18d. Assessment of sculpins in the Gulf of Alaska

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Executive Summary

The following report summarizes the information currently known about sculpins (Families: Cottidae, Hemitripteridae, Psychrolutdiae, and Rhamphocottidae) in the Gulf of Alaska (GOA). Sculpin catch has increased in the last several years from 583 t in 2006 to 960 t in 2007 and 1,943 t in 2008. The 2009 catch as of October is also high at 1,146 t. These catches are mainly the result of increased catches of sculpins in the shallow-water flatfish fishery.

Summary of changes in assessment inputs

1. Sculpin catch within the GOA fisheries was updated with complete 2008 and partial 2009 data as of October 7, 2009. In addition, catch data from 2003-2007 have been updated due to changes in the Catch Accounting System.
2. Biomass estimates from the 2009 GOA bottom trawl survey have been added.
3. Information on catch by target fishery, retention, and catch species composition has been updated through 2009.
4. Survey length compositions are updated with data from the 2009 survey.
5. Layout and tables have changed somewhat as the result of there being a new assessment author.

Summary of results

As in the 2008 assessment, we recommend a Tier 5 approach for sculpins using M=0.19 and average survey biomass from the last four surveys (2003-2009). The 2009 survey biomass estimate for sculpins was 40,726 t, a substantial increase from the 2007 survey estimate of 32,468 t. This increase resulted in a slight increase in the recommended ABC and OFL. Catch has remained below the OFL for GOA sculpins, so the stock complex is not experiencing overfishing. Data are not available for assessing whether the population is overfished.

harvest recommendations for GOA sculpins in 2010-2011					
M	**average biomass (t)**	F_{ABC}	**ABC (t)**	F_{OFL}	**OFL (t)**
0.19	33,307	0.1425	4,746	0.19	6,328
2009 specifications					
0.19	30,836		4,394		5,859

Introduction

Description, scientific names, and general distribution

Sculpins are a group of benthic-dwelling predatory teleost fish, that include 46 species in waters off the coast of Alaska. Sculpins have been identified to species in the AFSC surveys since 2001. During AFSC surveys of the Gulf of Alaska, only 39 of 46 listed species of sculpins have been identified (Table 1). It is not clear whether the other 7 species exist in the GOA. Sculpin diversity is high in the GOA and many of these species are also found in the Bering Sea (Table 1). Sculpins are broadly distributed throughout the shelf and slope regions of the Gulf of Alaska occupying all benthic habitats and depths. In this assessment, we mainly focus on large sculpin species from the genera *Myoxocephalus*, *Hemitripterus*, and *Hemilepidotus* which observers from the North Pacific Groundfish Observer Program have recently begun to identify sculpin catch to genus.

Management units

Sculpins are managed as part of the GOA Other Species complex, which also includes sharks, octopus and squid. A single TAC is specified for the entire Other Species complex. Historically this TAC was established as 5% or less of the sum of the TACs for all other assessed target species in the GOA Fishery Management Plan (FMP). In 2008, the North Pacific Fishery Management Council (NPFMC) adopted an amendment to set harvest specifications for the Other Species complex by calculating individual OFL and ABC for each species group and aggregating these into a single Other Species OFL and ABC. Sculpins are currently non-targets in the GOA, so future catch of sculpins may depend solely on the TAC and spatial temporal limitations placed on target fisheries. Vulnerability analyses indicate that sculpins could be managed as a separate assemblage and catch could be constrained within a spatial context.

Reproductive Ecology

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. 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 pollock, which are broadcast spawners with pelagic eggs. In the western Pacific, great sculpins *Myoxocephalus polyacanthocephalus* are reported to have 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 contrast, preliminary information on reproduction for bigmouth sculpin (*Hemitripterus bolini*) in the Gulf of Alaska shows fecundity averaged 2283 eggs per female (Morgan Busby, AFSC, personal comm.). The diversity of sculpin species in the Gulf of Alaska suggests that each sculpin population might respond differently to environmental changes (whether natural or fishing induced). Within each sculpin species, observed spatial differences in fecundity, egg size, and other life history characteristics suggest local population structure (Tokranov, 1985).

Life history (GOA-specific)

Information such as depth range, distribution, and maximum length has been collected for several years for many species during surveys. There are no GOA-specific age and growth, maturity data for sculpins identified in this management region. Known life history characteristics for selected sculpin species in the GOA are presented in Table 2. With the exception of data for bigmouth sculpins, all fecundity and maturity data in Table 2 are from outside GOA region.

