **Pelagic Trawl** | **Pot** | **Longline** |
| Atka Mackerel | 452 | - | - | - |
| Pacific Cod | 202 | - | 8 | 164 |
| Rockfish | 8 | - | - | - |
| Sablefish | - | - | <1 | <1 |

**2007**
**Eastern Bering Sea**

**Large sculpins**

| Target fishery | Gear type | | | |
|---|---|---|---|---|
| | **Bottom Trawl** | **Pelagic Trawl** | **Pot** | **Longline** |
| Pacific Cod | 1,184 | - | 241 | 763 |
| Yellowfin Sole | 2,276 | - | - | - |
| Rocksole | 630 | - | - | - |
| Flathead Sole | 387 | - | - | - |
| Pollock | 2 | 162 | - | - |
| Atka Mackerel | 89 | - | - | - |

Table 20.6. Sculpin retained and discarded catch (mt) for the BSAI for 2003-2007. *Source: NMFS AK Region catch accounting system.*

**Sculpins**

| | Retained | Discarded | Total | Percent Retained |
|---|---|---|---|---|
| **BSAI** | | | | |
| 2003 | 51 | 5,563 | 5,614 | 1% |
| 2004 | 86 | 5,934 | 6,019 | 1% |
| 2005 | 111 | 5,530 | 5,642 | 2% |
| 2006 | 167 | 5,547 | 5,714 | 3% |
| 2007 | 423 | 7,150 | 7,573 | 6% |

Table 20.7. Sculpin complex biomass (mt) from the 2003-2008 Bering Sea shelf survey and the coefficient of variation (CV) in biomass for 2008.

| | | Biomass | | | | | | CV |
|---|---|---|---|---|---|---|---|---|
| **Sculpin species** | **common** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2008** |
| *Myoxocephalus jaok* | plain | 79,337 | 68,671 | 76,540 | 66,819 | 77,836 | 56,935 | 0.15 |
| *Myoxocephalus polyacanthocephalus* | great | 64,486 | 58,505 | 55,957 | 54,456 | 63,132 | 70,223 | 0.13 |
| *Hemitripterus bolini* | bigmouth | 29,274 | 34,748 | 31,002 | 30,116 | 27,859 | 30,846 | 0.14 |
| *Hemilepidotus jordani* | yellow Irish lord | 14,220 | 33,630 | 27,380 | 31,684 | 23,765 | 32,389 | 0.35 |
| *Myoxocephalus verrucosus* | warty | 7,058 | 10,089 | 25,897 | 16,099 | 13,370 | 11,397 | 0.27 |
| *Gymnocanthus pistilliger* | threaded | 1,137 | 1,275 | 1,977 | 2,385 | 4,126 | 2,174 | 0.38 |
| *Dasycottus setiger* | spinyhead | 1,274 | 1,019 | 4,469 | 2,479 | 1,949 | 870 | 0.18 |
| *Gymnocanthus galeatus* | armorhead | 720 | 785 | 1,551 | 1,732 | 990 | 2,113 | 0.60 |
| *Icelus spiniger* | thorny | 715 | 616 | 543 | 596 | 478 | 940 | 0.20 |
| *Triglops pingeli* | ribbed | 142 | 556 | 264 | 400 | 309 | 368 | 0.49 |
| *Hemilepidotus papilio* | butterfly | 628 | 379 | 370 | 1,491 | 1,653 | 543 | 0.47 |
| *Malacocottus zonurus* | darkfin | 11 | 122 | 35 | 69 | 46 | 1 | 0.76 |
| *Triglops macellus* | roughspine | 10 | 62 | 111 | 168 | 57 | 176 | 0.86 |
| *Triglops scepticus* | spectacled | 298 | 29 | 112 | 365 | 217 | 184 | 0.56 |
| *Icelus spatula* | spatulate | 3 | 13 | 20 | 46 | 49 | 23 | 0.22 |
| sculpin unid (all others) | | 0 | 10 | 0 | 0 | 0 | 42 | 0.56 |
| *Artediellus pacificus* | hookhorn | 0 | trace | 3 | 1 | 4 | 3 | 0.50 |
| *Triglops forficata* | scissortail | 0 | 0 | 0 | 0 | 0 | | - |
| *Leptocottus armatus* | staghorn | 0 | 0 | 210 | 91 | 0 | 20 | 1.00 |
| *Enophrys diceraus* | antlered | 0 | 0 | 0 | 0 | 0 | | - |
| *Blepsias bilobus* | crested | | | | 23 | 0 | | - |
| *Hemilepidotus Hemilepidotus* | Red Irish lord | | | | | 5 | | - |
| *Nauticthys pribilovius* | eyeshade | | | | | 1 | | - |
| *Eurymen gyrinus* | smoothcheek | | | | | 4 | | - |
| **Total** | | **199,313** | **210,509** | **226,441** | **209,020** | **215,850** | **209,247** | **0.09** |

Table 20.8. Sculpin complex biomass (mt) from the 2002, 2004 and 2008 Bering Sea slope survey and the coefficient of variation (CV) for 2008.

| | | Biomass | | | CV |
|---|---|---|---|---|---|
| **Sculpin species** | **common** | **2002** | **2004** | **2008** | **2008** |
| *Gymnocanthus galeatus* | armorhead | <1 | | | |
| *Myoxocephalus polyacanthocephalus* | great | 44 | 5 | 9 | 1 |
| *Hemitripterus bolini* | bigmouth | 1,920 | 1,289 | 3,216 | 0.15 |
| *Hemilepidotus jordani* | yellow Irish lord | | 113 | 7 | 0.74 |
| *Dasycottus setiger* | spinyhead | 1,158 | 701 | 381 | 0.16 |
| *Malcocottus zonurus* | darkfin | 1,525 | 1,798 | 1,109 | 0.33 |
| *Icelus spiniger* | thorny | 74 | 39 | 6 | 0.74 |
| *Icelus canalictulatus* | Blacknose | 122 | | 40 | 0.45 |
| *Icelus euryops* | Wide-eye | 11 | | 4 | 0.6 |
| *Icelus spatula* | Spatulate | | | <1 | 0.71 |
| *Triglops scepticus* | spectacled | 58 | 57 | 30 | 0.39 |
| *Psychrolutes phrictus* | blob | 1,471 | | 1,145 | 0.19 |
| *Zesticelus profundorum* | Flabby | <1 | | <1 | 0.33 |
| *Rastrinus scutiger* | roughskin | <1 | | | |
| sculpin unid (all others) | | | 1,486 | | |
| **Total** | | **6,386** | **5,488** | **5,948** | **0.11** |

Table 20.9. Sculpin complex biomass (mt) from the 1997-2006 Aleutian Islands trawl survey and the coefficient of variation (CV) for 2006.

| **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 20.10. List of available natural mortality information for sculpins.

