Appendix 1
Essential Fish Habitat Text Descriptions
Adult Summer EFH Maps
Habitat associations, biological associations, predator/prey associations, and life histories of fishes in the Bering Sea and Aleutian Islands Groundfish Fishery Management Plan

Essential Fish Habitat Descriptions

General

Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH is described for FMP-managed species by life stage using guidance from the EFH Final Rule (50 CFR 600.815), including the EFH Level of Information definitions. New analytical tools are used and recent scientific information is incorporated for each life history stage from updated scientific habitat assessment reports. EFH descriptions include both text and maps, if information is available for a species' particular life stage. These descriptions are risk averse, supported by scientific rationale, and account for changing oceanographic conditions, regime shifts, and the seasonality of migrating fish stocks. EFH descriptions are interpretations of the best scientific information.

Table 1 EFH information levels for BSAI Groundfish life stages

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Pollock	1	1	2	2	2
Pacific cod	x	2	2	2	2
Sablefish	x	x	x	1	1
Yellowfin sole	1	1	1	1	1
Greenland turbot	1	1	1	2	2
Arrowtooth flounder	1	1	1	2	2
Kamchatka flounder	1	1	1	1	1
Northern rock sole	x	1	1	1	1
Alaska plaice	1	1	x	1	1
Rex sole	1	1	1	2	2
Dover sole	1	1	1	2	2
Flathead sole	1	1	2	2	2
Pacific ocean perch	*Sebastes* spp. early life stages grouped 1			2	2
Northern rockfish				2	2
Shortraker rockfish				2	2
Blackspotted/ rougheye rockfish				1	2
Other rockfish (Dusky)				1	1
Thornyhead rockfish (shortspine)	x	x	2	2	2
Atka mackerel	1	1	x	1	2
Squids	x	x	x	1	1
Sculpins (Great, Yellow Irish Lord, Bigmouth)	x	x	na	x	2
Skates (Alaska, Bering, Aleutian)[1]	1	x	1	2	2
Skates (Mud)	x	x	x	x	2
Sharks	x	x	x	x	x
Octopuses (Pacific Giant)	x	x	x	x	2
Forage fish complex	x	x	x	x	x
Grenadiers	x	x	x	x	x

X Indicates insufficient information is available to describe EFH

1 Indicates general distribution data are available for some or all portions of the geographic range of the species

2 Indicates quantitative data (density or habitat-related density) are available for the habitats occupied by a species or life stage

na One juvenile stage exists – see Late Juveniles

[1] Several Egg Case Concentration Sites (nursery areas) have been identified as HAPC in the BSAI.

Walleye Pollock

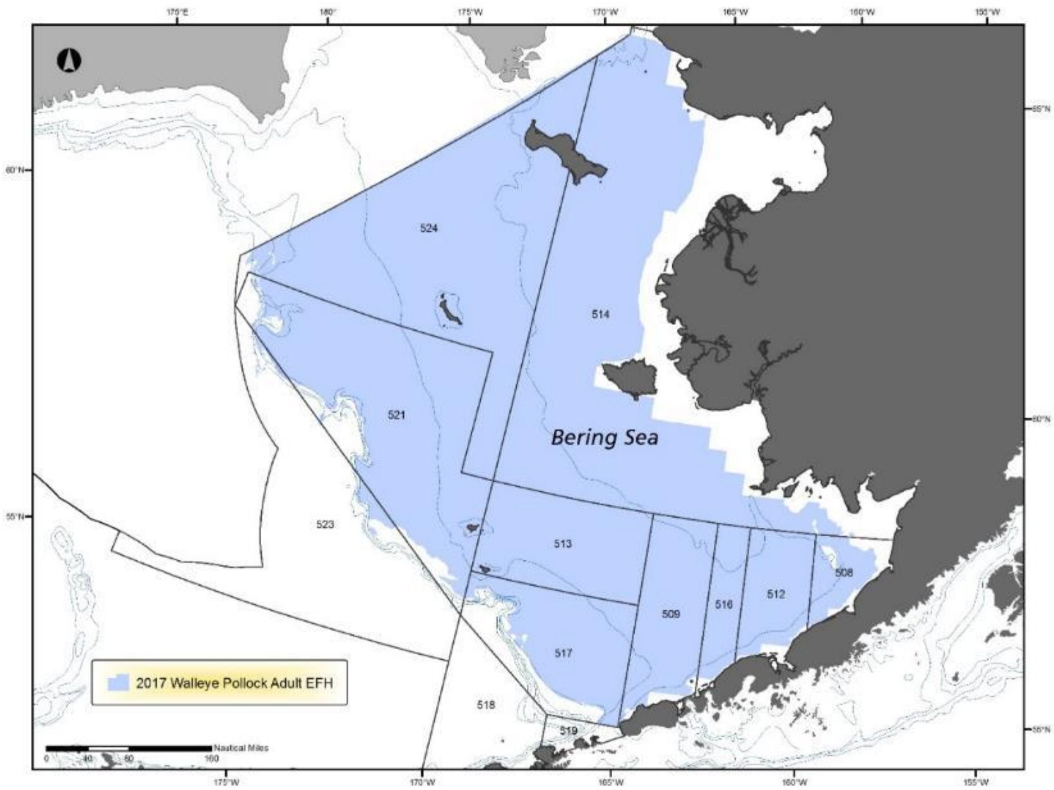
Eggs: EFH for walleye pollock eggs is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m), upper slope (200 to 500 m), and intermediate slope (500 to 1,000 m) throughout the BSAI.

Larvae: EFH for larval walleye pollock is the general distribution area for this life stage, located in epipelagic waters along the entire shelf (0 to 200 m), upper slope (200 to 500 m), and intermediate slope (500 to 1,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile walleye pollock is the habitat-related density area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI. Relative abundance of age 1 pollock is used as an early indicator of year class strength and is highly variable (presumably due to survival factors and differential availability between years).

Late Juveniles: EFH for late juvenile walleye pollock is the habitat-related density area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI. Substrate preferences, if they exist, are unknown.

Adults: EFH for adult walleye pollock is the habitat-related density area for this life stage, located in the lower and middle portion of the water column along the entire shelf (~10 to 200 m) and slope (200 to 1,000 m) throughout the BSAI. Substrate preferences, if they exist, are unknown.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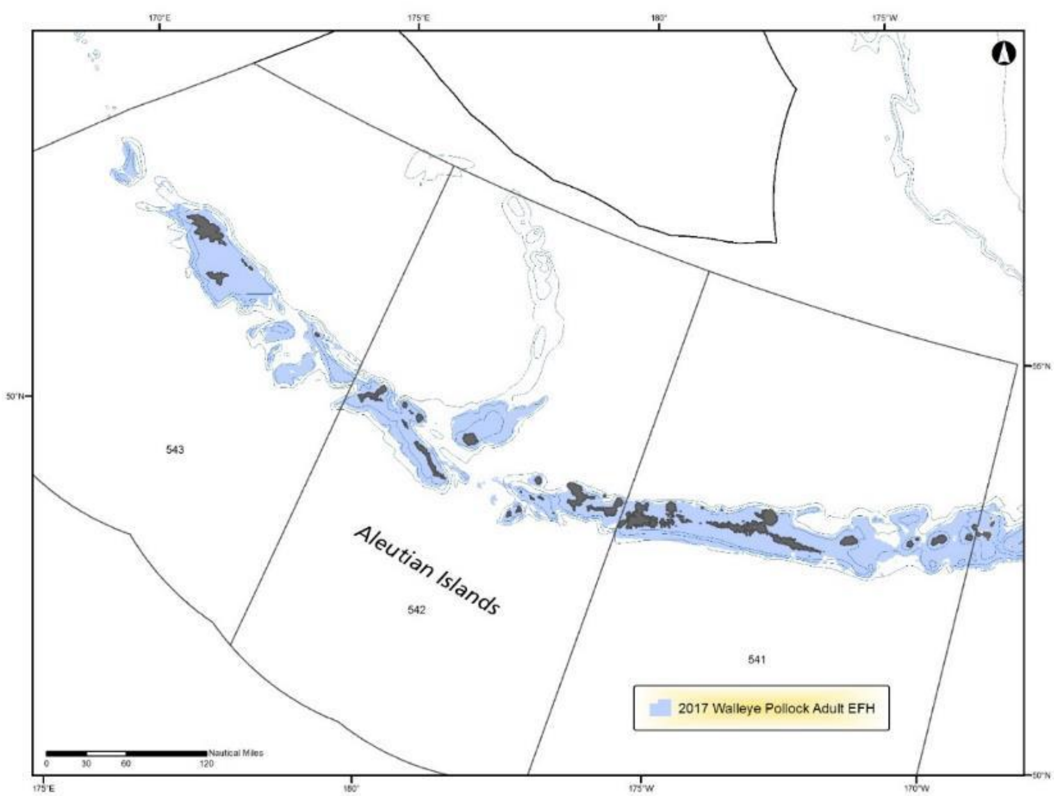
2017 Walleye Pollock Adult EFH
Nautical Miles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2017 Walleye Pollock Adult EFH
Nautical Miles

Pacific Cod

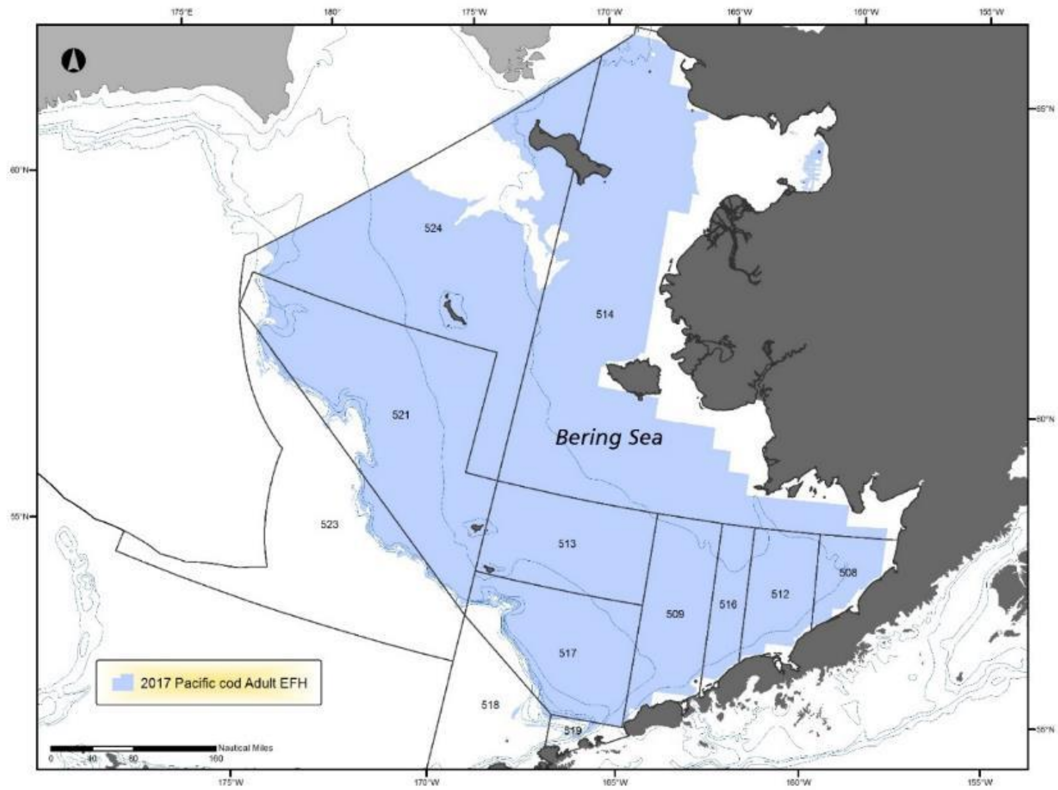
Eggs: No EFH description determined. Insufficient information is available. Pacific cod eggs, which are demersal, are rarely encountered during surveys in the BSAI.

Larvae: EFH for larval Pacific cod is the habitat-related density area for this life stage, located in epipelagic waters along much of the middle (50 to 100 m) and outer (100 to 200 m) Eastern Bering Sea (EBS) shelf, with hotspots in the vicinity of the middle shelf north of Unimak Pass and the Pribilof Islands. The habitat-related density area of larval Pacific cod in the Aleutian Islands (AI) is unknown.

Early Juveniles: EFH for early juvenile Pacific cod is the habitat-related density area for this life stage, centered over the middle (50 to 100 m) EBS shelf between the Pribilof Islands and the Alaska Peninsula and broadly similar to the habitat-related density area for larval Pacific cod, but not extending as far north. The habitat-related density area of early juvenile Pacific cod in the AI is unknown.

Late Juveniles: EFH for late juvenile Pacific cod is the habitat-related density area for this life stage, including nearly all of the EBS shelf (0 to 200 m) and upper slope (200 to 500 m), with highest abundances in the inshore portions of the central and southern domains of the EBS shelf, and broadly throughout the AI at depths up to 500 m.