Fishery

There are no directed fisheries for sculpin species in the GOA at this time. Sculpins, in 2008, constituted about 65% of the GOA Other Species catch. Prior to 2005 when skates were still included in the complex they were 7-19% of the other species catch (Table 3). Retained catch of sculpin species in the GOA has increased recently from 7% in 2003 to 20% in 2009 (Table 3). Sculpins are caught incidentally by a wide variety of fisheries. Based on data from the NMFS AKRO the main fisheries that catch sculpins are the flatfish, Pacific cod, and IFQ halibut fisheries (Table 4). It is unclear which sculpin species were commonly taken in GOA groundfish fisheries prior to 2004, because observers did not regularly identify animals in these groups to species. Sculpin catch has increased in the last several years from 583 t in 2006 to 960 t in 2007 and 1,943 t in 2008. The 2009 catch as of October is also high at 1,146 t. These catches are mainly the result of increased catches of sculpins in the shallow-water flatfish fishery (Table 4).

In 2002-2003, the observer program of AFSC initiated a species identification project to address 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 Alaskan waters, *Hemitripterus* probably represents only one species, the bigmouth sculpin (Stevenson 2004). Another member of this genus that may occur in waters off the coast of Alaska, the sea raven (*H. villosus*), has never been identified in any of the GOA trawl surveys conducted by AFSC. It is reasonable to assume that all sculpins identified by observers as *Hemitripterus* sculpins were bigmouth sculpins. According to total catch figures for 2007 from the NMFS Alaska Regional Office (AKRO), the aforementioned large sculpin genera contributed the vast majority of all sculpin catch in the GOA region (Table 5).

The observer catch composition data in Table 5 show that in 2007, *Hemilepidotus* spp. (the Irish lords) made up 65% of the sculpin total observed catch. *Hemitripterus* spp. (bigmouth sculpin) constituted approximately 18% of the total sculpins. In 2008, the first year observers identified the top 5 species of sculpins to species, shows that *Hemilepidotus jordani* (yellow Irish lord) were 62% of all sculpin catch in the GOA, followed by Irish lord unidentified. In 2009 the catch percentage of *H. jordani* is lower but still the largest fraction of sculpin catch. *Myoxocephalus* species make up only a small part of GOA sculpin catches (Table 5).

Data

Survey data

Biomass estimates

Aggregate sculpin biomass in the GOA shows no clear trend, and should probably not be used as an indicator of population status for a complex with so much species diversity (Table 6). Trends in biomass were available for only selected sculpin species for the period 1984-2000due to difficulties with species identification and survey priorities. Species specific biomass estimates are available for the 2001-2009 surveys. Almost 95% of the sculpin biomass is dominated by the larger sculpin species in the GOA. Yellow Irish lord is the most abundant (~45.5% of the sculpin biomass), followed by the genera *Myoxocephalus* at ~27% and bigmouth sculpin at ~22% of the sculpin biomass (Table 7 and Figure 1).

Biomass trends show that the bigmouth sculpin declined between 1984 and 2001, but has remained relatively stable since then (Figure 1). Yellow Irish lord biomass has increased over the last three surveys, which has resulted in an increase in total sculpin biomass (Table 7 and Figure 2). The coefficient of variations (CVs) for the survey biomass estimates of 7 out of 12 sculpins species are below 0.3, suggesting that the GOA survey is doing an adequate job assessing the biomass of the more abundant species (Table 8).

Length frequency

Length measurements (fork length, FL in mm) have been collected for a variety of sculpin species during AFSC surveys. The four most abundant species from the GOA survey have been measured on every biennial survey since 2003: yellow Irish lord, plain sculpin, great sculpin and bigmouth sculpin (Figure 3). These length compositions have remained fairly stable during this period. One interesting observation is that the surveys tend to catch bigmouth sculpins on the higher side of the length range, similar to the length observations of bigmouth from the eastern Bering Sea (EBS) shelf survey. 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.

Sample sizes for length frequency analysis for GOA:

Species	**2003**	**2005**	**2007**	**2009**
yellow Irish lord	917	1034	1044	2573
plain sculpin	81	126	176	153
great sculpin	208	201	209	304
bigmouth sculpin	81	61	51	64

Analytic Approach

Sculpins in the GOA are managed under Tier 5, where OFL = M * average survey biomass and ABC = 0.75 * M * average survey biomass. Average biomass was calculated as the average of the last 4 GOA trawl survey estimates (Table 6). The following methods were employed to evaluate natural mortality with life history parameters: Alverson and Carney 1975, Pauly 1980, Charnov 1993, Hoenig 1983, Rikhter and Efanov 1976. Little information was available for sculpin stocks in the GOA FMP area, so M was estimated by applying these methods to data for Russian sculpin species. Considering the uncertainty inherent in applying this method to sculpin species and stocks not found in the GOA, as well as that great and plain sculpin are the most abundant in the GOA and have estimates of M in the literature, we elected to use the lowest estimate of M, 0.19, which is one of the estimates for great sculpin (Table 8). Although new estimates of *M* are available for sculpins in the BSAI, no new data are available for the GOA and we recommend keeping the status quo until GOA-specific estimates are available.

Results

Applying the M estimate of 0.19 to the average survey biomass estimates, we calculate an ABC of 0.75 * 0.19 * (33,307) = 4,746 t for the GOA. The GOA OFL is calculated as 0.19 * (33,307) = 6,328 t for the GOA.