| Species | Area | Sex | Hoenig | Rikhter & Efanov | Alverson & Carney | Jensen | Charnov |
|---|---|---|---|---|---|---|---|
| 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 | | | |
| | E. Bering Sea* | *M* | 0.17 | | 0.08 | 0.41 | 0.45 |
| | E. Bering Sea* | *F* | 0.15 | | 0.04 | 0.47 | 0.51 |
| | Aleutian Is.* | *M* | 0.21 | | 0.21 | 0.23 | 0.27 |
| | Aleutian Is.* | *F* | 0.16 | | 0.12 | 0.27 | 0.31 |
| Pacific staghorn sculpin | California | *F* | 0.42 | | | | |
| Threaded sculpin | E. Bering Sea | *M* | 0.42 | | 0.36 | 0.60 | 0.65 |
| | E. Bering Sea | *F* | 0.47 | | 0.58 | 0.36 | 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 | | 0.24 | 0.39 | 0.43 |
| | E. Bering Sea* | *F* | 0.25 | | 0.26 | 0.27 | 0.30 |
| Plain sculpin | E. Bering Sea* | *M* | 0.28 | | 0.25 | 0.38 | 0.42 |
| | E. Bering Sea* | *F* | 0.26 | | 0.17 | 0.27 | 0.55 |
| | Kamchatka | *M* | 0.47 | 0.32 | | | |
| | Kamchatka | *F* | 0.35 | 0.22 | | | |
| Warty sculpin | E. Bering Sea* | *M* | 0.28 | | 0.16 | 0.58 | 0.63 |
| | E. Bering Sea* | *F* | 0.23 | | 0.16 | 0.41 | 0.47 |
| Bigmouth sculpin | E. Bering Sea* | *Both* | 0.21 | | 0.23 | 0.21 | 0.24 |

References: AFSC; Jensen 1996; Panchenko 2001; Panchenko 2002; Tokranov 1985; Tokranov 1988; Tokranov 1989; Tokranov 1995; Hoff 2000; Tokranov and Orlov 2001, Tokranov et al. 2003; Weiss 1969
* Natural mortality estimates new for 2008 (based on unpublished data from TenBrink).

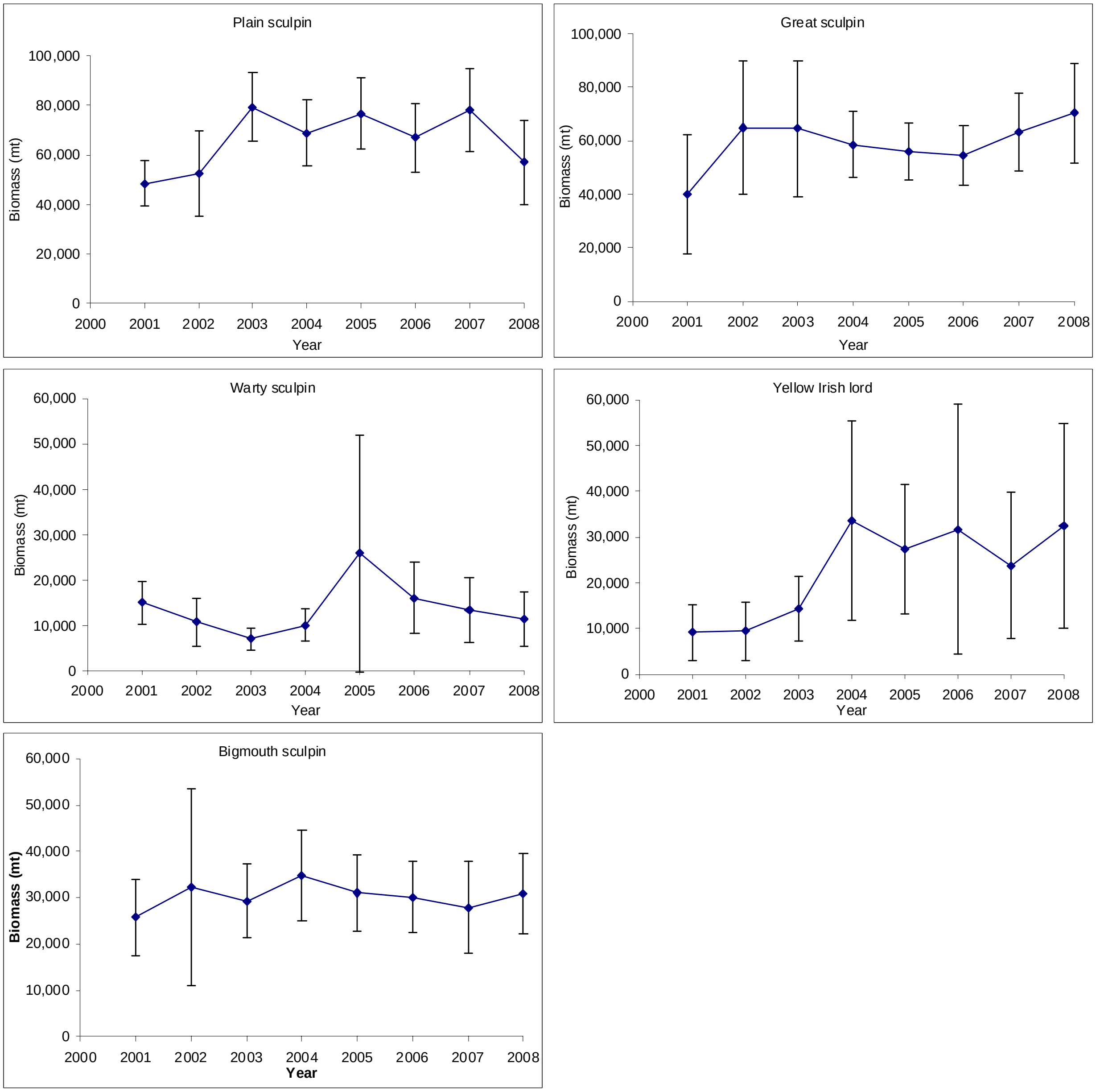



Figure 20.1. Biomass time series (with 95% Confidence Intervals) from annual EBS shelf bottom trawl surveys for selected sculpin species, 2001-2007