Adults: EFH for adult Pacific cod is the habitat-related density area for this life stage, including nearly all of the EBS shelf and slope, with highest abundances in the central and northern domains over the middle (50 to 100 m) and outer (100 to 200 m) shelf, and broadly throughout the AI at depths up to 500 m.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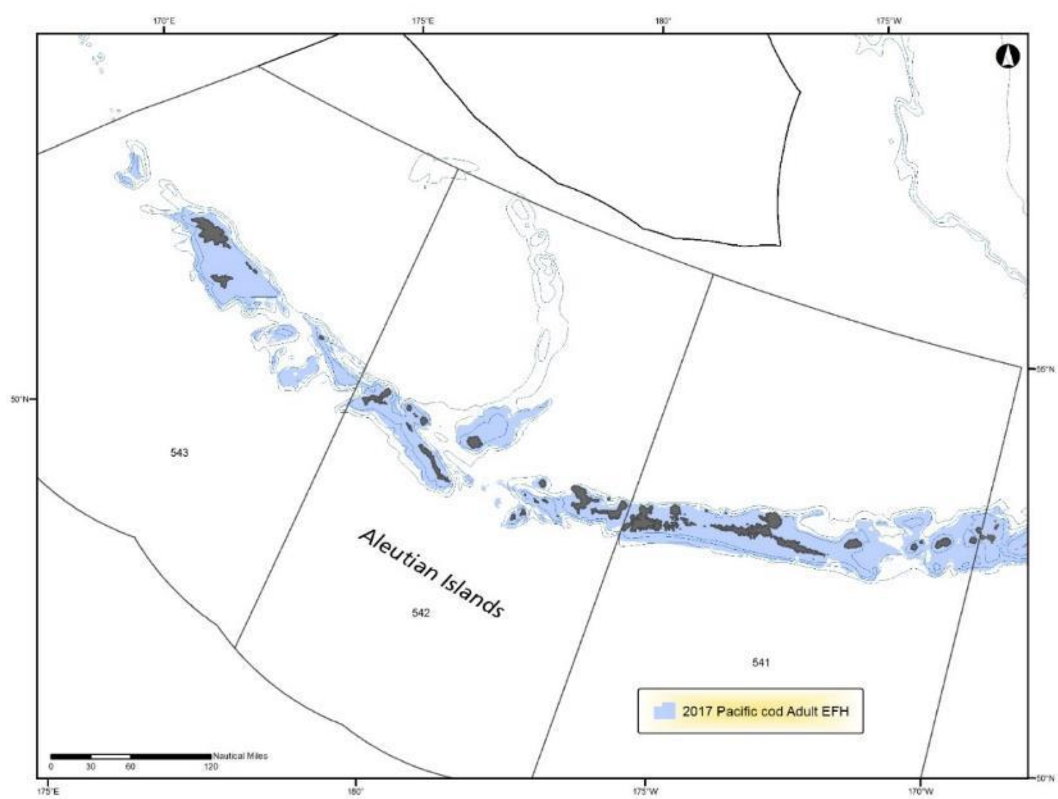
2017 Pacific cod Adult EFH
Nautical Miles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2017 Pacific cod Adult EFH
Nautical Miles

Sablefish

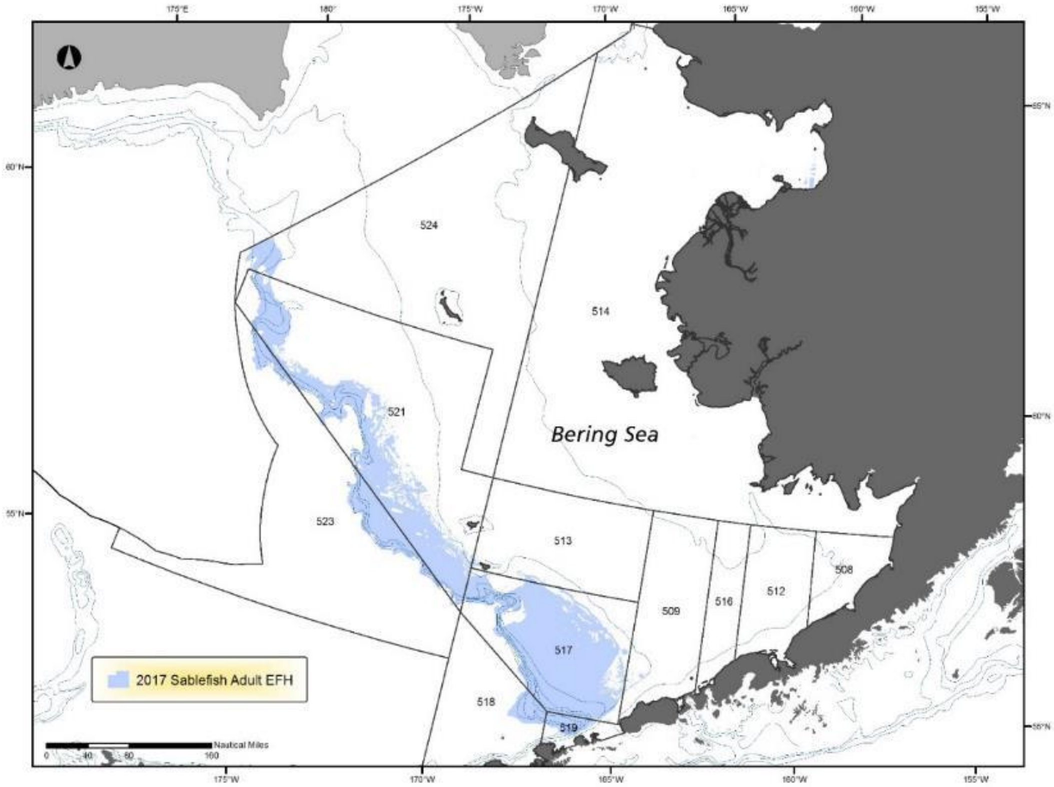
Eggs: No EFH description determined. Insufficient information is available. Scientific information notes the rare occurrence of sablefish eggs in the BSAI.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: No EFH description determined. Information is insufficient. Early juveniles have generally been observed in inshore water, bays, and passes, and on shallow shelf pelagic and demersal habitat.

Late Juveniles: EFH for late juvenile sablefish is the general distribution area for this life stage, located in the lower portion of the water column, varied habitats, generally softer substrates, and deep shelf gulleys along the slope (200 to 1,000 m) throughout the BSAI.

Adults: EFH for adult sablefish is the general distribution area for this life stage, located in the lower portion of the water column, varied habitats, generally softer substrates, and deep shelf gulleys along the slope (200 to 1,000 m) throughout the BSAI.



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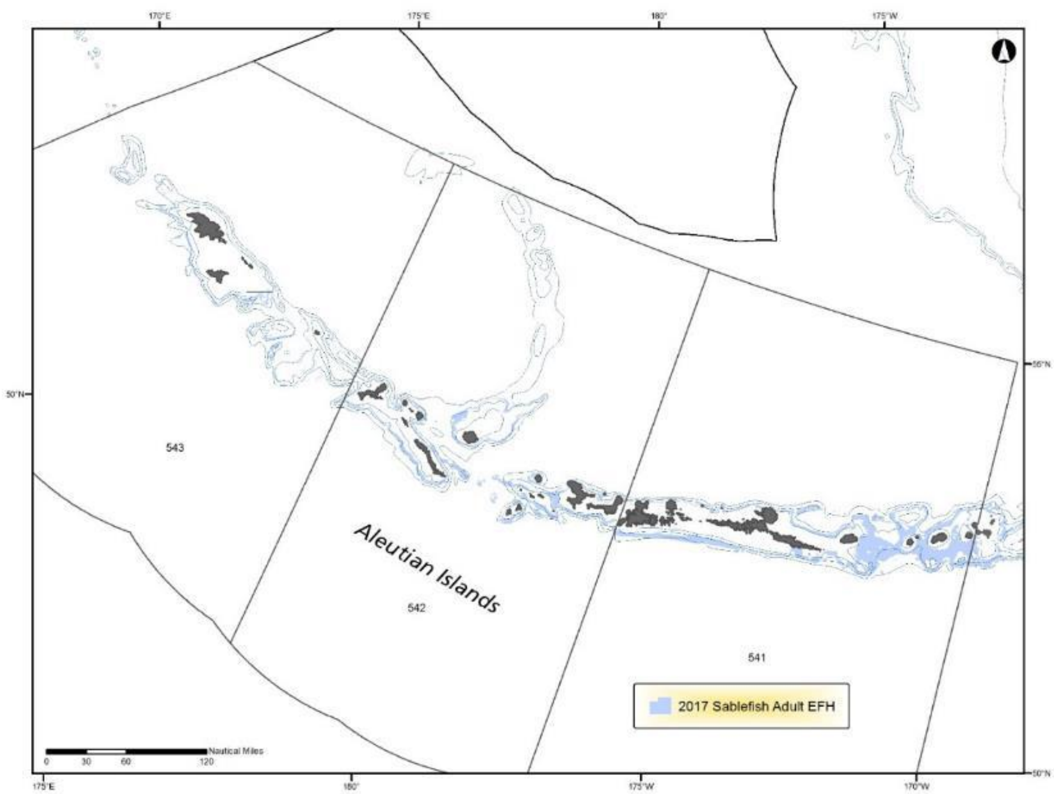
2017 Sablefish Adult EFH
Nautical Miles



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2017 Sablefish Adult EFH
Nautical Miles

Yellowfin Sole

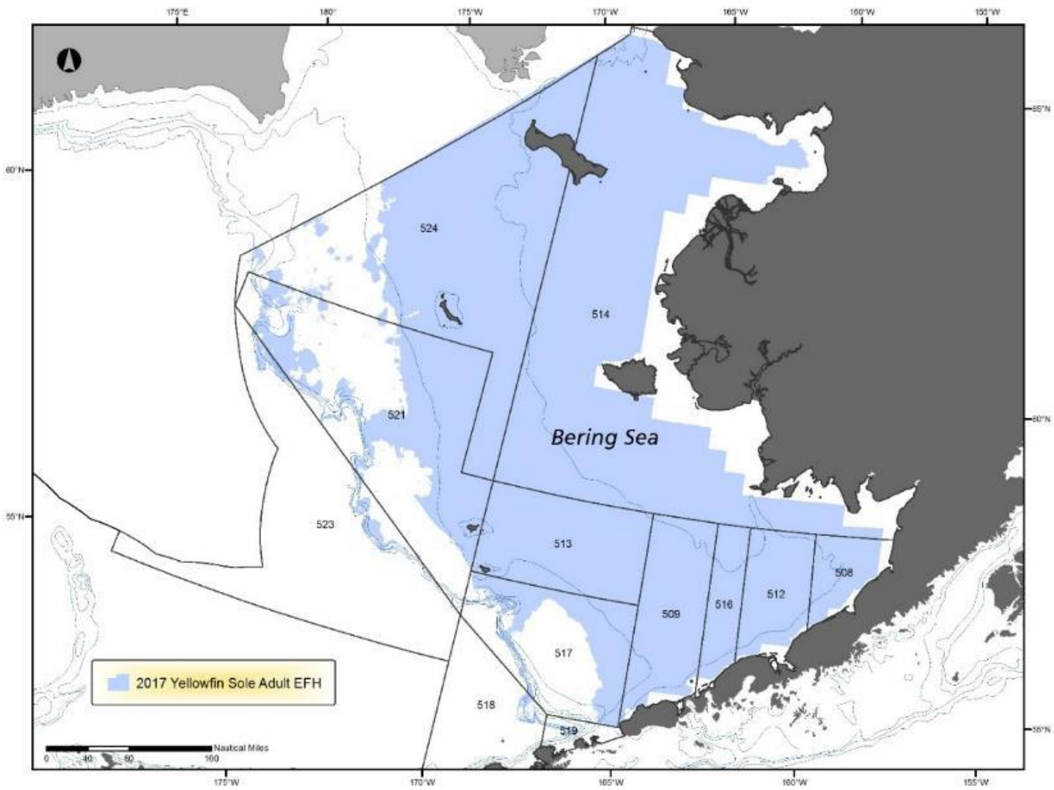
Eggs: EFH for yellowfin sole eggs is the general distribution area for this life stage, found to the limits of inshore ichthyoplankton sampling over a widespread area, to at least as far north as Nunivak Island.

Larvae: EFH for yellowfin sole larvae is the general distribution area for this life stage. Larvae have been found to the limits of inshore ichthyoplankton sampling over a widespread area, to at least as far north as Nunivak Island.

Early Juveniles: EFH for early juvenile yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. Most likely are habitat generalists on abundant physical habitat.

Late Juveniles: EFH for late juvenile yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand.

Adults: EFH for adult yellowfin sole is the general distribution area for this life stage, located in the lower portion of the water column within nearshore bays and along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are soft substrates consisting mainly of sand.



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2017 Yellowfin Sole Adult EFH
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Nautical Miles

Greenland Turbot

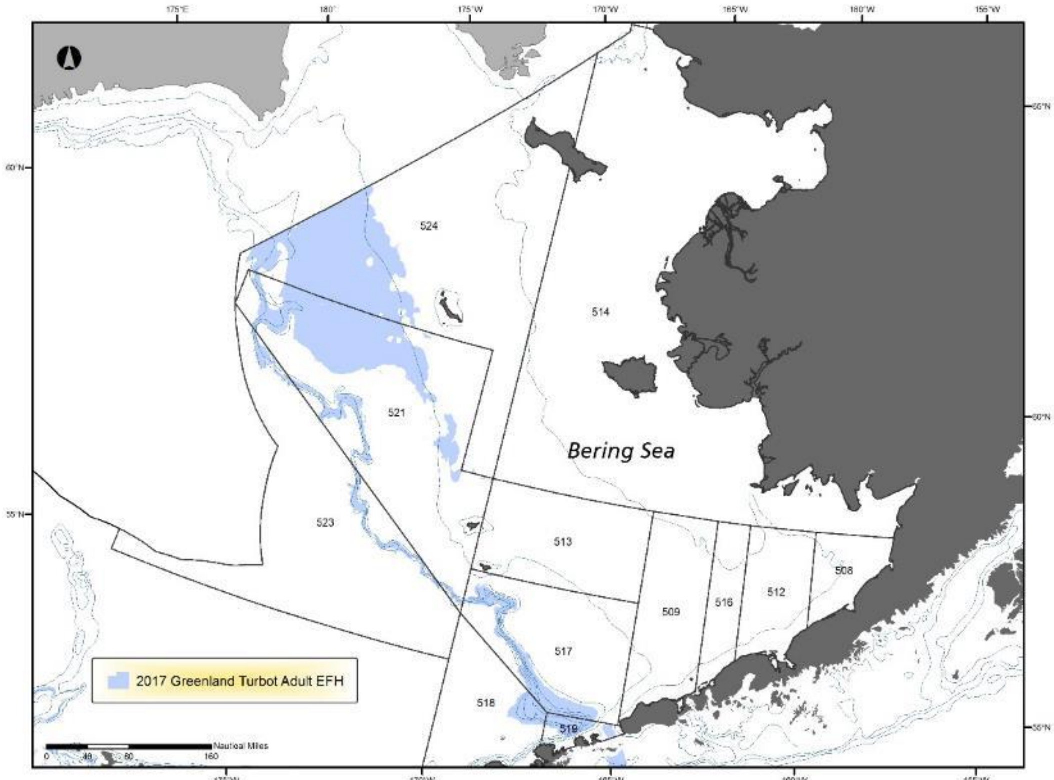
Eggs: EFH for Greenland turbot eggs is the general distribution area for this life stage, located principally in benthypelagic waters along the outer shelf (100 to 200 m) and slope (200 to 3,000 m) throughout the BSAI in the fall.