Because sculpin life histories differ substantially from other species groups in the GOA Other Species complex, we recommend that sculpins be managed as a separate complex with its own harvest specifications. 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 specific estimates of productivity.

Ecosystem Considerations

Ecosystem Effects on Stock

Little is known about sculpin food habits in the GOA, especially during fall and winter months. Limited information indicates that in the GOA the larger sculpin species prey on shrimp and other benthic invertebrates, as well as some juvenile walleye pollock (Figure 4). In the GOA the main predator of large sculpins are Pacific halibut, pinnipeds, small demersal fish and sablefish (Figure 4). Other sculpins in the GOA feed mainly on shrimp and benthic crustaceans (Figure 5). Other sculpins are mainly preyed upon by Pacific cod and is the main source of mortality (Figure 5). Source of above information from Aydin et al. (2007).

Fishery Effects on the Ecosystem

Analysis of ecosystem considerations for those fisheries that affect the stocks within this complex (see Table 4) is given in the respective fisheries SAFE chapter. The GOA 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)**			

Data gaps and research priorities

Severe data gaps exist in sculpin species life history characteristics, spatial distribution and abundance in Alaskan waters. Most importantly no data on maximum age exists for the four main sculpin species in the GOA. Therefore, collections for age data on Yellow Irish lord, Great sculpin, bigmouth sculpin and plain sculpin are needed from the GOA. It is essential that we continue to improve species identifications as well as collecting life history information from the fisheries. Over 90% of all sculpins caught in the fisheries of the GOA in 2004 were from the genera *Myoxocephalus, Hemitripterus,* and *Hemilepidotus.* Collecting seasonal food habits data (with additional summer collections) would help to clarify the role of

both large and small sculpin species within the GOA ecosystem. These data are necessary in deciding creative management strategies for non-target species.

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. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA Tech Memo.178 298pp.

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.

Gaichas, S.K., D. Courtney, T. TenBrink, M. Nelson, S. Lowe, J. Hoff, B. Matta and J. Boldt. 2004. BSAI Squid and Other species stock assessment. 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.

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

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 1. Sculpin species that have been observed during AFSC GOA bottom trawl surveys.

Family	Scientific name	Common name
Cottidae	*Artediellus pacificus*	Pacific hookear sculpin
	Artedius lateralis	Smoothhead sculpin
	Bolinia euryptera	Broadfin sculpin
	Enophyrs bison	Buffalo sculpin
	Enophrys diceraus	Antlered sculpin
	Gymnocanthus galeatus	Armorhead sculpin
	Gymnocanthus pistilliger	Threaded sculpin
	Hemilepidotus hemilepidotus	Red Irish Lord
	Hemilepidotus jordani	Yellow Irish Lord
	Hemilepidotus papilio	Butterfly sculpin
	Hemilepidotus spinosus	Brown Irish lord
	Hemilepidotus zapus	Longfin Irish lord
	Icelinus borealis	Northern sculpin
	Icelinus burchami	Dusky sculpin
	Icelinus filamentosus	Threadfin sculpin
	Icelinus tenuis	Spotfin sculpin
	Icelus spatula	Spatulate sculpin
	Icelus spiniger	Thorny sculpin
	Icelus uncinalis	Uncinate sculpin
	Jordania zonope	Longfin sculpin
	Leptocottus armatus	Pacific staghorn sculpin
	Microcottus sellaris	Brightbelly sculpin
	Myoxocephalus jaok	Plain sculpin
	Myoxocephalus polyacanthocephalus	Great sculpin
	Myoxocephalus verrucocus	Warty sculpin
	Paricelinus hopliticus	Thornback sculpin
	Radulinus asprellus	Slim sculpin
	Rastrinus scutiger	Roughskin sculpin
	Thecopterus aleuticus	Whitetail 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
Hemitripteridae	*Blepsias bilobus*	Crested sculpin
	Hemitripterus bolini	Bigmouth sculpin
	Nautichthys oculofasciatus	Sailfin sculpin
	Nautichthys pribilovius	Eyeshade sculpin
Psychrolutidae	*Dasycottus setiger*	Spinyhead sculpin
	Eurymen gyrinus	Smoothcheek sculpin
	Malacoccottus zonurus	Darkfin sculpin
	Malacocottus kincaidi	Blackfin sculpin
	Psychrolutes paradoxus	Tadpole sculpin
	Psychrolutes phrictus	Blob sculpin
Rhamphocottidae	*Rhamphocottus richardsoni*	Grunt sculpin

Table 2. Life history information available for selected GOA sculpin species. "O" designates data was obtained from individuals of that species outside the GOA region.