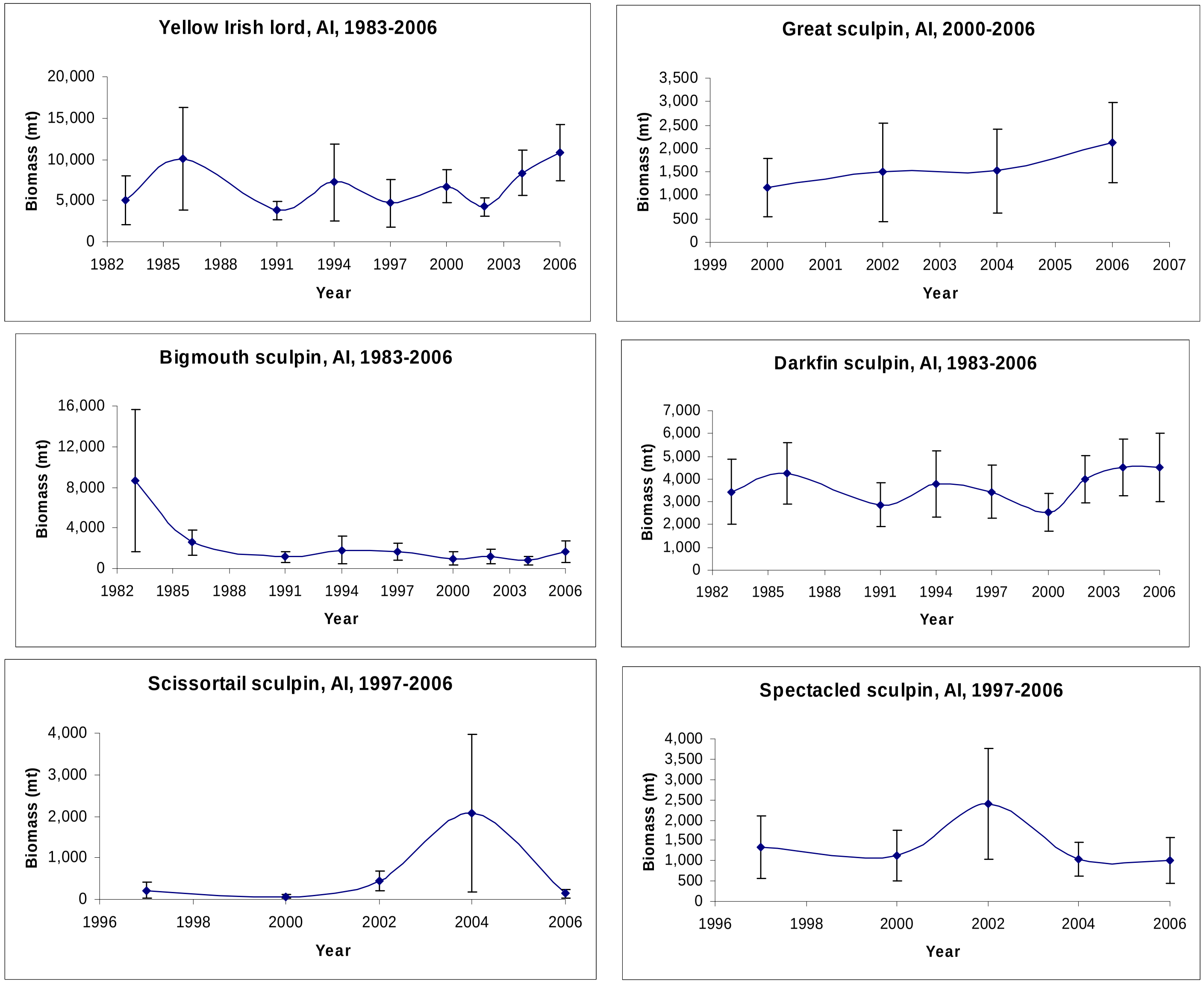



Figure 20.2. Biomass time series (with 95% Confidence Intervals) for the six most abundant sculpin species in Aleutian Islands trawl survey 1980-2006. Note: Some sculpin species were not regularly identified to species-level until recent surveys.

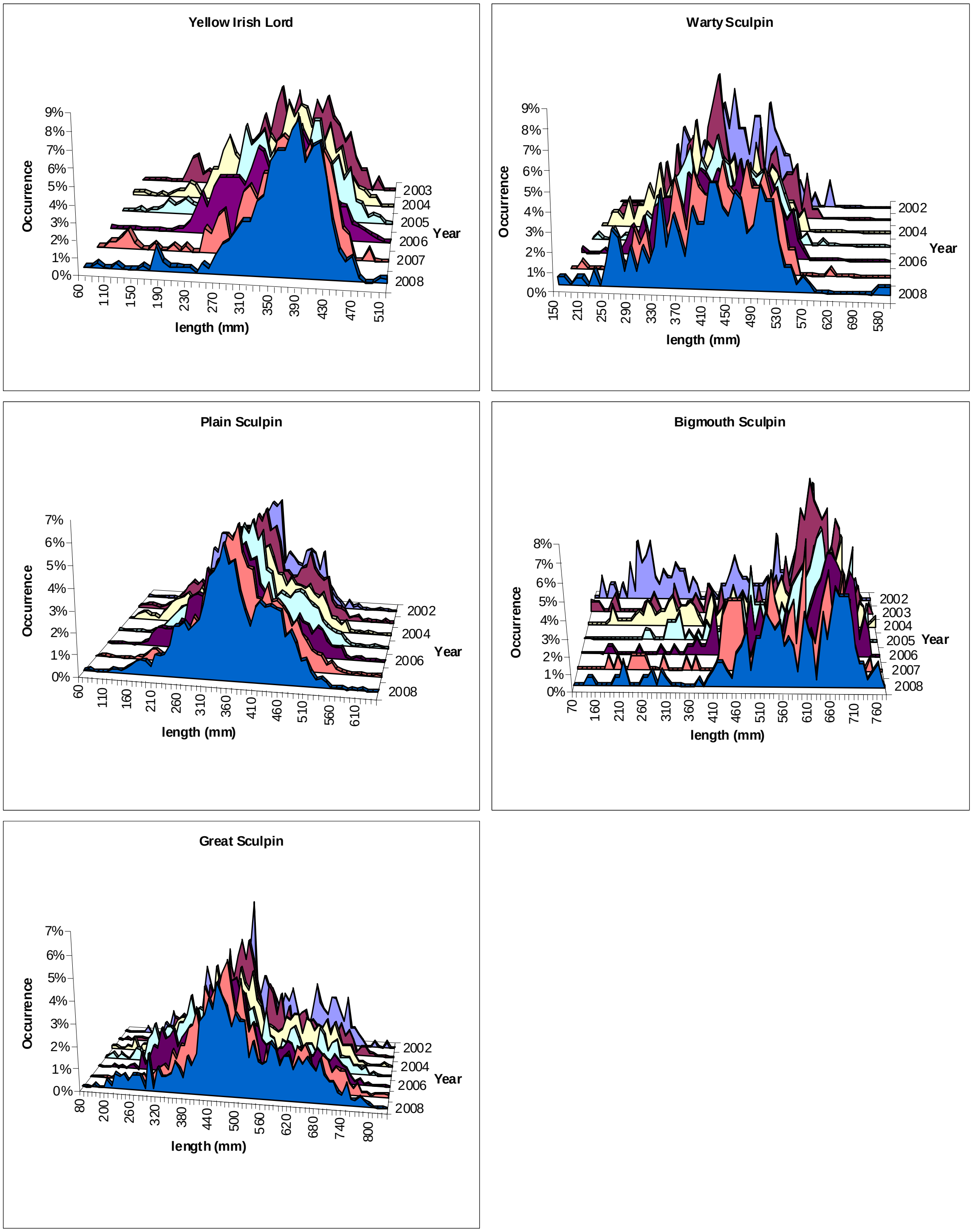



Figure 20.3. Length frequencies (fork length, FL in mm) from EBS shelf survey data for the five most abundant sculpin species in EBS.