Larvae: EFH for larval Greenland turbot is the general distribution area for this life stage, located principally in benthypelagic waters along the outer shelf (100 to 200 m) and slope (200 to 3,000 m) throughout the BSAI and seasonally abundant in the spring

Early Juveniles: EFH for early juvenile Greenland turbot is the general distribution area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud.

Late Juveniles: EFH for late juvenile Greenland turbot is the habitat-related density area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud.

Adults: EFH for late adult Greenland turbot is the habitat-related density area for this life stage, located in the lower and middle portion of the water column along the outer shelf (100 to 200 m), upper slope (200 to 500 m), and lower slope (500 to 1,000 m) throughout the BSAI wherever there are softer substrates consisting of mud and sandy mud.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2017 Greenland Turbot Adult EFH
Nautical Miles

Arrowtooth Flounder

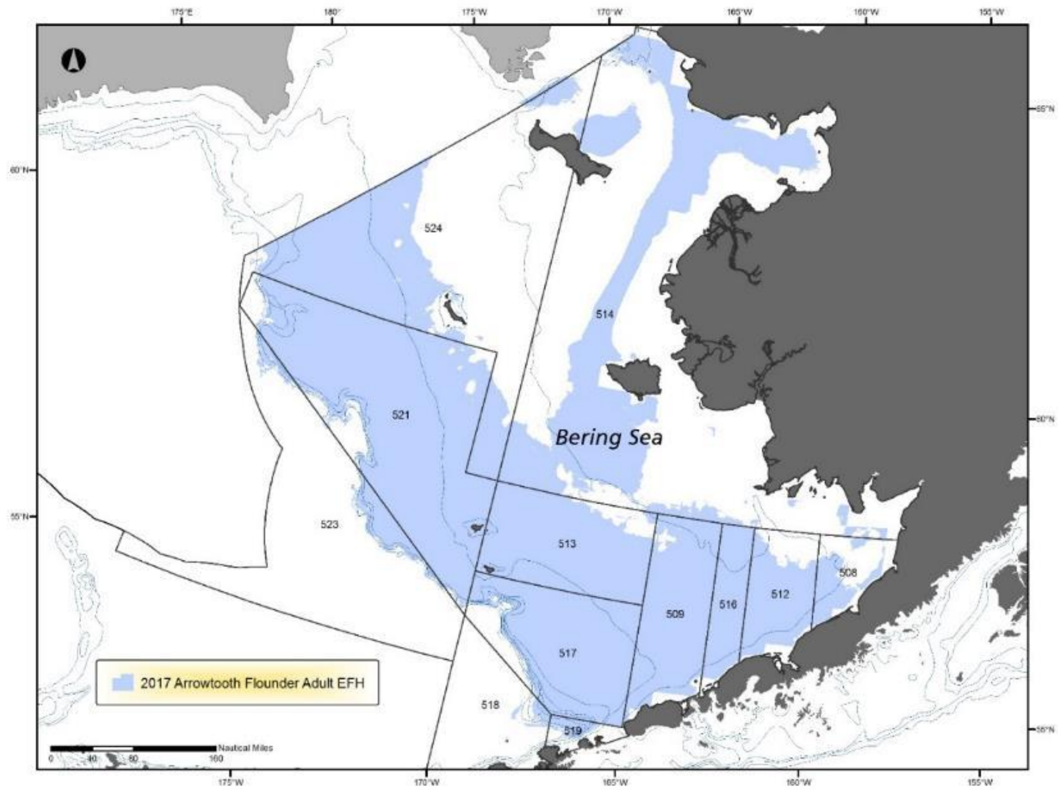
Eggs: EFH for arrowtooth flounder eggs is the general distribution area for this life stage, located in demersal habitat throughout the shelf (0 to 200 m) and upper slope (200 to 500 m).

Larvae: EFH for larval arrowtooth flounder is the general distribution area for this life stage, found in epipelagic waters located in demersal habitat throughout the shelf (0 to 200 m) and upper slope (200 to 500 m).

Early Juveniles: EFH for early juvenile arrowtooth flounder is the general distribution area for this life stage, located in demersal habitat of the inner (0 to 50 m) and middle (50 to 100 m) shelf.

Late Juveniles: EFH for late juvenile arrowtooth flounder is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud.

Adults: EFH for adult arrowtooth flounder is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50), middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud.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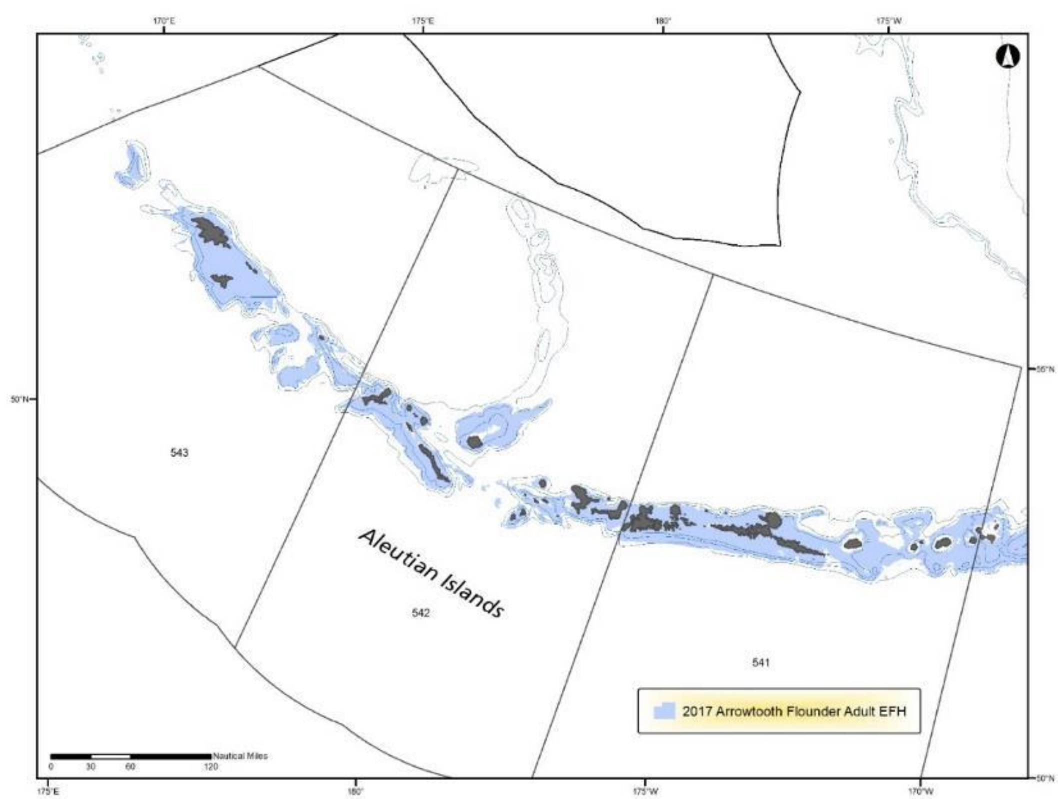
2017 Arrowtooth Flounder Adult EFH
Nautical Miles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2017 Arrowtooth Flounder Adult EFH
Nautical Miles

Kamchatka Flounder

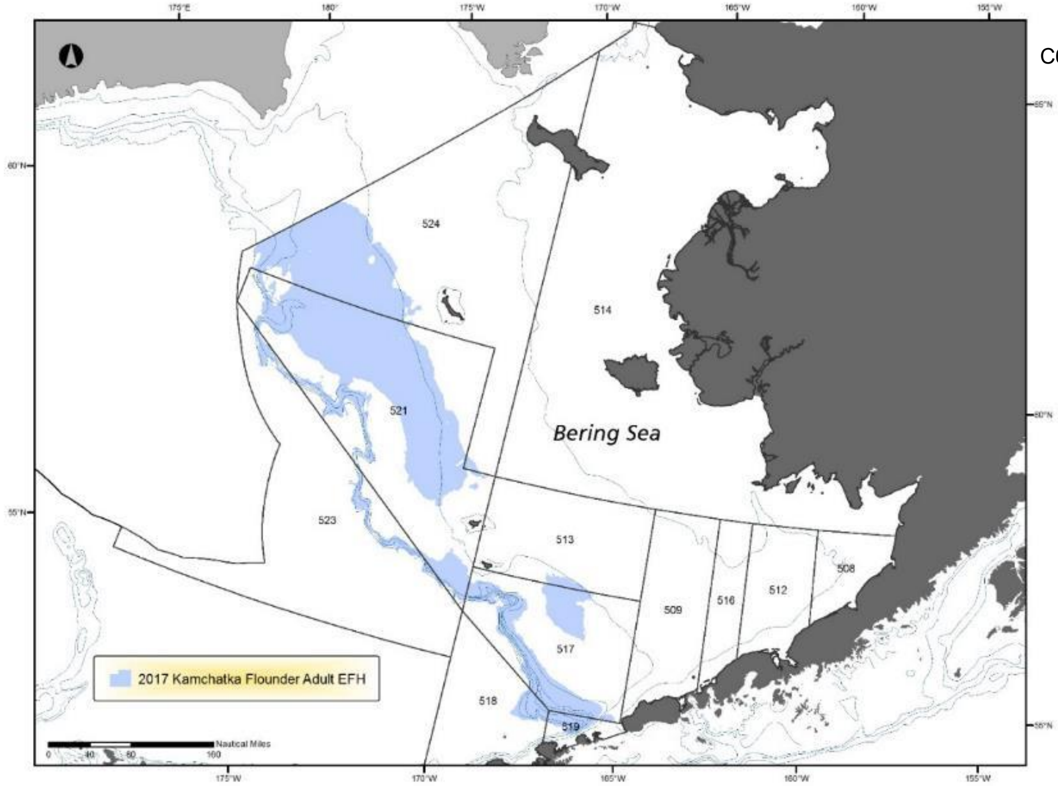
Eggs: EFH for Kamchatka flounder eggs is the general distribution area for this life stage, located in demersal habitat of the middle (50 to 100 m) and outer (100 to 200 m) shelf and upper slope (200 to 500 m).

Larvae: EFH for larval Kamchatka flounder is the general distribution area for this life stage, located in mesopelagic waters in the the middle (50 to 100 m) and outer (100 to 200 m) shelf and upper slope (200 to 500 m). Late stage Kamchatka flounder have been caught at depths of 400 m in the Bering Sea.

Early Juveniles: EFH for early juvenile Kamchatka flounder is the general distribution area for this life stage, located in demersal habitat of the the middle (50 to 100 m) and outer (100 to 200 m) shelf.

Late Juveniles: EFH for late juvenile Kamchatka flounder is the general distribution area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud.

Adults: EFH for adult Kamchatka flounder is the general distribution area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m), and outer (100 to 200 m) shelf and slope waters down to 600 m throughout the BSAI wherever there are softer substrates consisting of gravel, sand, and mud.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2017 Kamchatka Flounder Adult EFH
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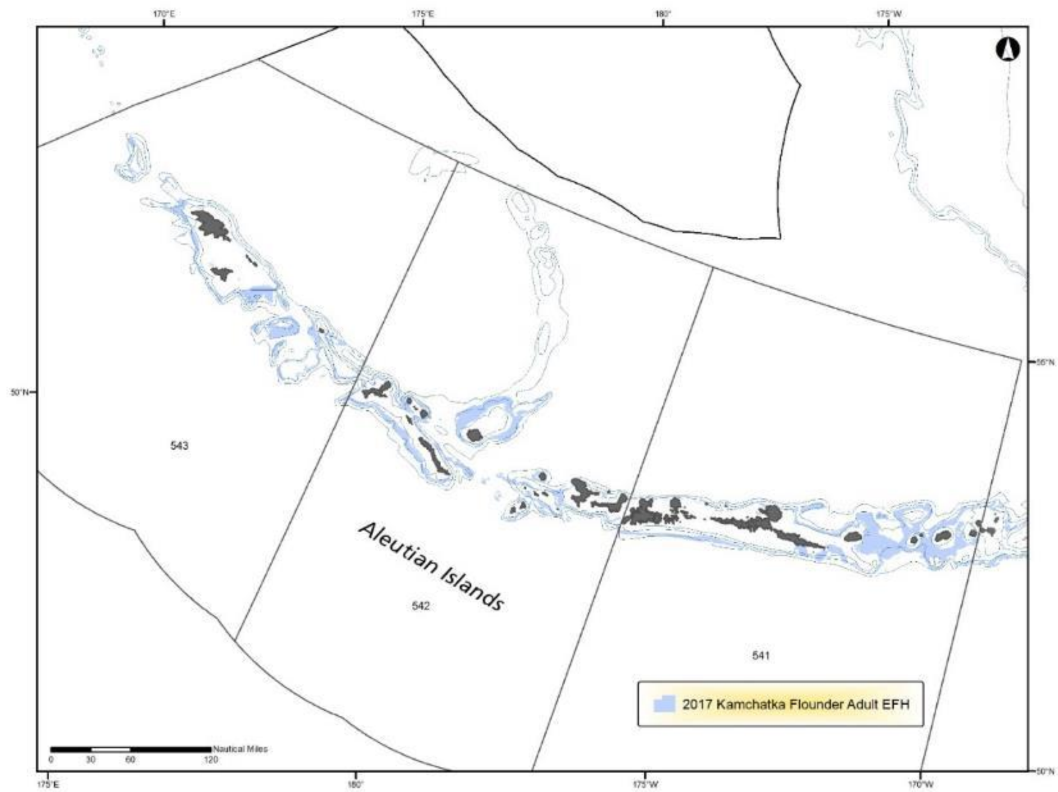
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2017 Kamchatka Flounder Adult EFH
Nautical Miles