Species	common name	maximum length (cm)		maximum age		fecundity (x1000)	age at 50% maturity
		O	GOA	O	GOA		
Myoxocephalus joak	plain	75	59	15		25.4 - 147	5 - 8
M. polyacanthocephalus	great	82	72	13		48 - 415	6 - 8
M. verrucosus	warty	78				2.7	
Hemitripterus bolini	bigmouth	83	86			2.3	
Hemilepidotus jordani	yellow Irish lord	65	50	13		25 - 241	6 - 7
H. papilio	butterfly	38					
G. pistilliger	threaded	27		13		5 - 41	
G. galeatus	armorhead	46	28	13		12 - 48	
Dasycottus setiger	spinyhead	45	22	11			
Icelus spiniger	thorny	17					
Triglops pingeli	ribbed	20		6		1.8	
T. forficate	scissortail	30	28	6		1.7	
T. scepticus	spectacled	25		8		3.1	

References: AFSC; Panchenko 2002; Panchenko 2003; Tokranov 1985; Andriyashev 1954; Tokranov 1988a; Tokranov 1988b; Tokranov 1995; Tokranov and Orlov 2001; Busby, AFSC, personal comm.
Notes: Estimate of Natural mortality (M) is the lowest estimate of M derived from several methods as presented in Gaichas et al. (2004); blanks indicate no life history data found.

Table 3. GOA total sculpin complex catch, retention rate, total Other Species catch, and sculpin percentage of Other Species catch, 1997-2009*. *Source: AKRO Catch Accounting System except for retention rate, which was estimated from fishery observer data obtained from the AFSC Fishery Monitoring and Analysis program.*

Year	Sculpin complex total catch	retention rate	Other species total catch	Percent of Other Species catch
1997	898		4,823	19%
1998	526		7,422	7%
1999	544		3,788	14%
2000	940		5,455	17%
2001	587		3,383	17%
2002	919		8,162	11%
2003	629	7%	6,262	10%
2004	816	9%	5,865	14%
2005+	626	16%	2,512	25%
2006	583	16%	3,882	15%
2007	960	19%	3,026	32%
2008	1,943	14%	2,984	65%
2009*	1,146	20%	2,085	55%

+ Beginning in 2005, skates were removed from Other Species complex.

* 2009 data as of October 7, 2009.

Table 4. Total GOA sculpin catch (mt) by target fishery, 2003-2009. *Source: AKRO Catch Accounting System.*

target fishery	2003	2004	2005	2006	2007	2008	2009*
arrowtooth flounder	16	7	19	36	38	16	16
deep flatfish	17	4	1	6	5	1	3
flathead sole	1	125	2	1	0	18	2
IFQ_halibut	36	43	20	15	27	152	113
other target	22	0	10	0	7	0	10
Pacific cod	69	412	294	351	437	740	487
rex sole	27	19	11	7	8	4	26
rockfish	24	58	28	32	31	23	34
sablefish	1	2	17	4	7	2	18
shallow flatfish	113	129	199	125	376	969	425
pollock	1	0	0	2	22	15	6

* 2009 data are as of October 7, 2009.

Table 5. Estimated species composition of GOA incidental sculpin catches, 2007-2009*, based on fishery observer data. *Source: NMFS AFSC Fishery Monitoring and Analysis Program.*

	2007	**2008**	**2009***
Hemitripterus spp.**	18.0%		
H. bolini		7.8%	16.1%
Hemilepidotus spp.	65.0%		
Hemilepidotus unidentified		16.4%	23.6%
H. hemilepidotus		<1%	<1%
H. jordani		61.7%	37.3%
Myoxocephalus spp.	9.0%		
Myoxocephalus unidentified		<1%	2.9%
M. verrucosus		<1%	<1%
M. jaok		<1%	<1%
M. polyacanthocephalus		10.0%	5.4%
Miscellaneous sculpins§	8.0%	3.4%	14.1%

* 2009 data are incomplete.

** Hemitripterus spp. probably represents only one species (bigmouth sculpin).
§ Miscellaneous sculpins includes unidentified sculpins as well as darkfin, scissortail, and longfin Irish lord.

Table 6. Sculpin complex biomass estimates based on NMFS bottom-trawl surveys, 1984-2007.

Year	Biomass	CV
1984	40,954	0.08
1987	31,328	0.11
1990	25,556	0.18
1993	25,371	0.12
1996	31,313	0.26
1999	30,783	0.11
2001	30,418	0.28
2003	26,514	0.09
2005	33,519	0.09
2007	32,468	0.11
2009	40,726	0.11

Table 7. GOA trawl survey biomass estimates (mt) for individual sculpin species, 1996-2009, with 2009 CV.

species	**biomass**							**CV**
	1996	**1999**	**2001***	**2003**	**2005**	**2007**	**2009**	**2009**
crested	-	-	6	-	-	-	-	-
spinyhead	278	271	690	608	463	422	410	0.14
antlered	-	-	1	-	-	-	-	-
armorhead	13	15	60	78	28	58	216	0.22
threaded	3	-	21	<1	2	-	2	0.70
yellow Irish lord	17,804	20,255	20,945	12,064	15,952	15,720	25,219	0.16
butterfly	<1	1	-	-	-	-	-	-
bigmouth	4,246	3,983	3,471	5,767	5,543	3,126	3,154	0.19
thorny	1	-	1	<1	<1	<1	<1	-
Pacific staghorn	-	1	2	-	14	-	8	0.63
darkfin	477	371	335	607	944	790	614	0.22
plain	1,015	1,692	932	1,220	3,912	4,456	2,562	0.30
great	7,326	3,913	3,540	6,037	6,574	7,734	8,215	0.18
warty	-	-	339	-	-	33	-	-
scissortail	60	47	62	94	23	30	111	0.49
spectacled	90	233	12	40	105	96	68	0.83
total	**31,313**	**30,782**	**30,417**	**26,515**	**33,560**	**32,468**	**40,726**	**0.11**

* The 2001 trawl survey did not cover the eastern GOA, so those numbers are not directly comparable.