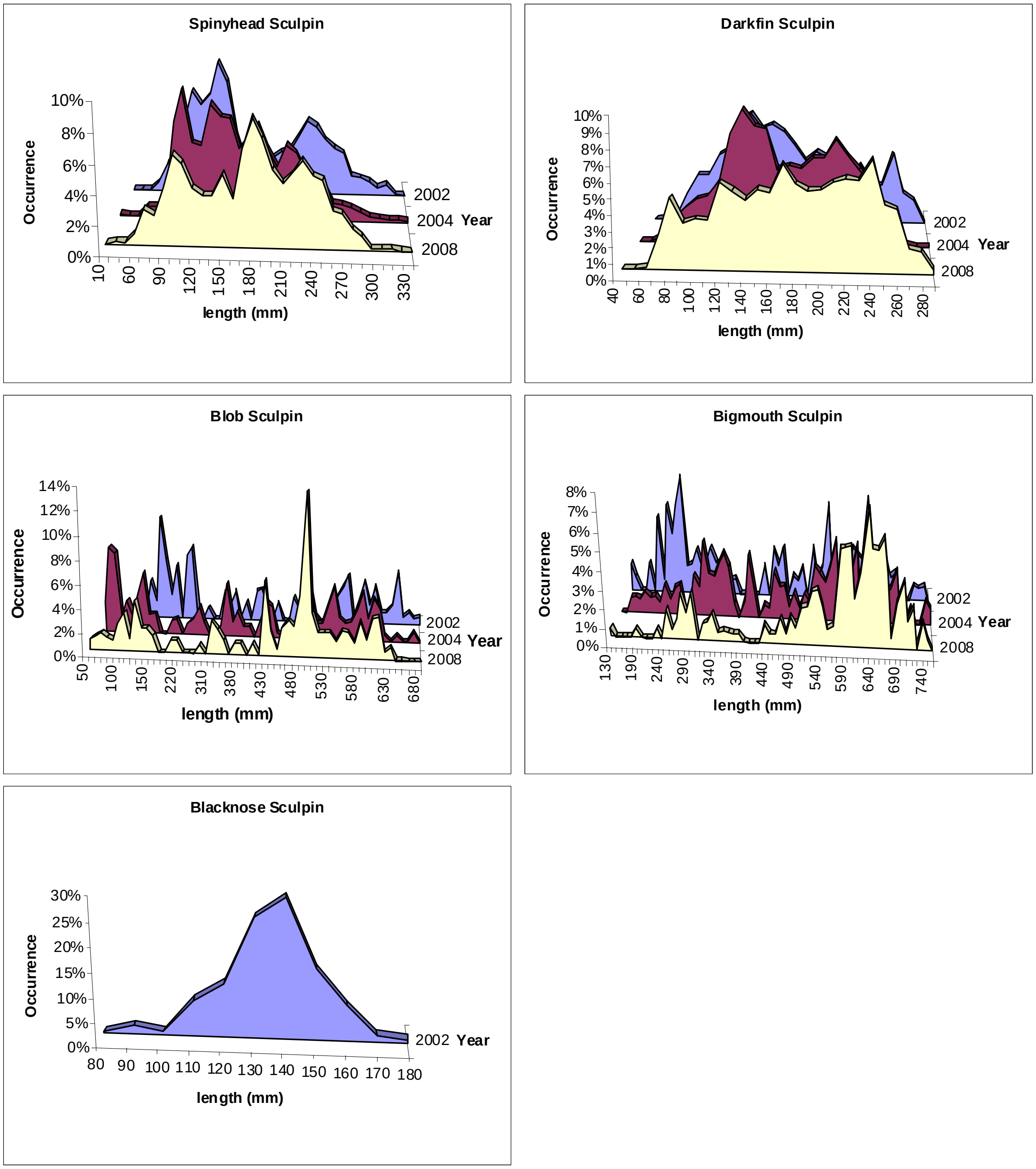



Figure 20.4. Length frequencies (fork length, FL in mm) from EBS slope survey data for the five most abundant sculpin species in EBS slope.

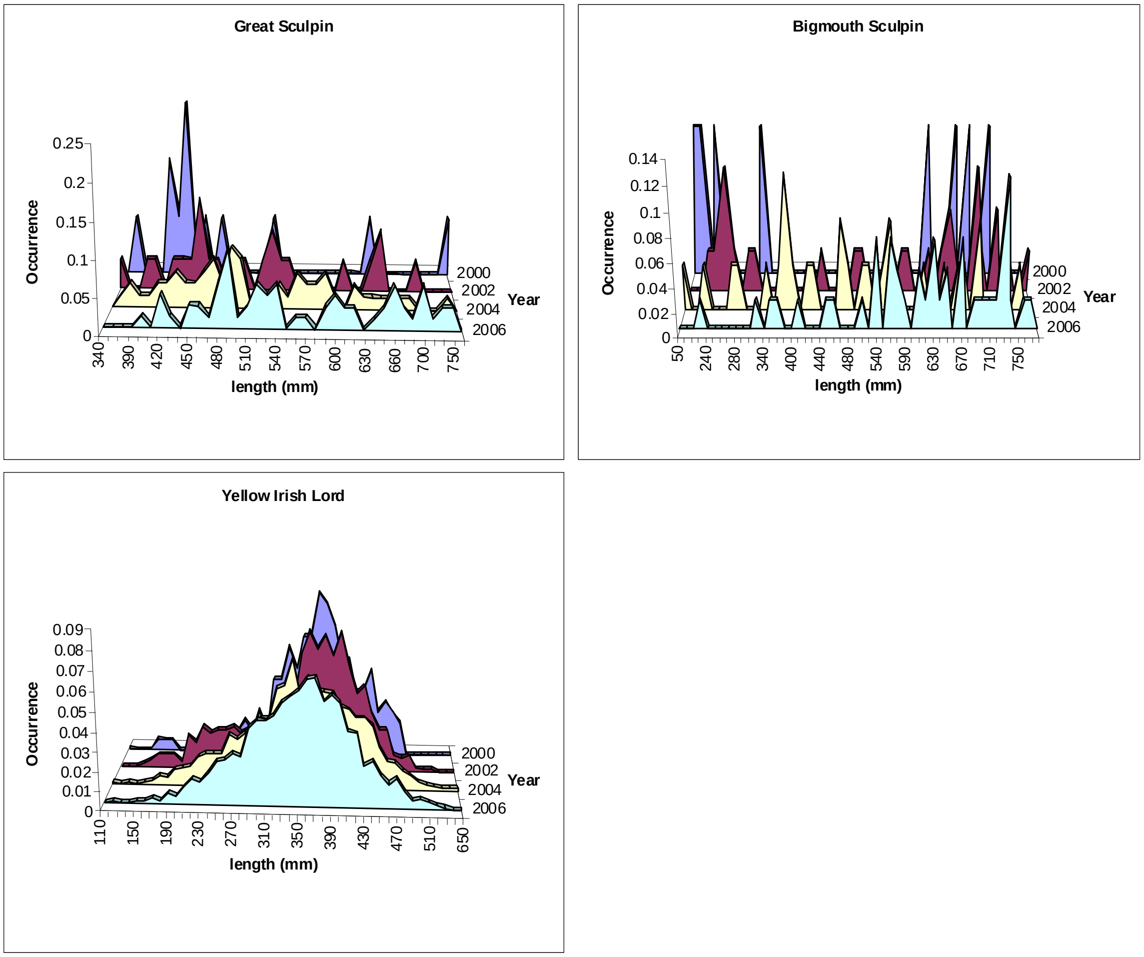
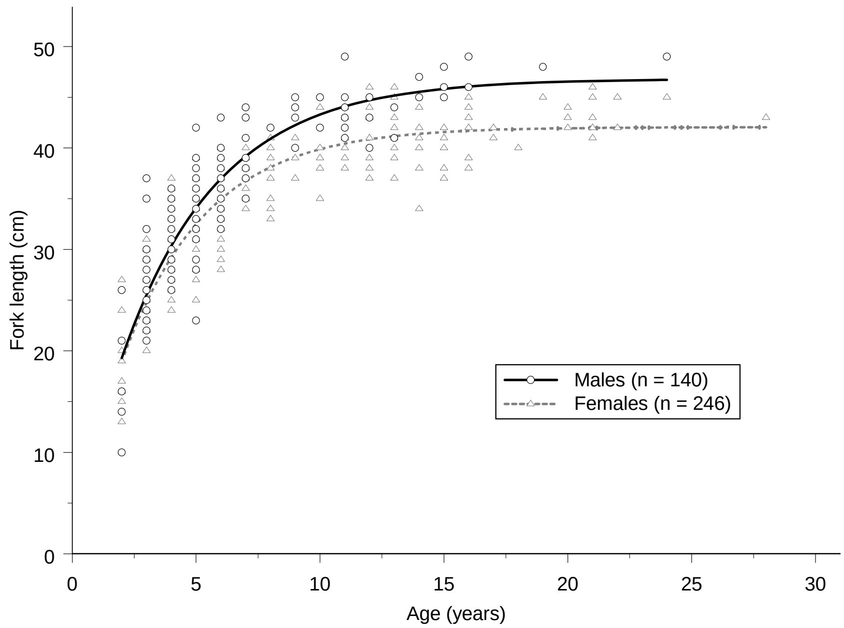



Figure 20.5. Length frequencies (fork length, FL in mm) from survey data for the 3 most abundant sculpin species in AI.