Northern

Rock Sole

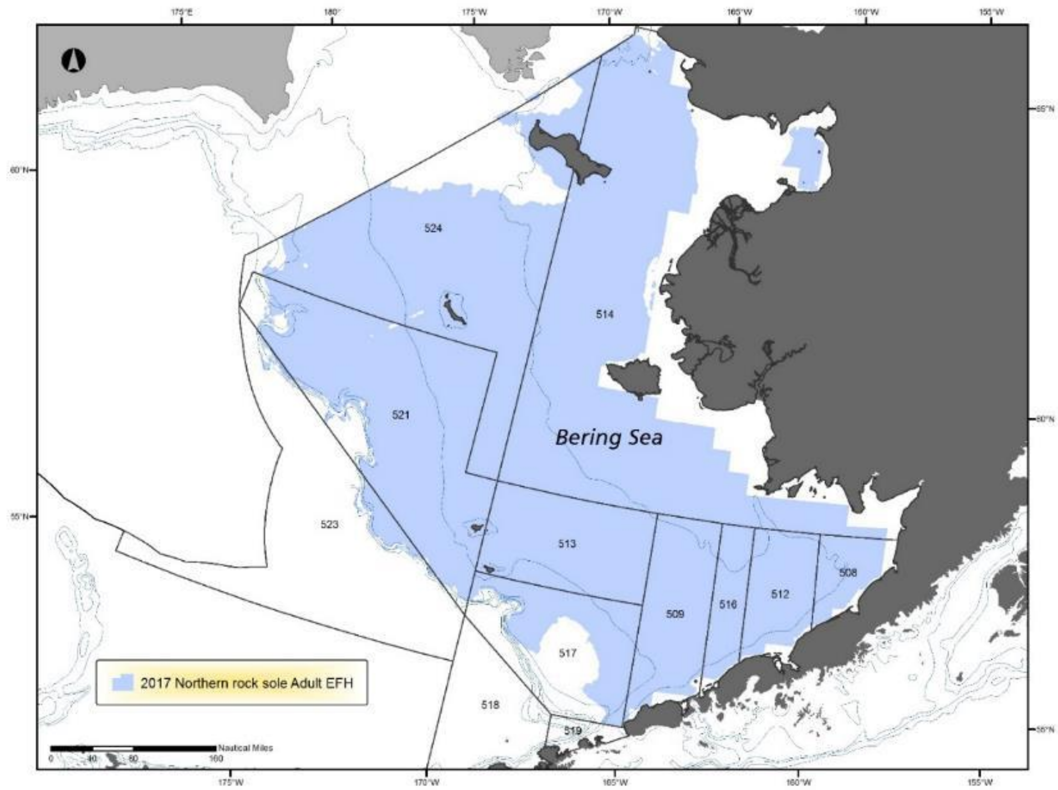
Eggs: No EFH description determined. Insufficient information is available.

Larvae: EFH for larval northern rock sole is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and upper slope (200 to 1,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand, gravel, and cobble. Upon settlement in nearshore areas from 1-40 m deep, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection but may be prevented from settling inshore by the seasonal inner front. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15-20 cm. Most likely are habitat generalists on abundant physical habitat.

Late Juveniles: EFH for late juvenile northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand, gravel, and cobble.

Adults: EFH for adult northern rock sole is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand, gravel, and cobble.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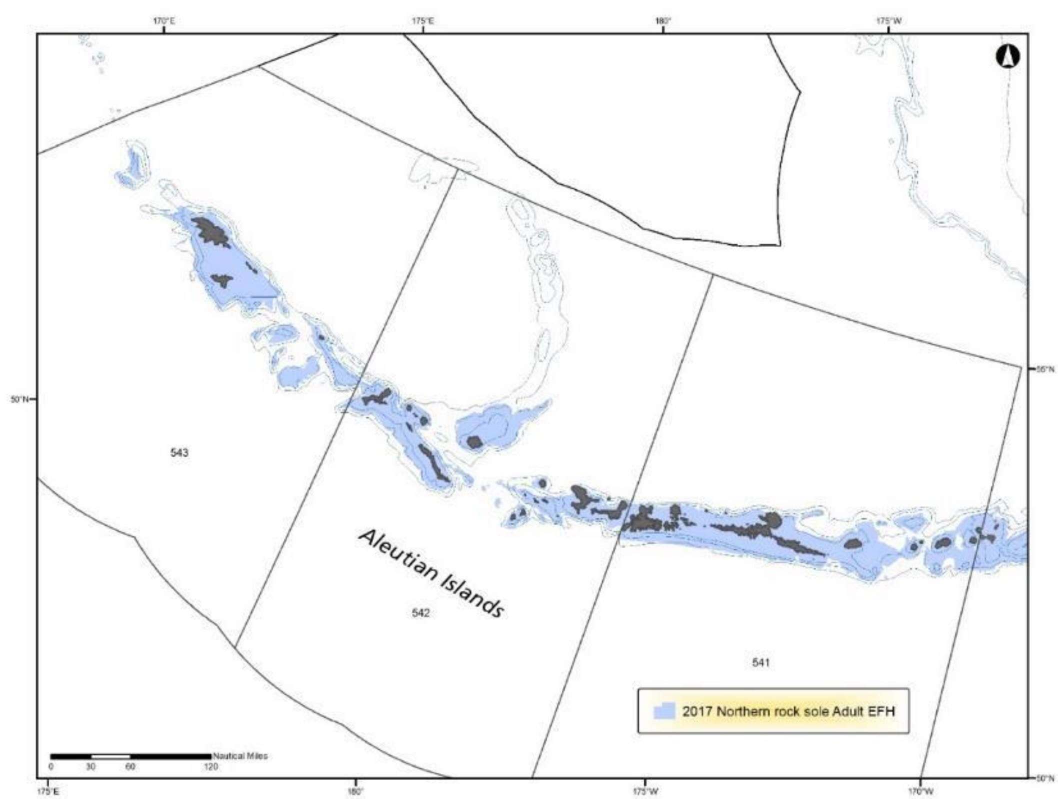
2017 Northern rock sole Adult EFH
Nautical Miles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2017 Northern rock sole Adult EFH
Nautical Miles

Alaska Plaice

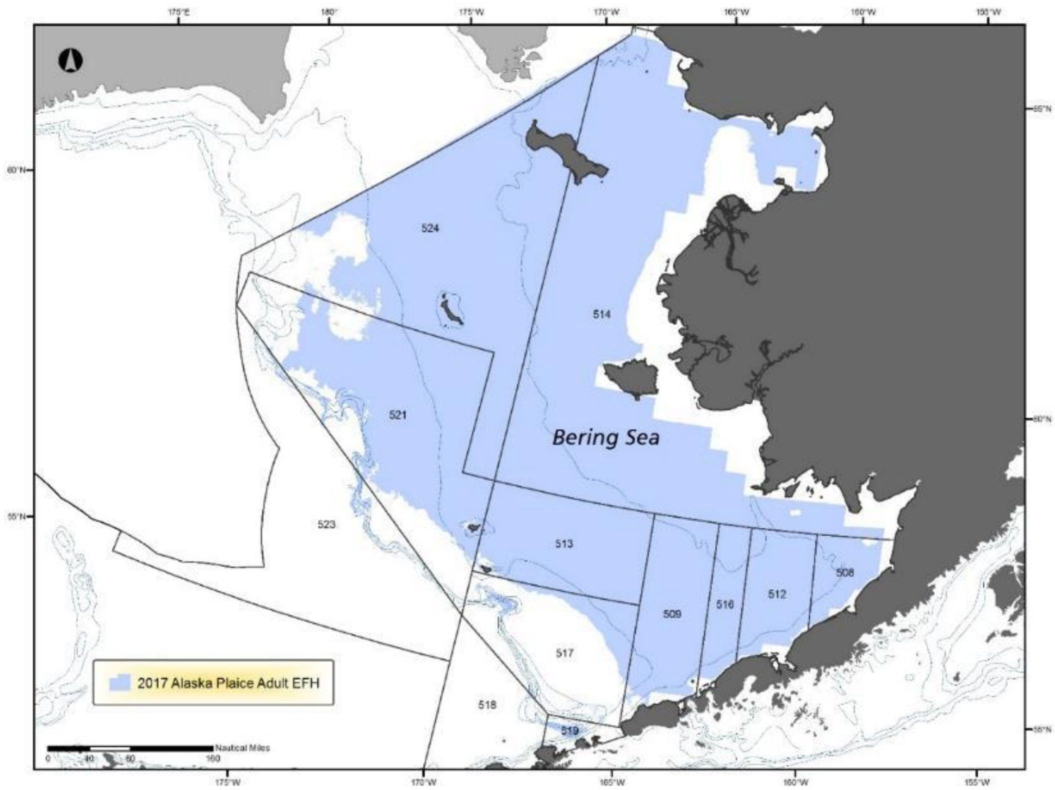
Eggs: EFH for Alaska plaice eggs is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and upper slope (200 to 500 m) throughout the BSAI in the spring.

Larvae: EFH for Alaska plaice larvae is the general distribution area for this life stage. Pelagic larvae are primarily collected from depths greater than 200 m, with the majority occurring over bottom depths ranging from 50 to 100 m. Densities of preflexion stage larvae are concentrated at depths 10 to 20 m.

Early Juveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: EFH for late juvenile Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud.

Adults: EFH for adult Alaska plaice is the general distribution area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud.



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2017 Alaska Plaice Adult EFH
Nautical Miles

Rex Sole

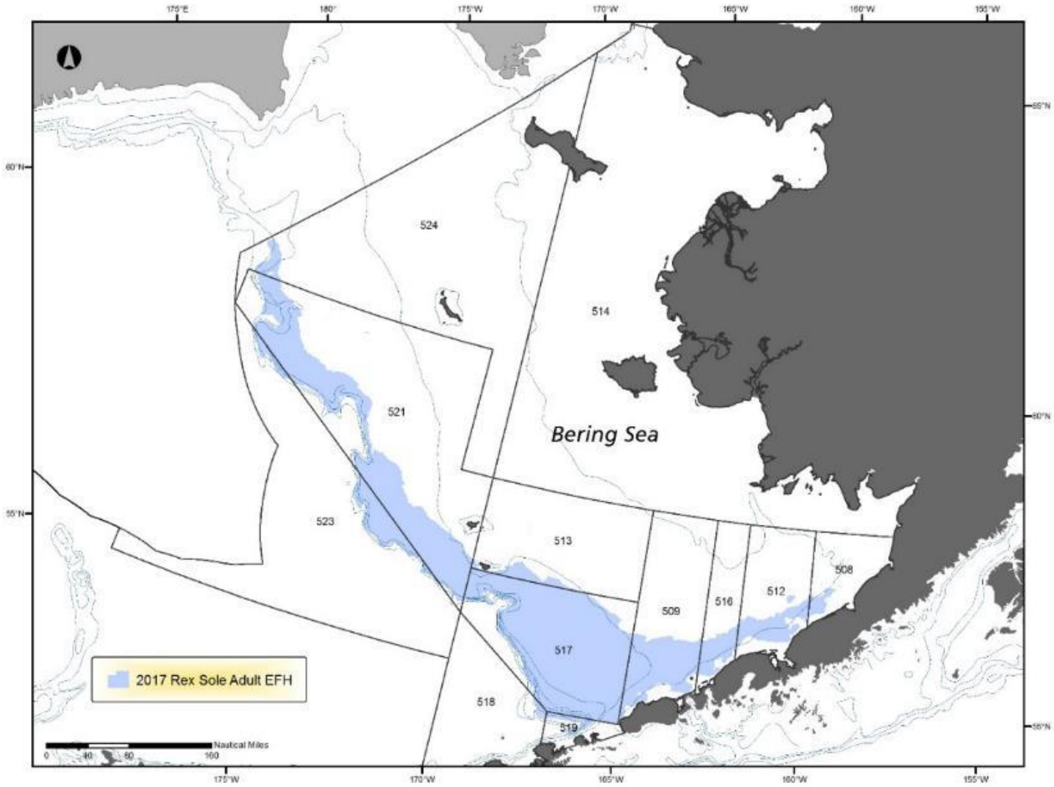
Eggs: EFH for rex sole eggs is the general distribution area for this life stage, located in epipelagic waters throughout the shelf (0 to 200 m) and upper slope (200 to 300 m).

Larvae: EFH for larval rex sole is the general distribution area for this life stage, located in epipelagic waters throughout the shelf (0 to 200 m) and upper slope (200 to 300 m).

Early Juveniles: EFH for early juvenile rex sole is the general distribution area for this life stage, located in demersal habitat of the inner (0 to 50 m) and middle (50 to 100 m) shelf.

Late Juveniles: EFH for late juvenile rex sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are substrates consisting of gravel, sand, and mud.