Table 8. List of available natural mortality information for sculpins.

Species	Area	Sex	Hoenig	Rikhter & Efanov	Alverson & Carney	Charnov
Arctic staghorn sculpin	W. Bering Sea	*males*	0.53			
	W. Bering Sea	*females*	0.47			
				0.41		
Common staghorn sculpin	Kamchatka	*males*	0.32	0.32		
	Kamchatka	*females*	0.25	0.26		
Red Irish Lord	Puget Sound		0.70			
Threaded sculpin	E. Bering Sea	*males*	0.42		0.36	0.65
		females	0.47		0.58	0.40
Armorhead sculpin	Kamchatka	*males*	0.38			
	Kamchatka	*females*	0.32			
Great sculpin	Kamchatka	*males*	0.47	0.32		
	Kamchatka	*males*		0.26		
	Kamchatka	*females*	0.32	0.22		
	Kamchatka	*females*		**0.19**		
Plain sculpin	Sea of Japan	*males*	0.35	0.41		
	Sea of Japan	*males*		0.32		
	Sea of Japan	*females*	0.28	0.26		
	Sea of Japan	*females*		0.22		

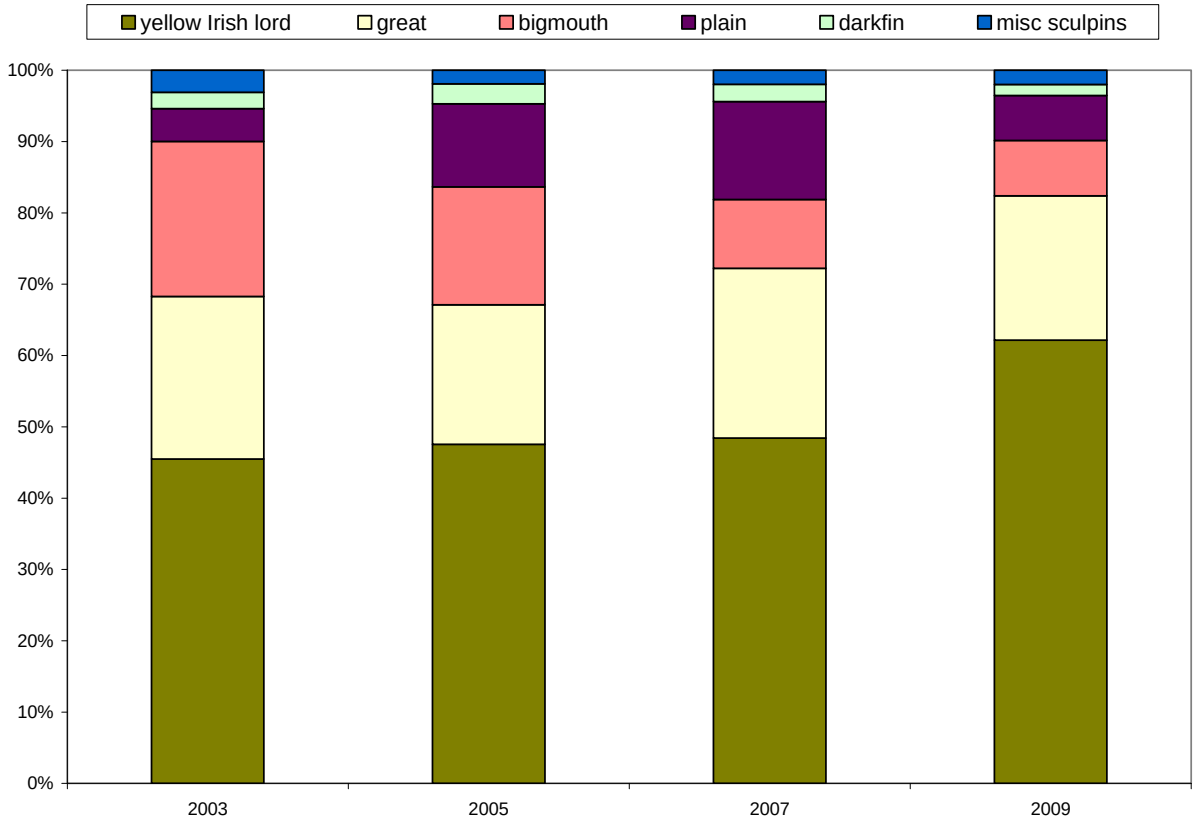

Figure 1. Species composition of the sculpin complex in the GOA. Data are from the 2003-2009 AFSC GOA bottom trawl surveys.