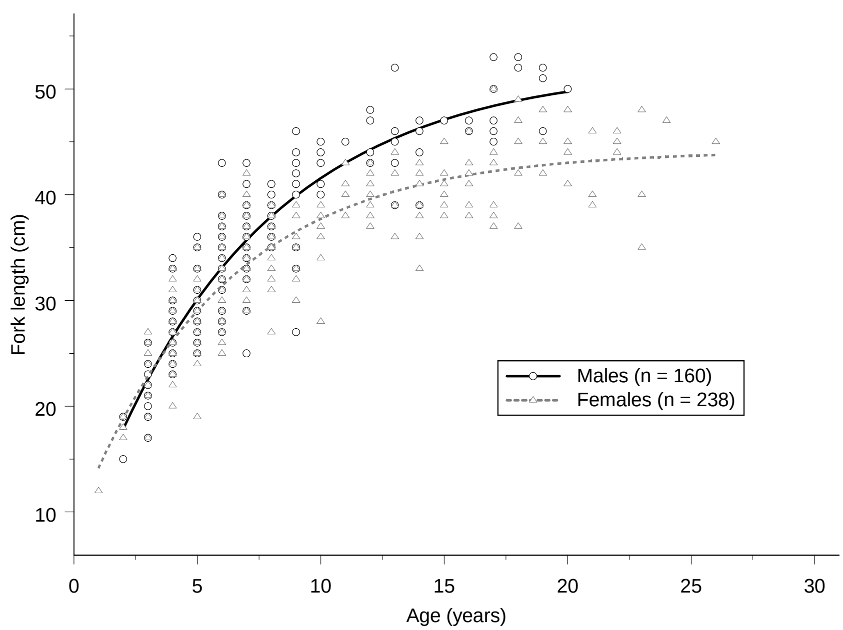




Figure 20.6. von Bertalanffy graphs for yellow Irish lords in the eastern Bering Sea (top) and Aleutian Islands (bottom).

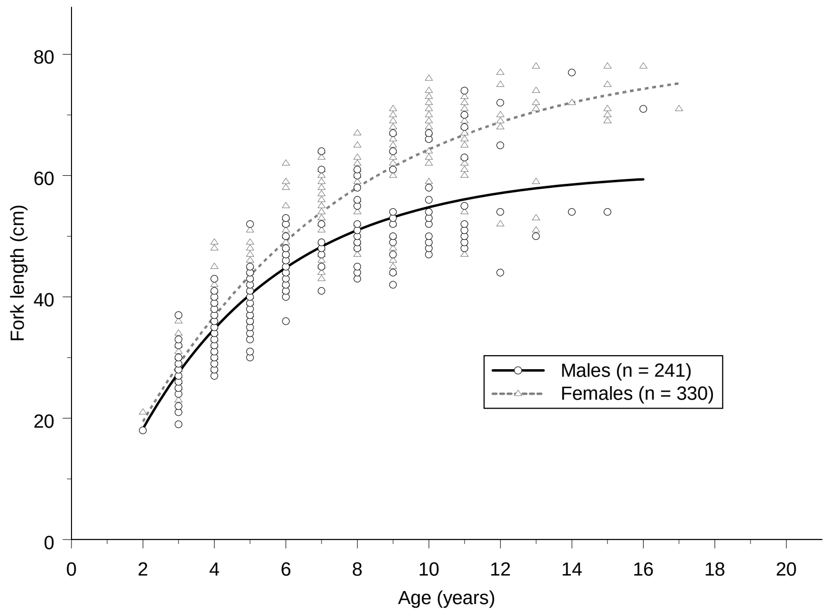



Figure 20.7. von Bertalanffy graph for <u>great sculpin</u> in the eastern Bering Sea.

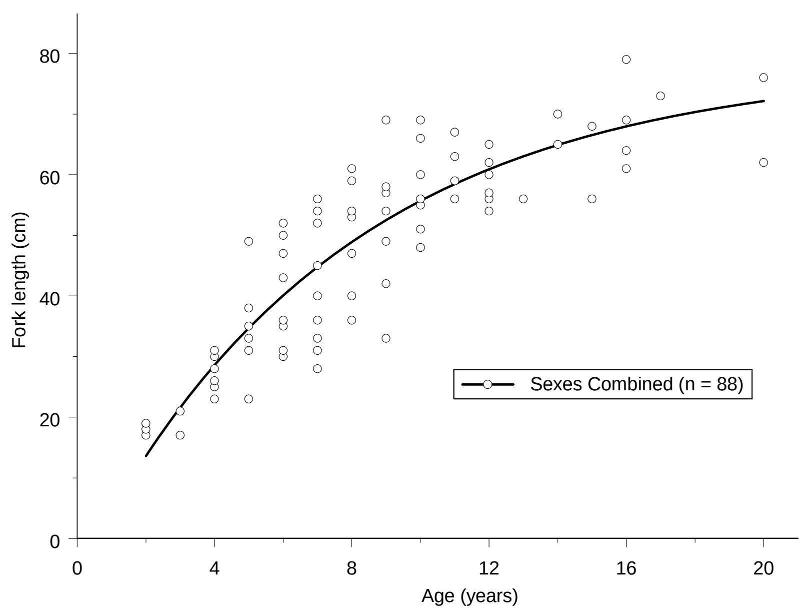



Figure 20.8. von Bertalanffy growth curves fitted to <u>bigmouth sculpin</u> length-at-age data.

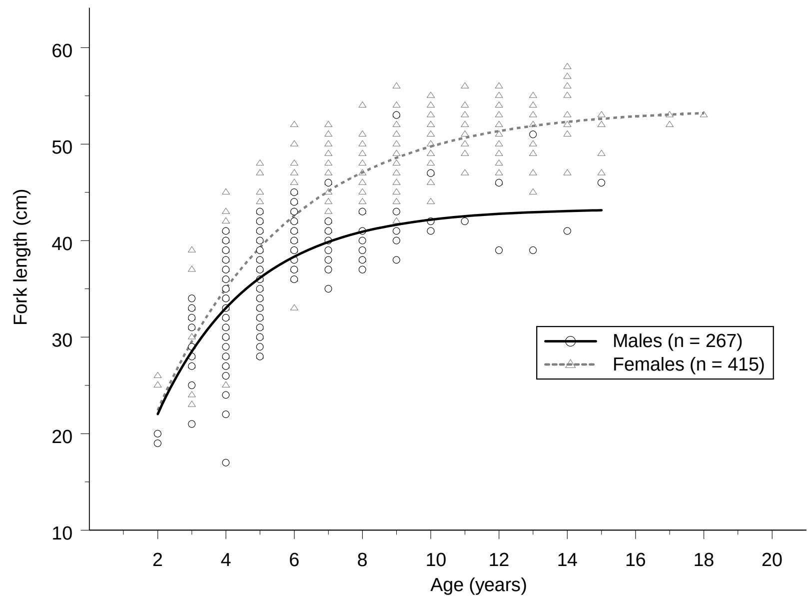



Figure 20.9. von Bertalanffy growth curves fitted to warty sculpin length-at-age data.