Adults: EFH for adult rex sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are substrates consisting of gravel, sand, and mud.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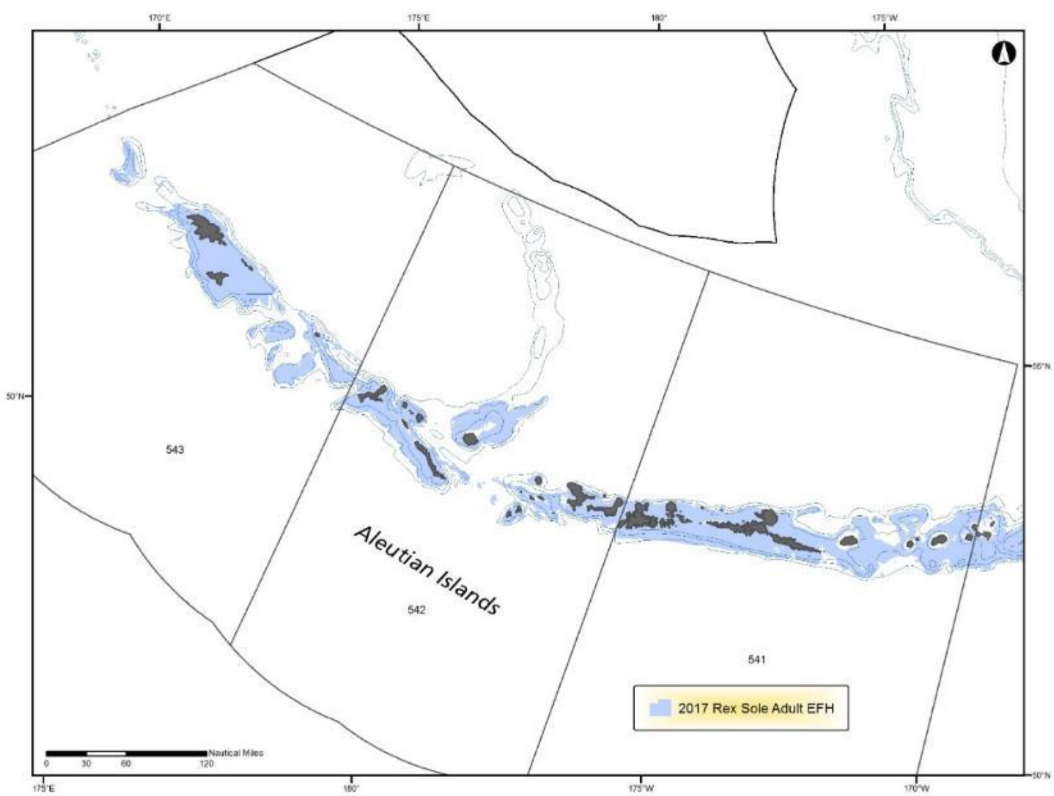
2017 Rex Sole Adult EFH
Nautical Miles


Aleutian Islands
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2017 Rex Sole Adult EFH
Nautical Miles

Dover Sole

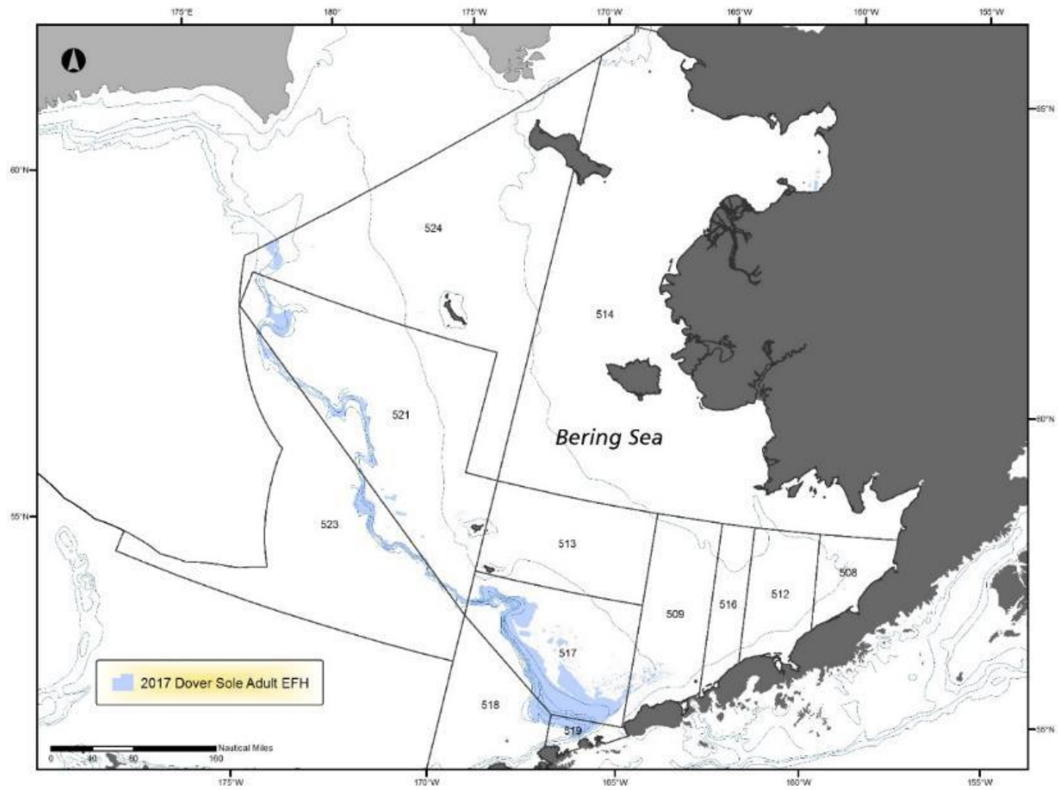
Eggs: EFH for Dover sole eggs is the general distribution area for this life stage, located in epipelagic waters throughout the shelf (0 to 200 m) and upper slope (200 to 500 m).

Larvae: EFH for larval Dover sole is the general distribution area for this life stage, located in epipelagic waters throughout the shelf (0 to 200 m) and upper slope (200 to 500 m).

Early Juveniles: EFH for early juvenile Dover sole is the general distribution area for this life stage, located in demersal habitat of the inner (0 to 50 m) and middle (50 to 100 m) shelf.

Late Juveniles: EFH for late juvenile Dover sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m), and outer (100 to 200 m) shelf and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates consisting of sand and mud.

Adults: EFH for adult Dover sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle (50 to 100 m) and outer (100 to 200 m) shelf, and upper (200 to 500 m) and intermediate (500 to 1000 m) slope throughout the BSAI wherever there are substrates consisting of sand and mud.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2017 Dover Sole Adult EFH
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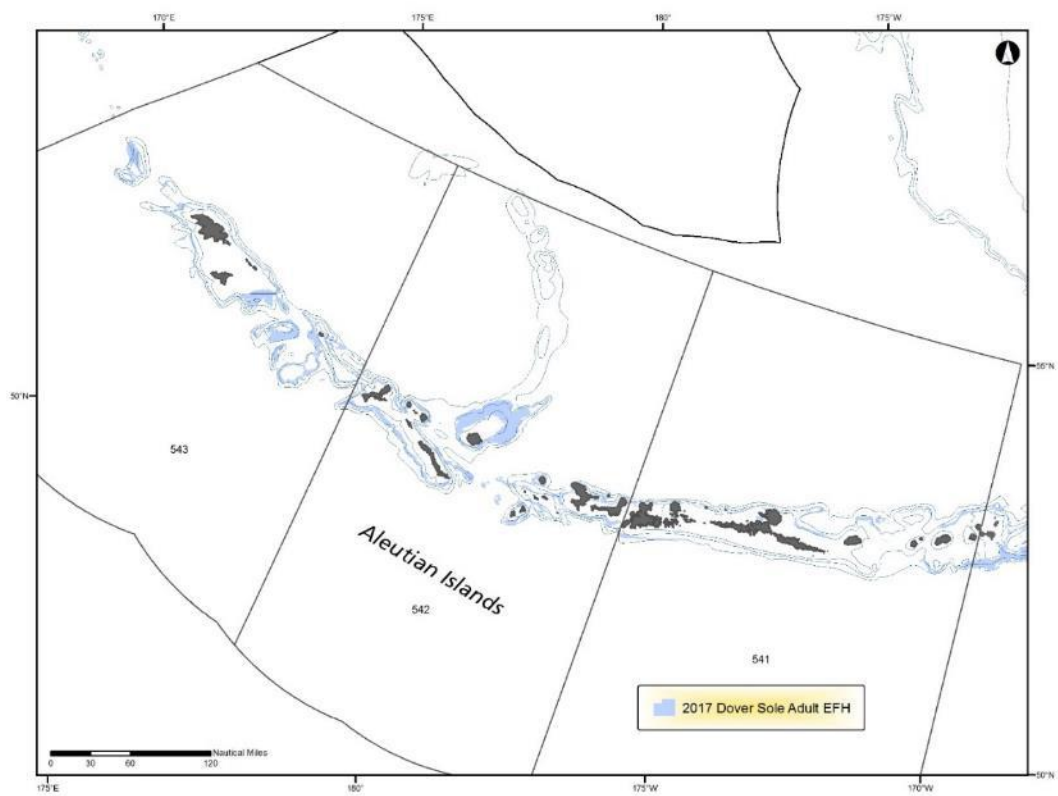
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Aleutian Islands
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2017 Dover Sole Adult EFH
Nautical Miles

Flathead Sole

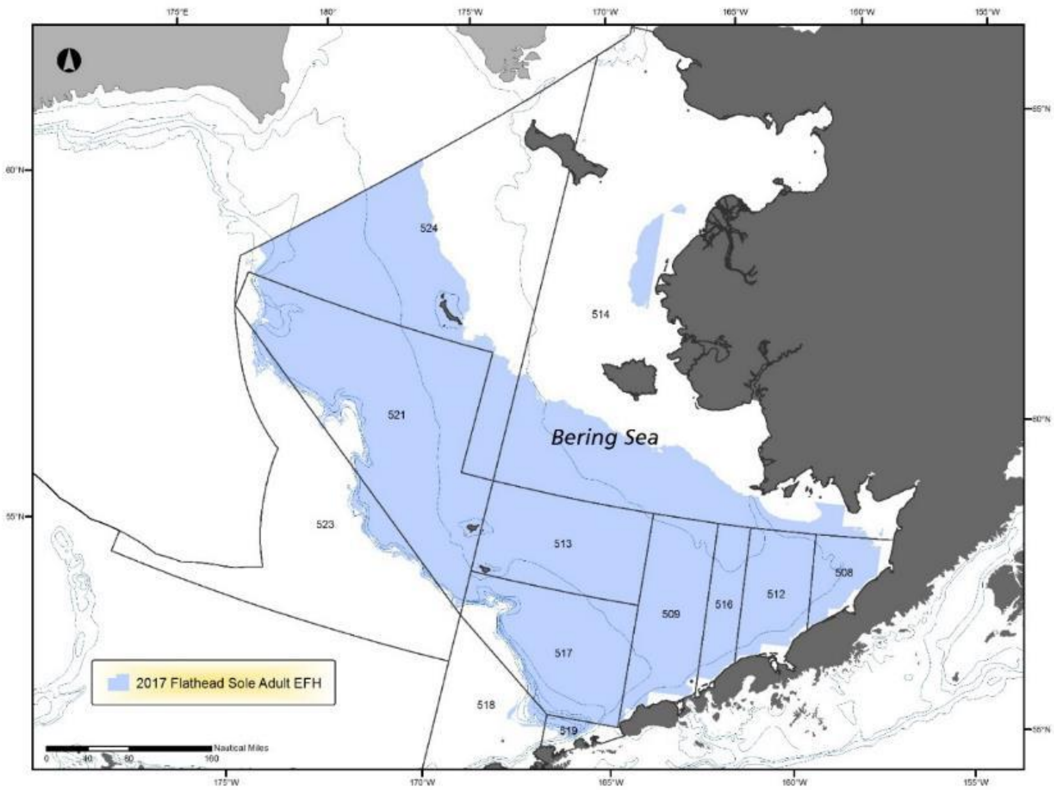
Eggs: EFH for flathead sole eggs is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the BSAI in the spring.

Larvae: EFH for larval flathead sole is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile flathead sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m) and middle (50 to 100 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud.

Late Juveniles: EFH for late juvenile flathead sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud.

Adults: EFH for adult flathead sole is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m), and outer (100 to 200 m) shelf throughout the BSAI wherever there are softer substrates consisting of sand and mud.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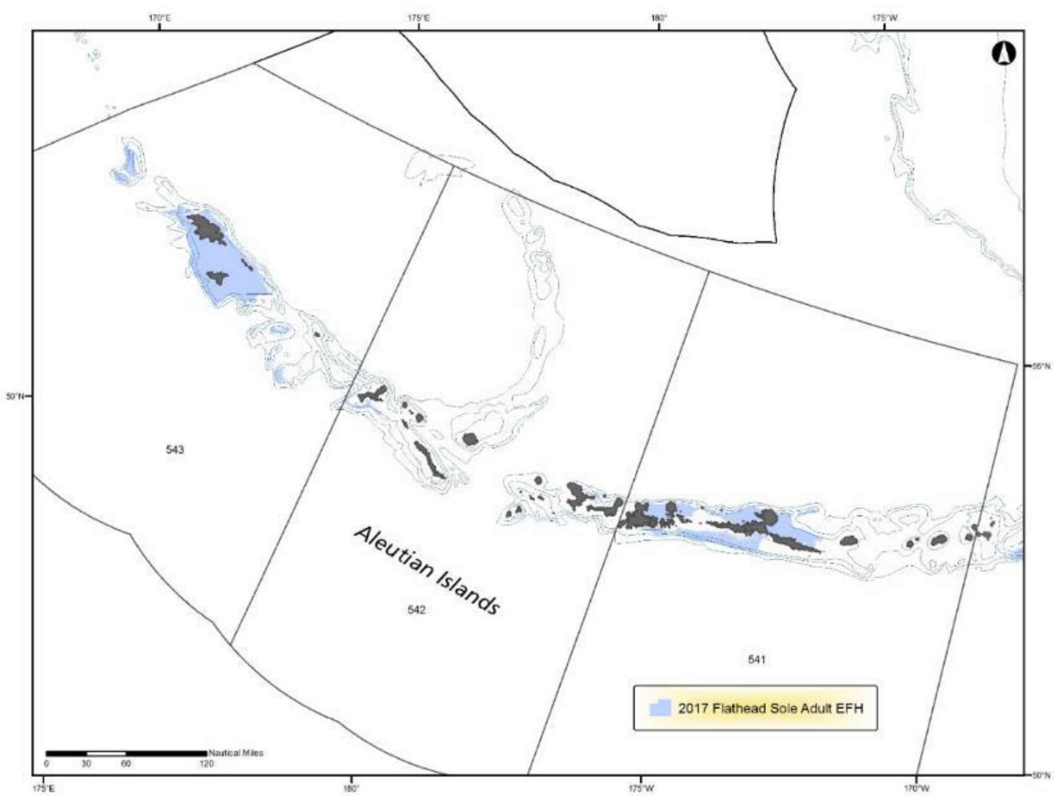
2017 Flathead Sole Adult EFH
Nautical Miles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2017 Flathead Sole Adult EFH
Nautical Miles

Pacific Ocean Perch

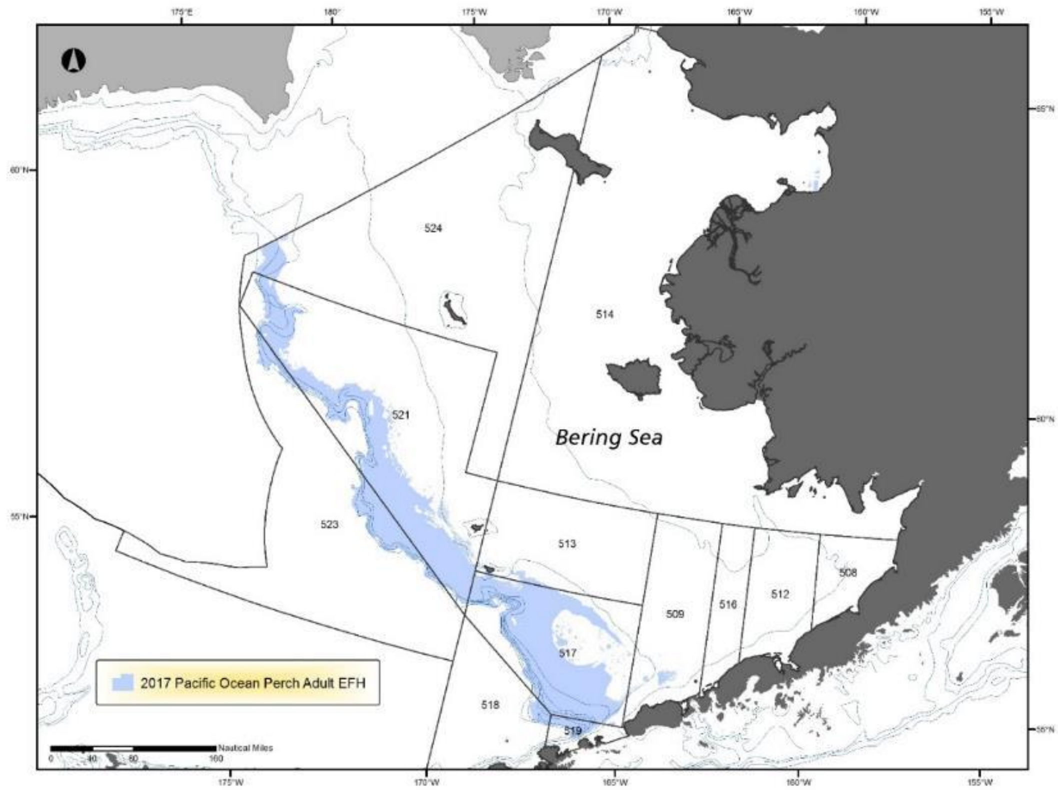
Eggs: EFH for Pacific ocean perch eggs is the general distribution area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m).