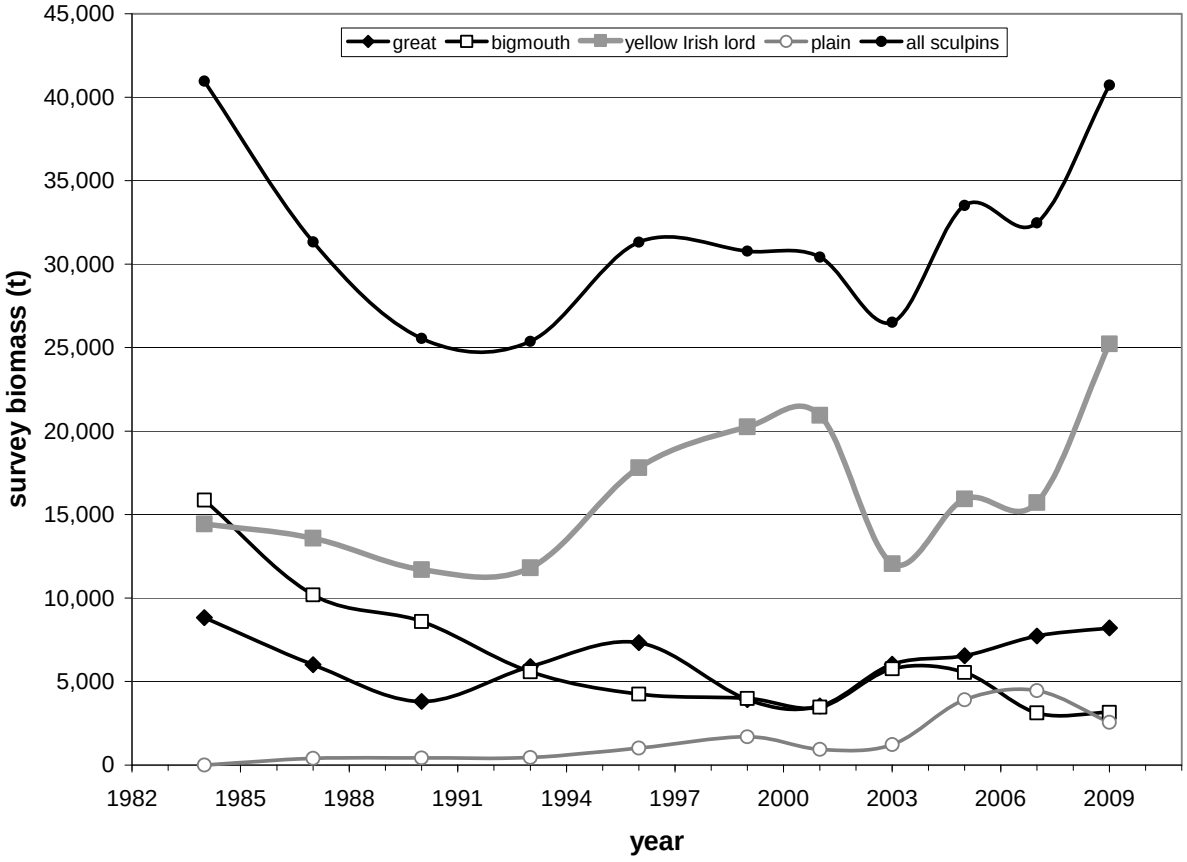

Figure 2. Time series of trawl survey biomass estimates for selected sculpin species and all sculpins combined in the GOA, 1984-2009.