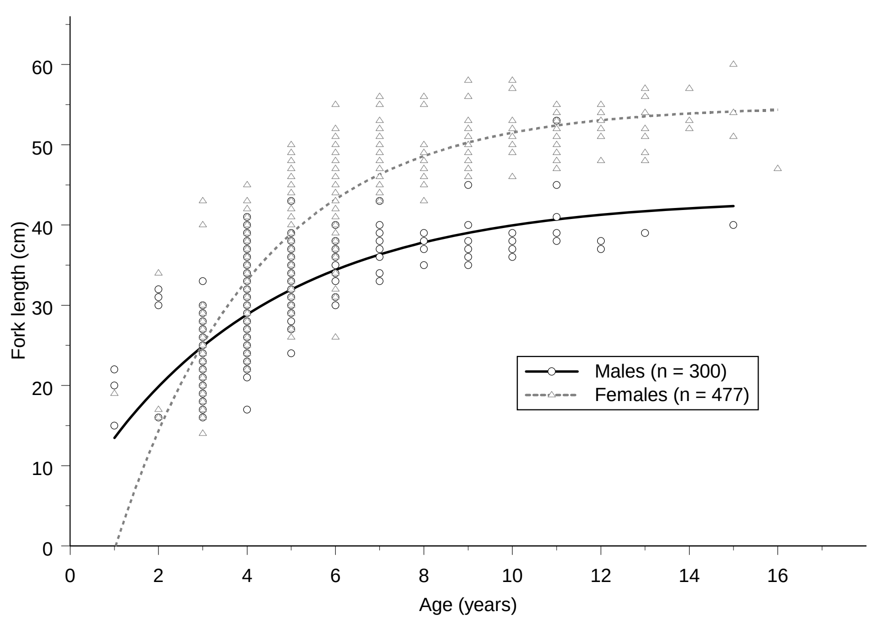



Figure 20.10. von Bertalanffy graph for plain sculpin in the eastern Bering Sea.

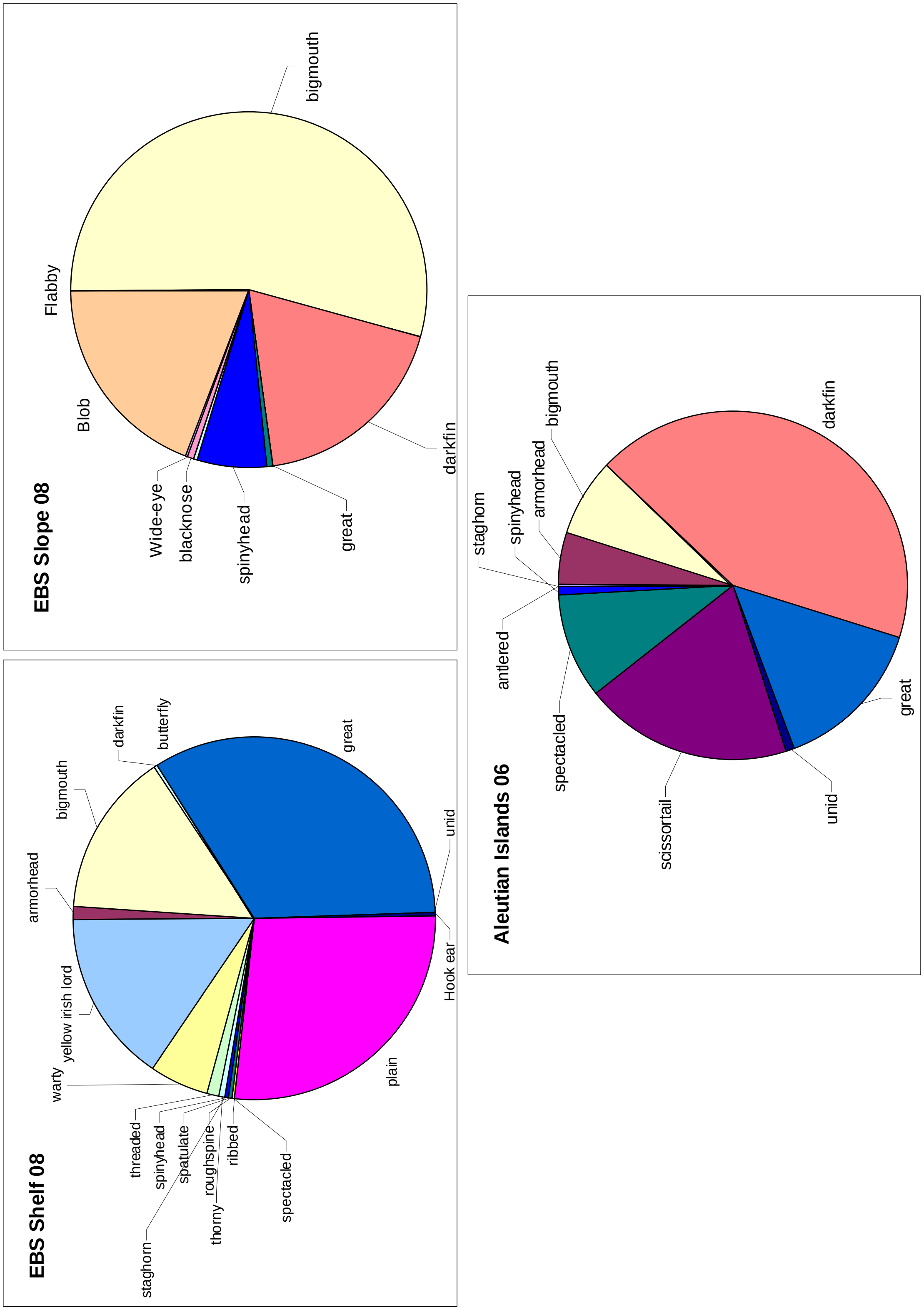



Figure 20.11. Sculpin Biomass estimates from the 2008 EBS shelf, 2008 EBS slope and 2006 AI surveys to show differences in species composition.