Larvae: EFH for larval Pacific ocean perch is the general distribution area for this life stage, located in pelagic waters along the middle and outer shelf (50 to 200 m) and slope (200 to 3,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile Pacific ocean perch is the general distribution area for this life stage, located throughout the water column along the entire shelf (0 to 200 m).

Late Juveniles: EFH for late juvenile Pacific ocean perch is the habitat-related density area for this life stage, located in the middle to lower portion of the water column along middle shelf (50 to 100 m), outer shelf (100 to 200 m), and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates consisting of boulders, cobble, gravel, mud, sandy mud, or muddy sand.

Adults: EFH for adult Pacific ocean perch is the habitat-related density area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates consisting of cobble, gravel, mud, sandy mud, or muddy sand.


524
514
521
Bering Sea
523
513
508
509
516
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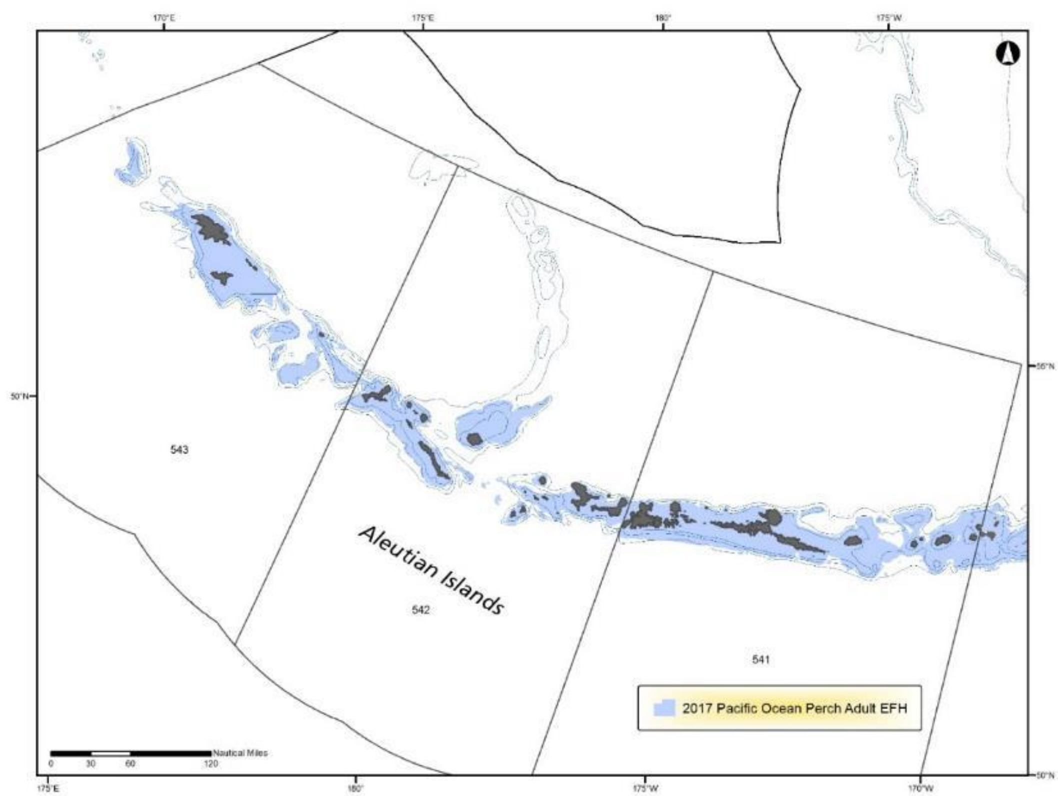
517
518
519
2017 Pacific Ocean Perch Adult EFH
Nautical Miles


543
Aleutian Islands
542
541
2017 Pacific Ocean Perch Adult EFH
Nautical Miles

Northern Rockfish

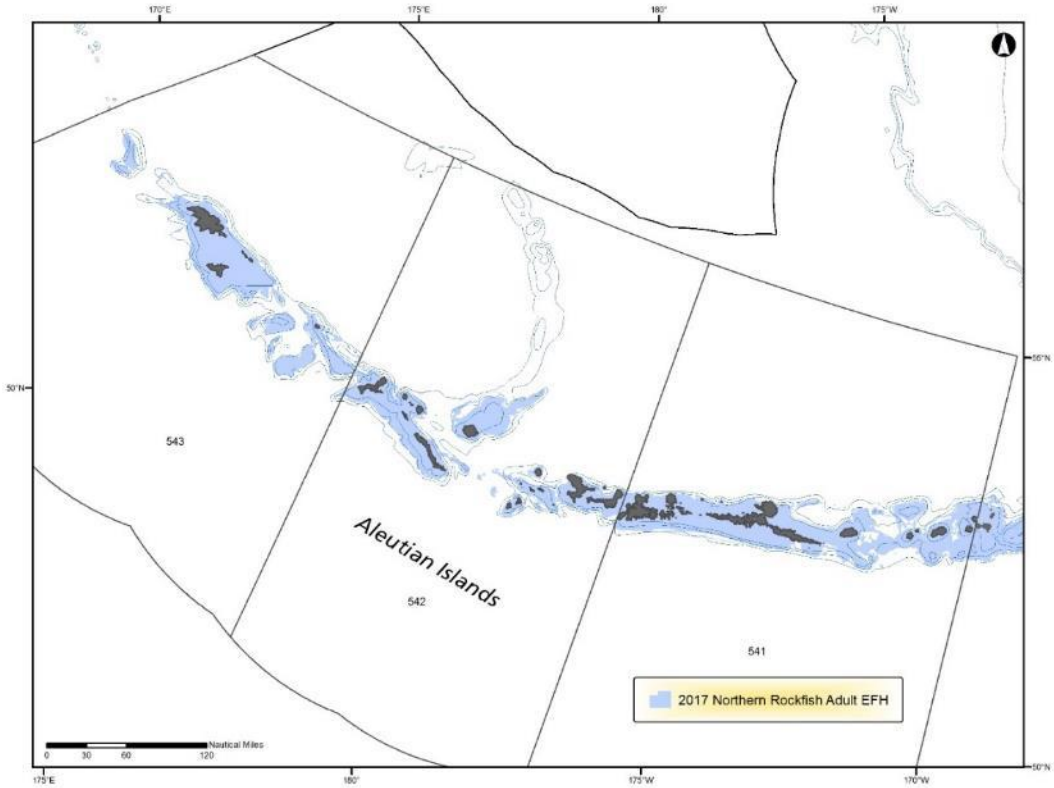
Eggs: EFH for northern rockfish eggs is the general distribution area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m).

Larvae: EFH for larval northern rockfish is the general distribution area for this life stage, located in pelagic waters along the middle and outer shelf (50 to 200 m) and slope (200 to 3,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile northern rockfish is the general distribution area for this life stage, located throughout the water column along the entire shelf (0 to 200 m).

Late Juveniles: EFH for late juvenile northern rockfish is the habitat-related density area for this life stage, located in the middle and lower portions of the water column along the outer shelf (100 to 200 m) throughout the BSAI, wherever there are substrates of cobble and rock.

Adults: EFH for adult northern rockfish is the habitat-related density area for this life stage, located in the middle and lower portions of the water column along the outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates of cobble and rock.


170°E
175°E
180°
175°W
55°N
50°N
543
542
541
Aleutian Islands
2017 Northern Rockfish Adult EFH
Nautical Miles
0
30
60
120
175°E
180°
175°W
170°W
50°N

Shortraker Rockfish

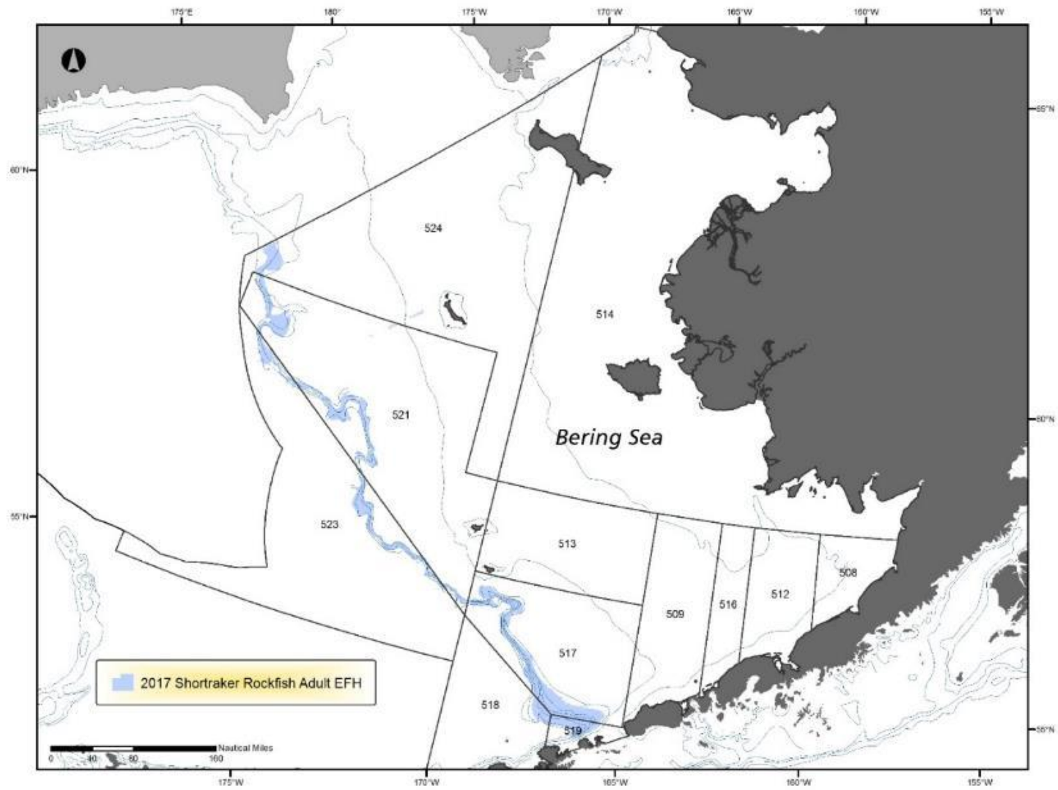
Eggs: EFH for shortraker rockfish eggs is the general distribution area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m).

Larvae: EFH for larval shortraker rockfish is the general distribution area for this life stage, located in pelagic waters along the middle and outer shelf (50 to 200 m) and slope (200 to 3,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile shortraker rockfish is the general distribution area for this life stage, located in pelagic waters throughout the middle and outer (50 to 200 m) shelf and slope (200 to 3,000 m).

Late Juveniles: EFH for late juvenile shortraker rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel.

Adults: EFH for adult shortraker rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel.