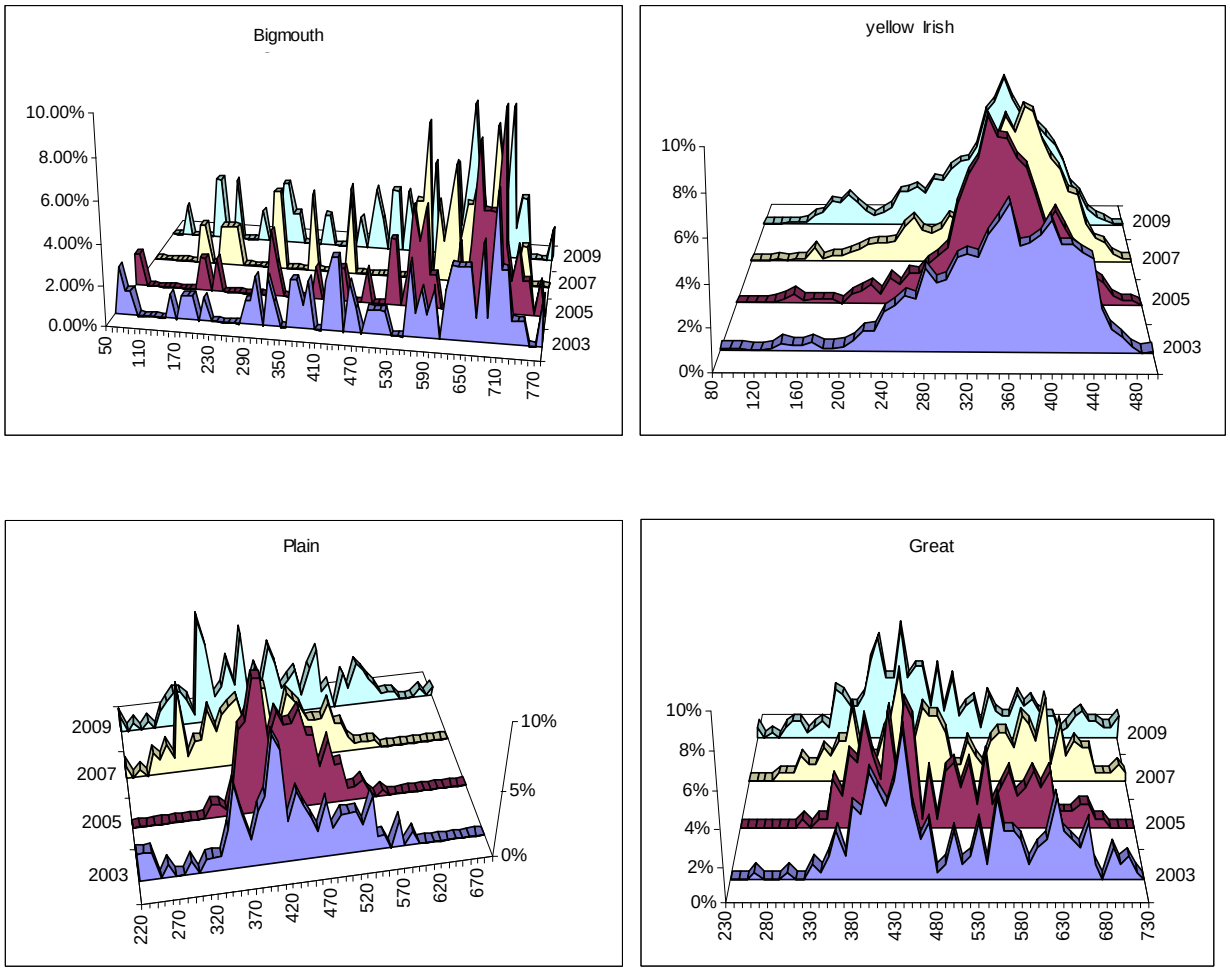

Figure 3. Length composition (fork length, FL in mm) from survey data for the 4 most abundant sculpin species in the GOA, 2003-2009.