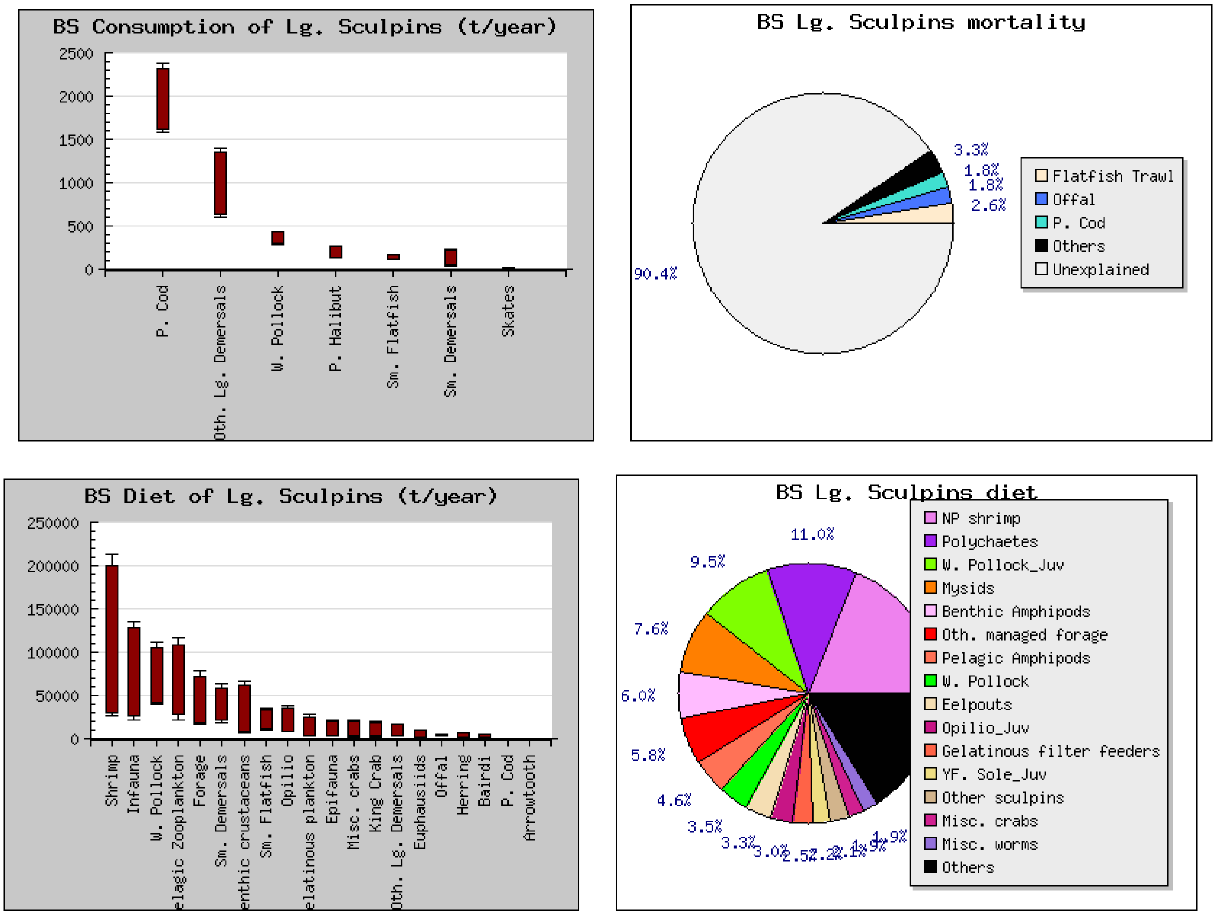


Figure 20.12. Figures showing Consumption, mortality, and diet of large sculpins from the Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

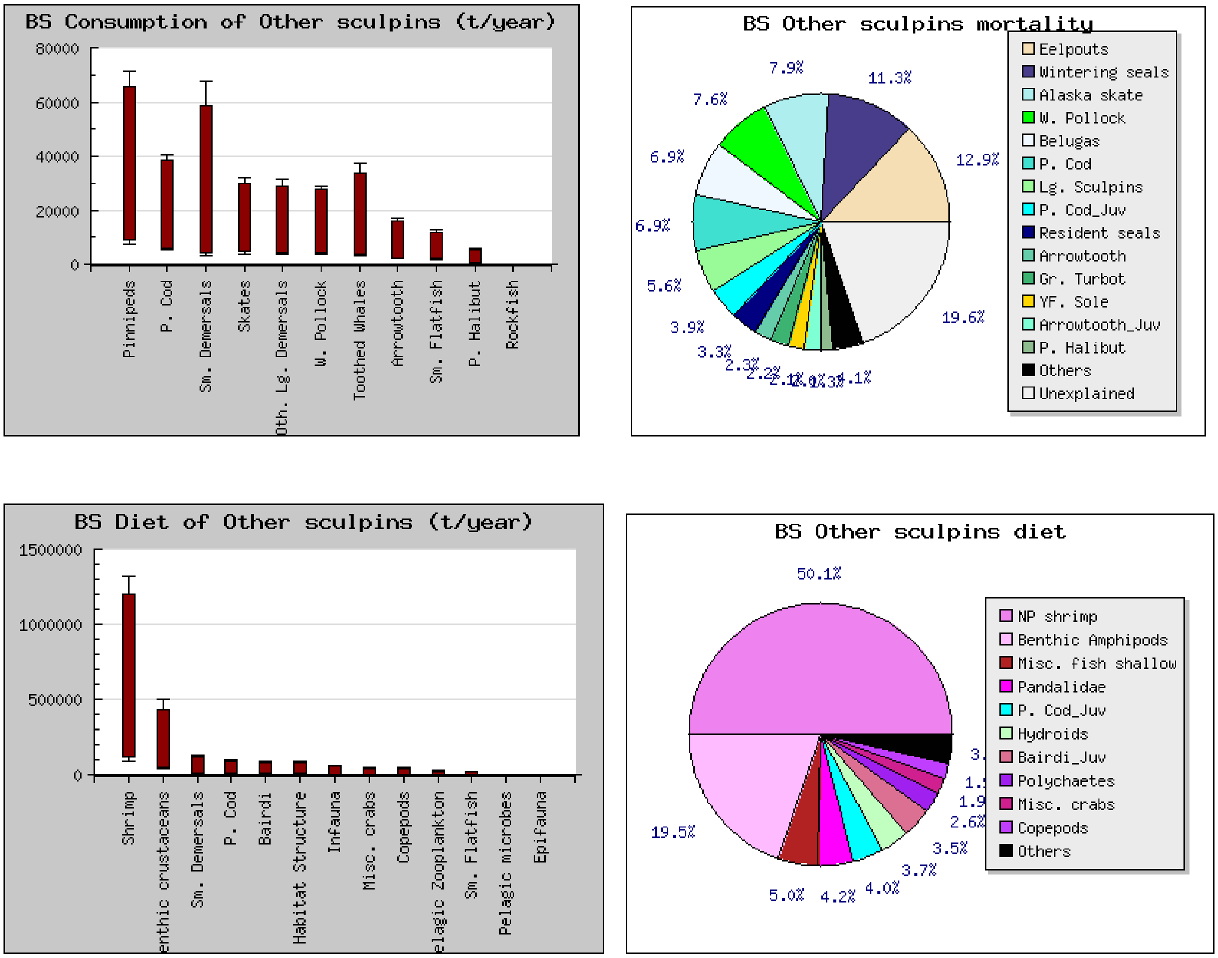



Figure 20.13. Figures showing Consumption, mortality, and diet of other sculpins from the Bering Sea. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