524
514
521
Bering Sea
523
513
508
509
516
512
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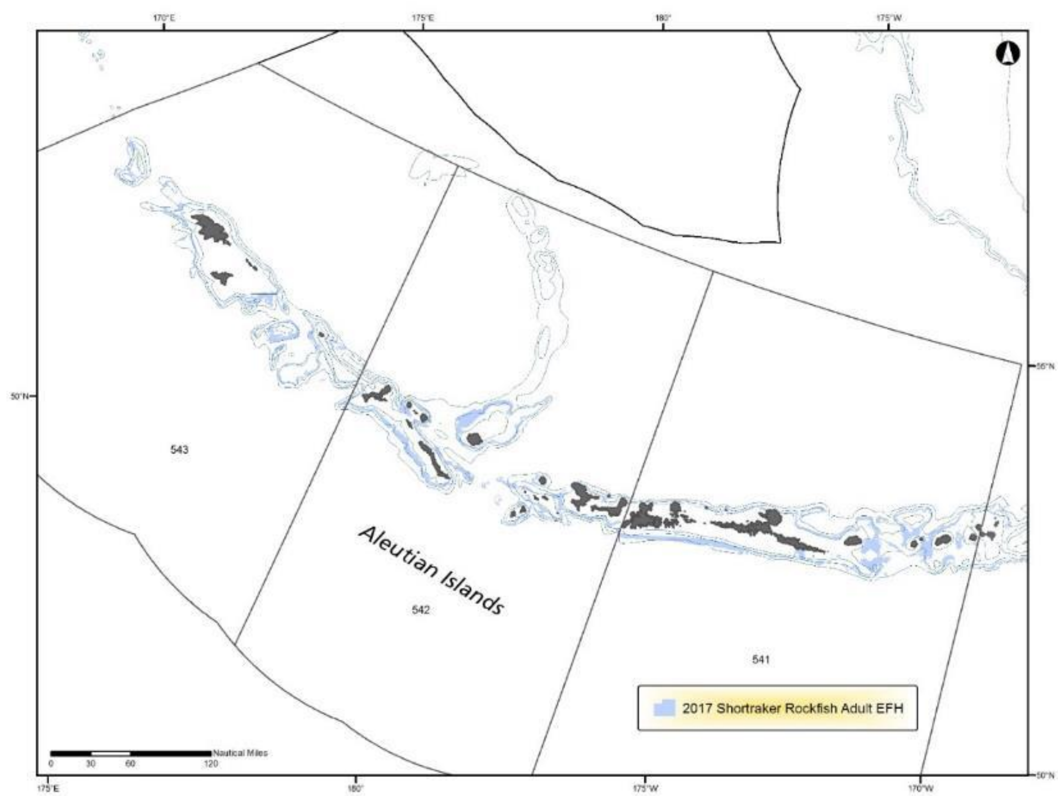
519
2017 Shortraker Rockfish Adult EFH
Nautical Miles


543
Aleutian Islands
542
541
2017 Shortraker Rockfish Adult EFH
Nautical Miles

Blackspotted and Rougheye Rockfishes

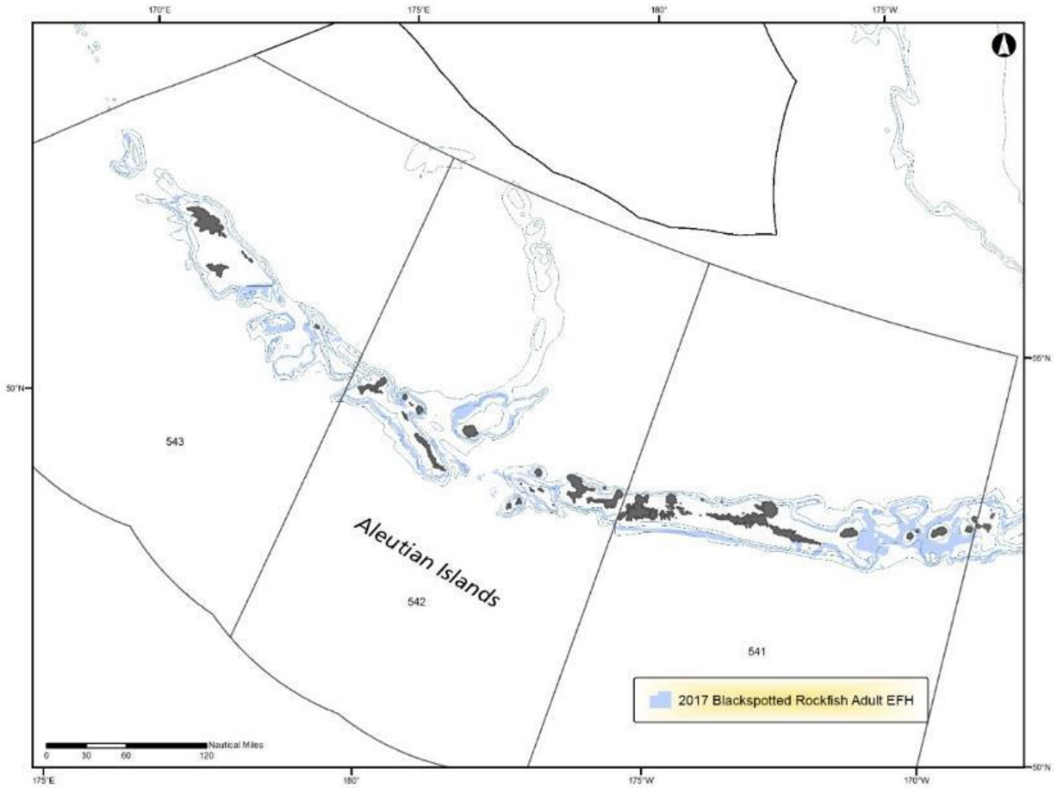
Eggs: EFH for blackspotted/rougheye rockfish eggs is the general distribution area for this life stage, located in the lower portion of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m).

Larvae: EFH for larval blackspotted/rougheye rockfish is the general distribution area for this life stage, located in pelagic waters along the middle and outer shelf (50 to 200 m) and slope (200 to 3,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile blackspotted/rougheye rockfish is the general distribution area for this life stage, located in pelagic waters throughout the middle and outer (50 to 200 m) shelf and slope (200 to 3,000 m).

Late Juveniles: EFH for late juvenile blackspotted/rougheye rockfish is the general distribution area for this life stage, located in the lower portion of the water column along the upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel

Adults: EFH for adult blackspotted/rougheye rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the upper slope (200 to 500 m) regions throughout the BSAI wherever there are substrates consisting of mud, sand, sandy mud, muddy sand, rock, cobble, and gravel.


170°E
175°E
180°
175°W
50°N
55°N
543
542
541
Aleutian Islands
2017 Blackspotted Rockfish Adult EFH
Nautical Miles
0
30
60
120
175°E
180°
175°W
170°W
50°N

Other Rockfish

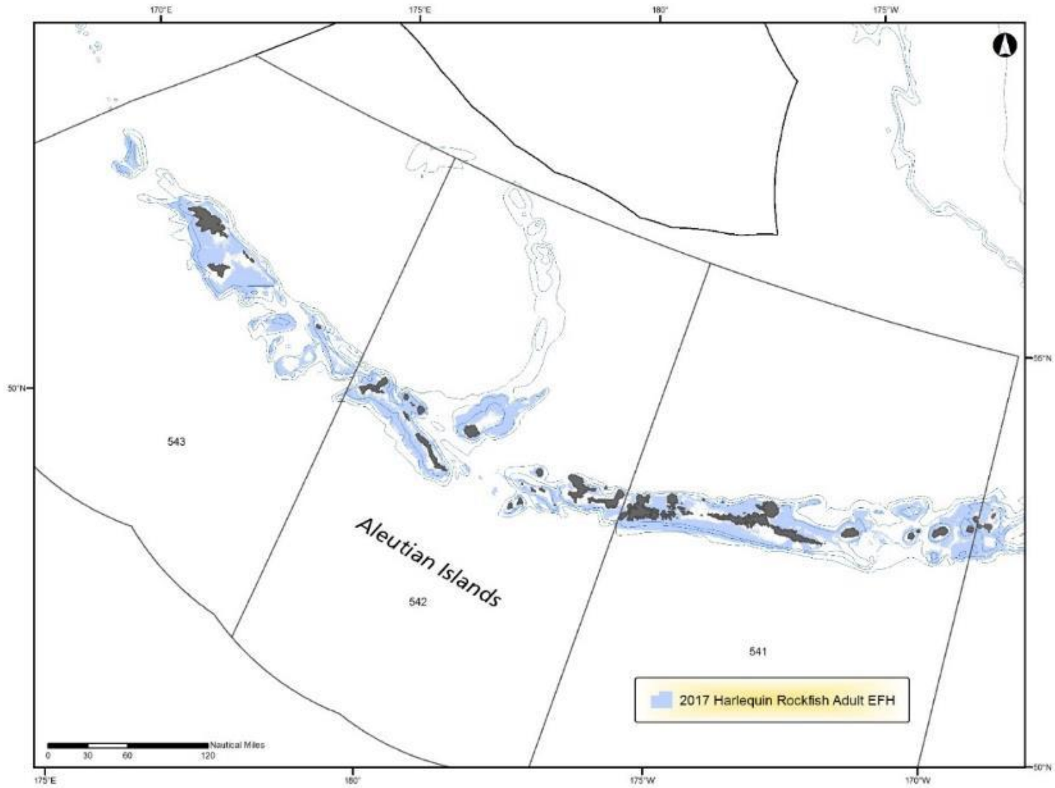
Eggs: EFH for dusky rockfish eggs is the general distribution area for this life stage, located in the middle and lower portions of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m).

Larvae: EFH for larval dusky rockfish is the general distribution area for this life stage, located in the pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the BSAI.

Early Juveniles: EFH for early juvenile dusky rockfish is the general distribution area for this life stage, located in the pelagic waters along the entire shelf (0 to 200 m) and slope (200 to 3,000 m) throughout the BSAI

Late Juveniles: EFH for late juvenile dusky rockfish is the habitat-related density area for this life stage, located in the middle and lower portions of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates of cobble, rock, and gravel

Adults: EFH for adult dusky rockfish is the habitat-related density area for this life stage, located in the middle and lower portions of the water column along the outer shelf (100 to 200 m) and upper slope (200 to 500 m) throughout the BSAI wherever there are substrates of cobble, rock, and gravel.



Aleutian Islands
543
542
541
2017 Harlequin Rockfish Adult EFH
Nautical Miles

Shortspine Thornyhead Rockfish

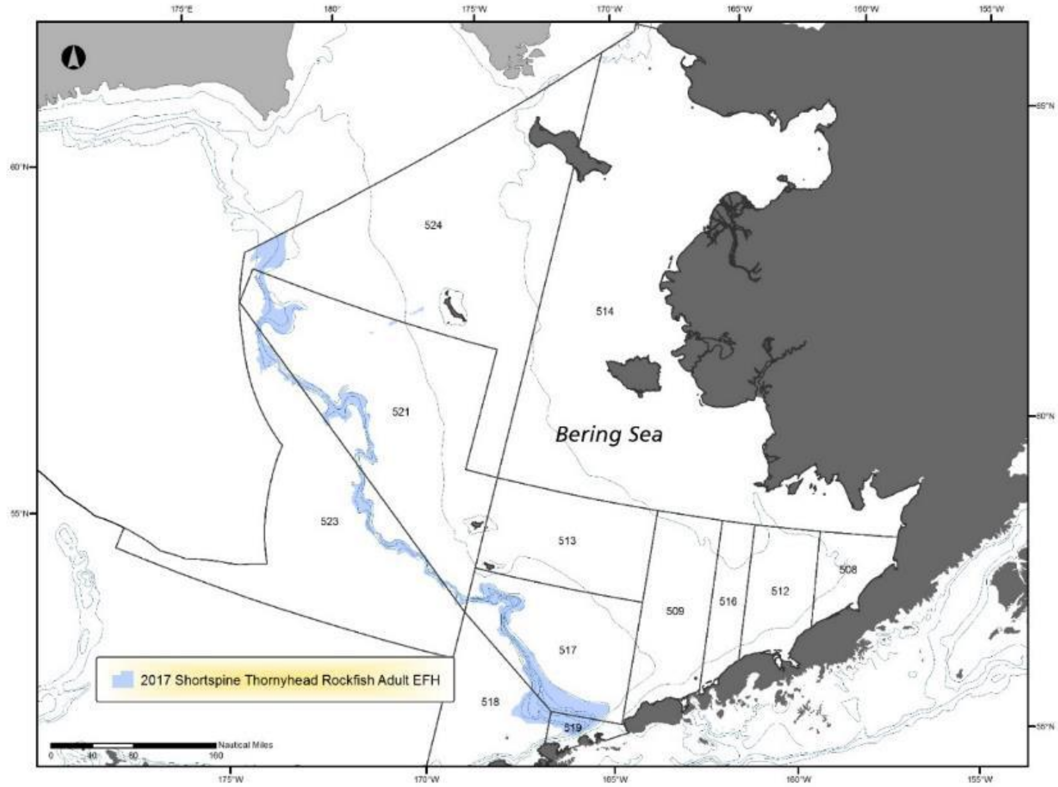
Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: EFH for early juvenile thornyhead rockfish is the habitat-related density area for this life stage, located in epipelagic waters along the middle and outer shelf (50 to 200 m) and upper to lower slope (200 to 1,000 m) throughout the BSAI.

Late Juveniles: EFH for late juvenile thornyhead rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle and outer shelf (50 to 200 m) and upper to lower slope (200 to 1,000 m) throughout the BSAI wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel.

Adults: EFH for adult thornyhead rockfish is the habitat-related density area for this life stage, located in the lower portion of the water column along the middle and outer shelf (50 to 200 m) and upper to lower slope (200 to 1,000 m) throughout the BSAI wherever there are substrates of mud, sand, rock, sandy mud, muddy sand, cobble, and gravel.