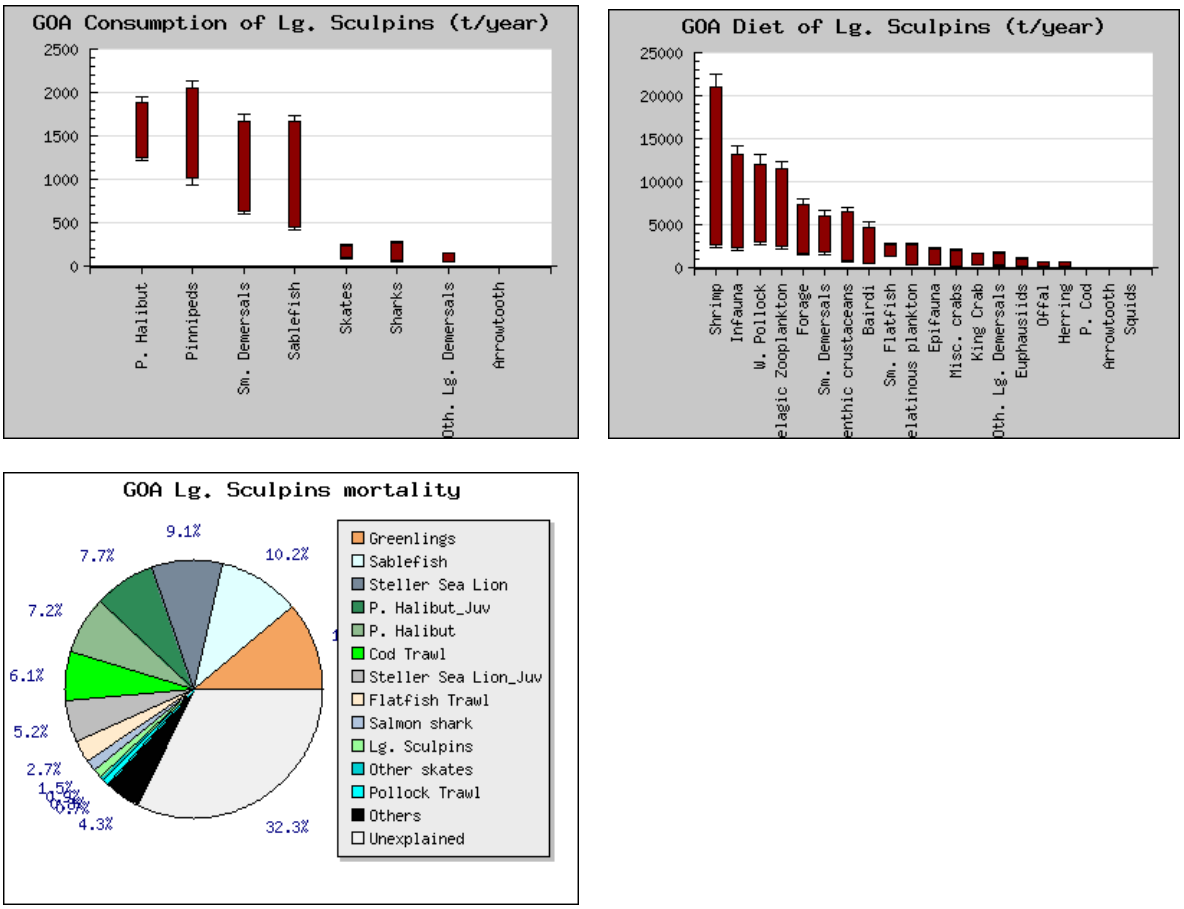

Figure 4. Diet, consumption and mortality information for Large Sculpins in the GOA.

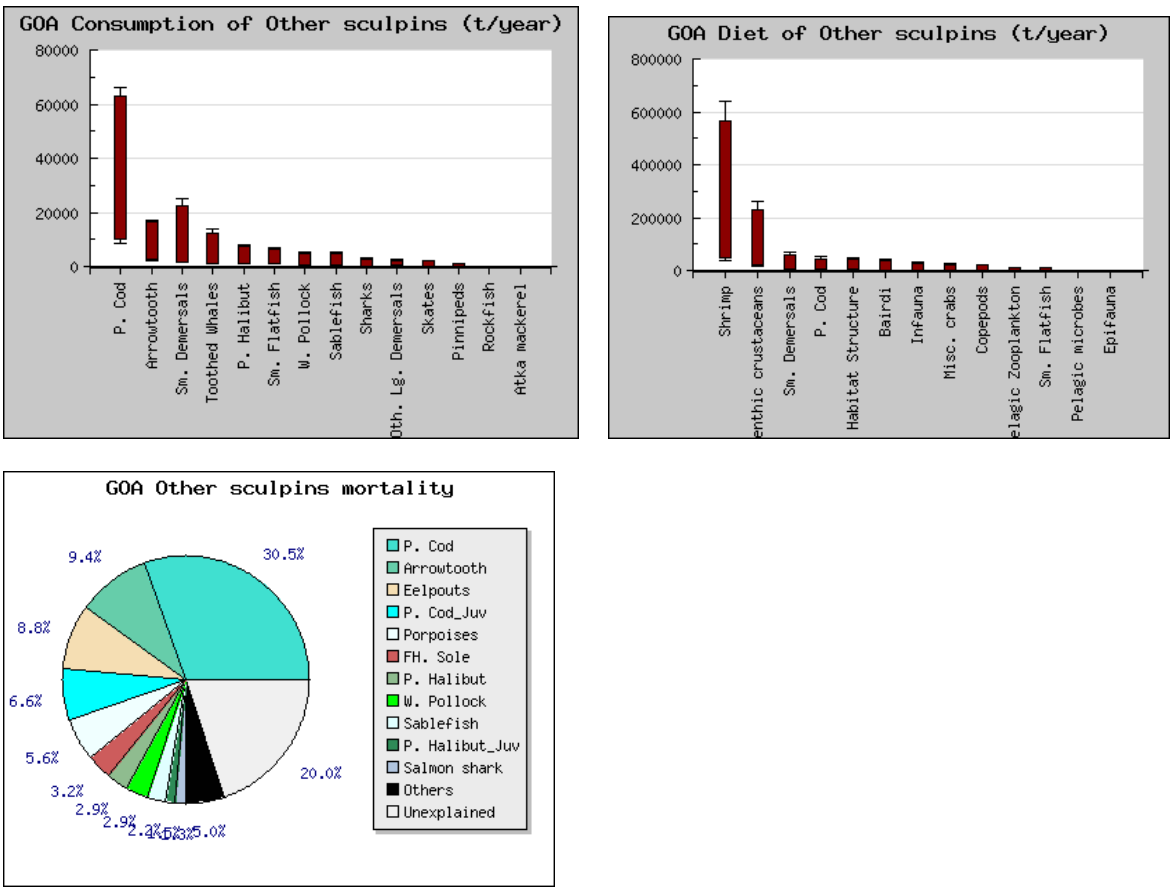

Figure 5. Diet, consumption and mortality information for Other Sculpins in the GOA.