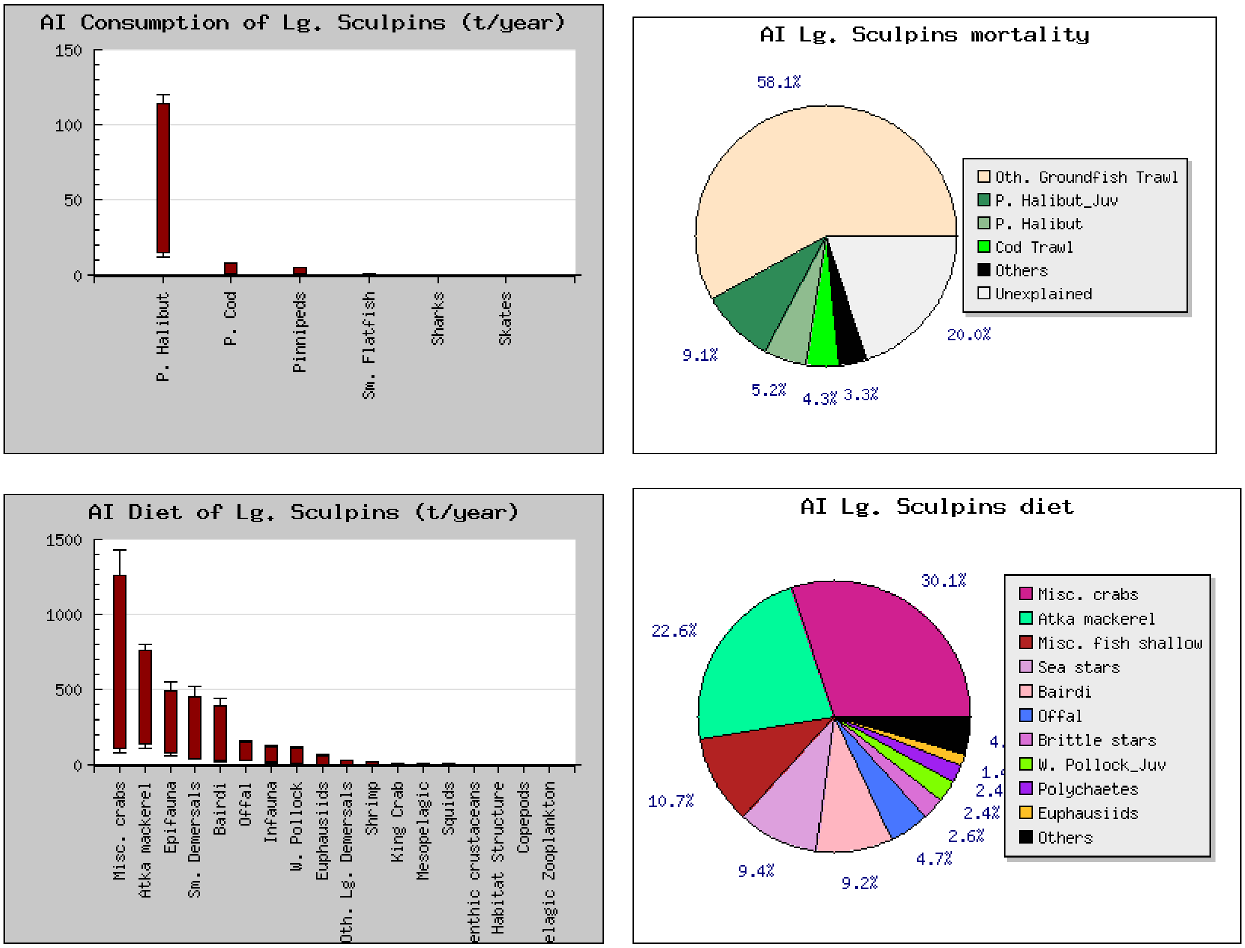



Figure 20.14. Figures showing Consumption, mortality, and diet of large sculpins from the Aleutian Islands. Source: REEM ecosystem website.
*Disclaimer: The above figures are in part the result of ecosystem modeling. The use of direct diet data for sculpins in the BSAI is limited.

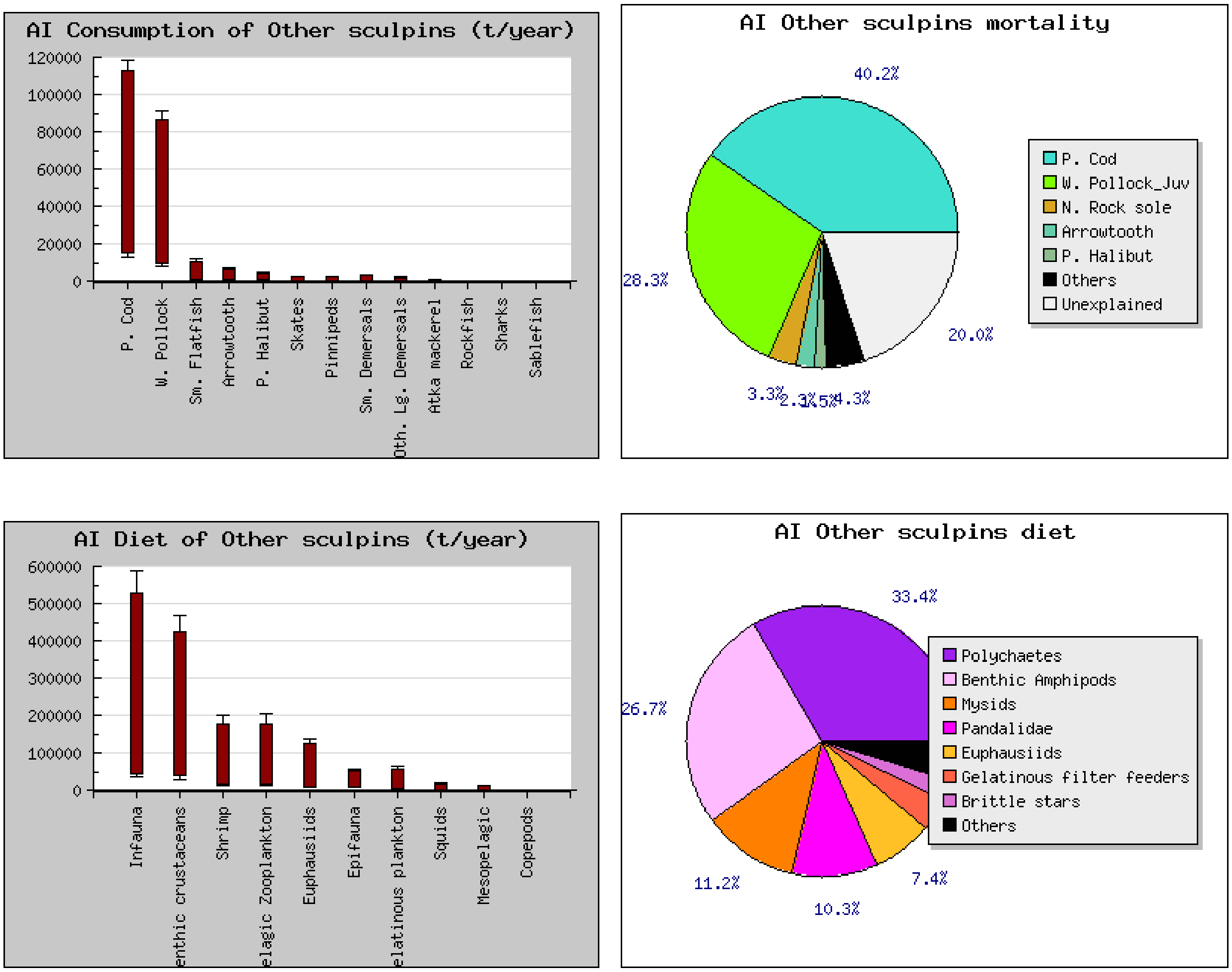



Figure 20.15. Figures showing Consumption, mortality, and diet of other sculpins from the Aleutian Islands. Source: REEM ecosystem website.

*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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