Bering Sea
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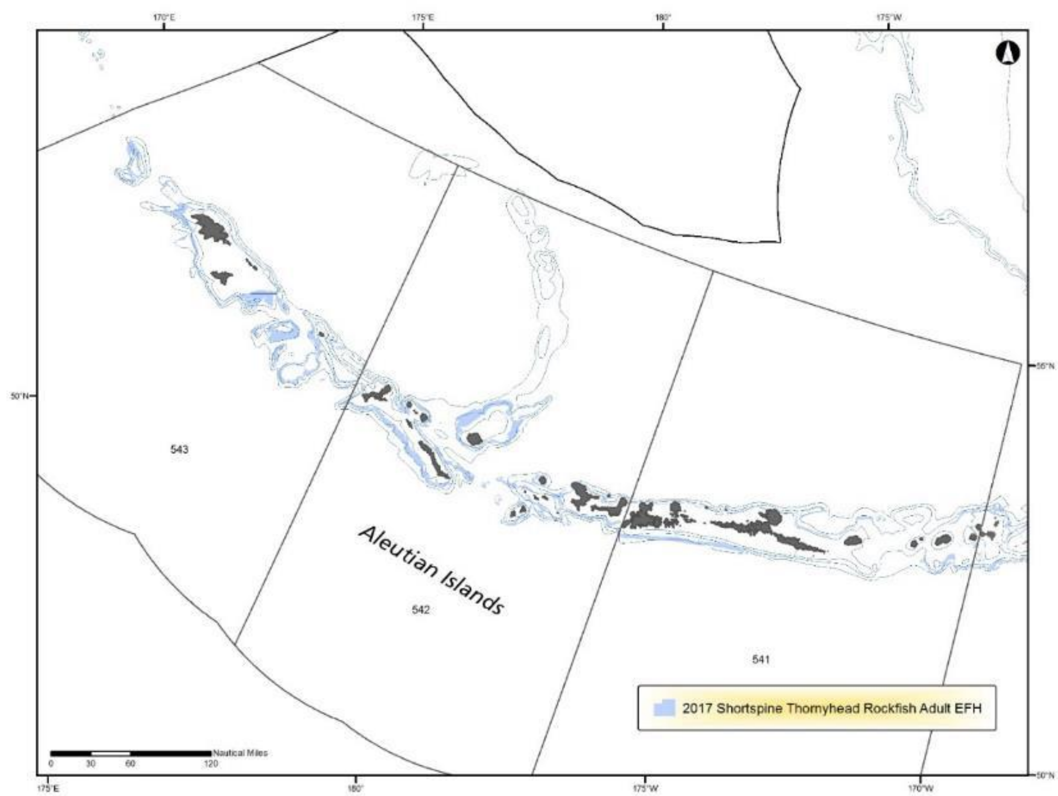
512
508
2017 Shortspine Thornyhead Rockfish Adult EFH
Nautical Miles


Aleutian Islands
543
542
541
2017 Shortspine Thornyhead Rockfish Adult EFH
Nautical Miles

Atka Mackerel

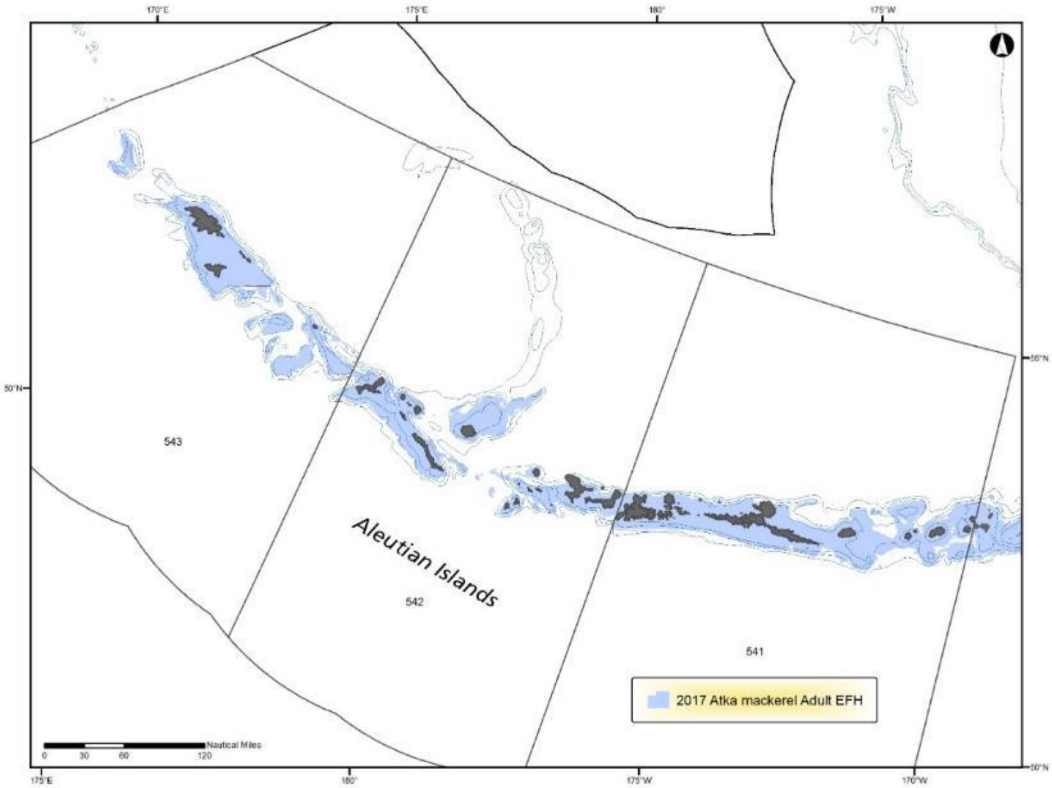
Eggs: EFH for Atka mackerel eggs is the general distribution area for this life stage, located in demersal habitat along the shelf (0 to 200 m). There are widespread observations of nesting sites throughout the Aleutian Islands; however observations are not complete for the entire area.

Larvae: EFH for larval Atka mackerel is the general distribution area for this life stage, located in epipelagic waters along the shelf (0 to 200 m), upper slope (200 to 500 m), and intermediate slope (500-1000 m) throughout the BSAI.

Early Juveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: EFH for late juvenile Atka mackerel is the general distribution area for this life stage, located in the entire water column, from sea surface to the sea floor, along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates of gravel and rock and in vegetated areas of kelp

Adults: EFH for adult Atka mackerel is the habitat-related density area for this life stage, located in the entire water column, from sea surface to the sea floor, along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates of gravel and rock and in vegetated areas of kelp. Habitat-related densities of Atka mackerel are available, usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift.


170°E
175°E
180°
175°W
55°N
50°N
543
542
541
Aleutian Islands
2017 Atka mackerel Adult EFH
Nautical Miles
0 30 60 120
175°E
180°
175°W
170°W

Squid

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

EarlyJuveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: EFH for older juvenile squid is the general distribution area for this life stage, located in the entire water column, from the sea surface to seafloor along the inner (0 to 50 m), middle (50 to 100 m), and outer (200 to 500 m) shelf and the entire slope (500 to 1,000 m) throughout the BSAI.

Adults: EFH for adult squid is the general distribution area for this life stage, located in the entire water column, from the sea surface to sea floor, along the inner (0 to 50 m), middle (50 to 100 m), and outer (200 to 500 m) shelf and the entire slope (500 to 1,000 m) throughout the BSAI.

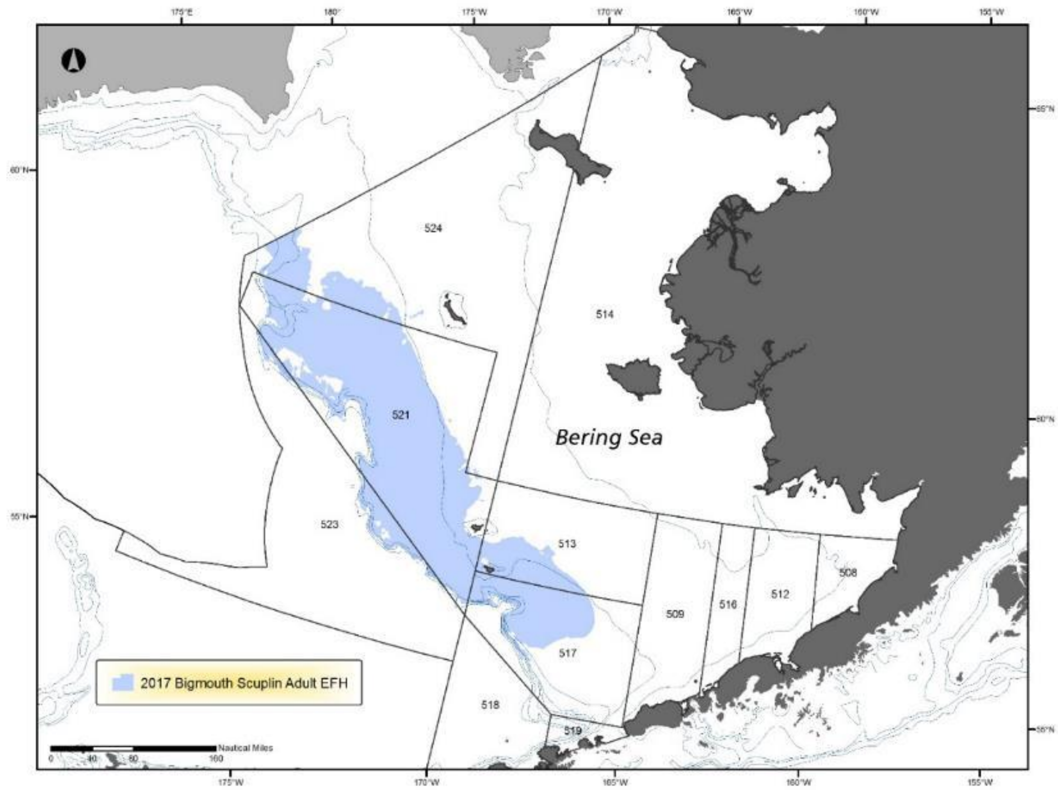
Sculpins

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Juveniles: No EFH description determined. Insufficient information is available.

Adults: EFH for adult sculpins is the habitat-related density area for this life stage, located in the lower portion of the water column along the inner (0 to 50 m), middle (50 to 100 m, outer shelf (100 to 200 m) and portions of the upper slope (200 to 500 m) throughout the BSAI wherever there are substrates of rock, sand, mud, cobble, and sandy mud.


Bering Sea
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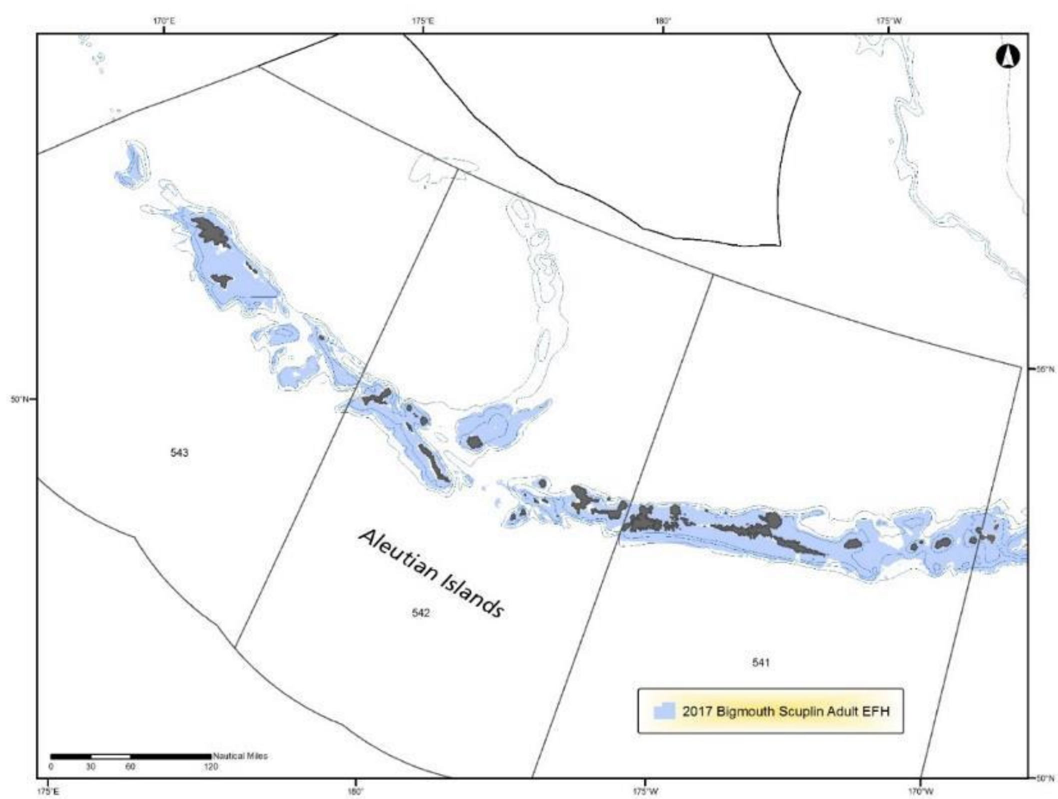
519
2017 Bigmouth Scuplin Adult EFH
Nautical Miles


Aleutian Islands
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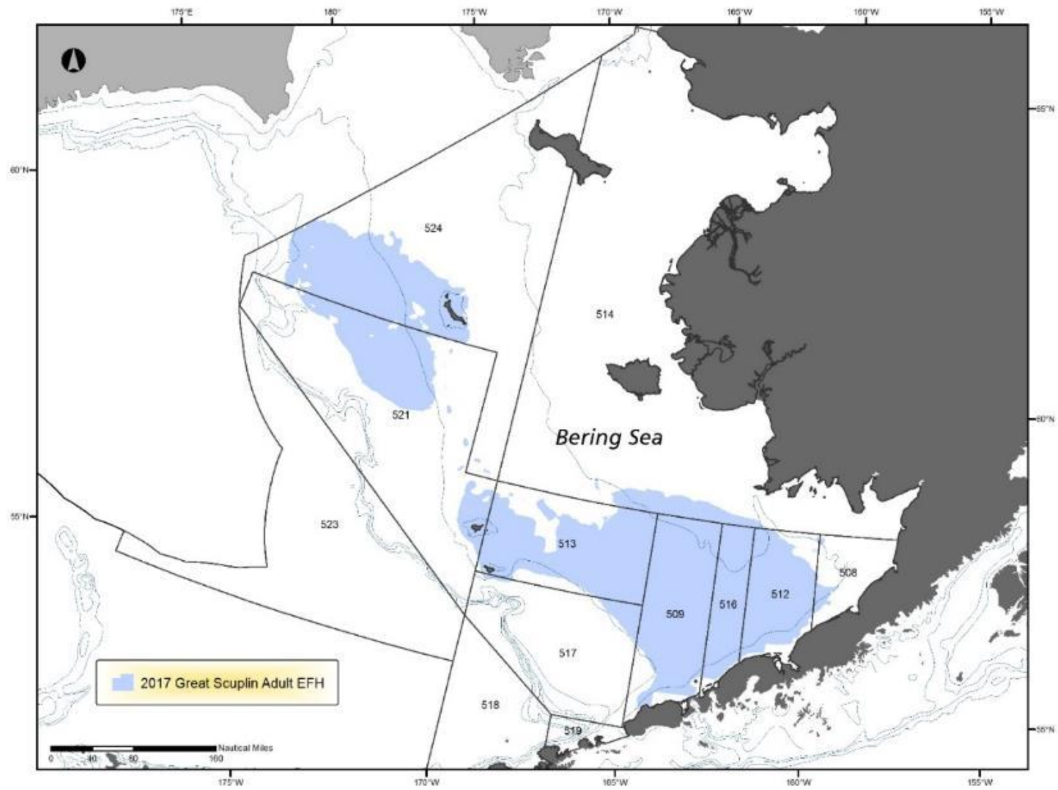
541
2017 Bigmouth Scuplin Adult EFH
Nautical Miles


Bering Sea
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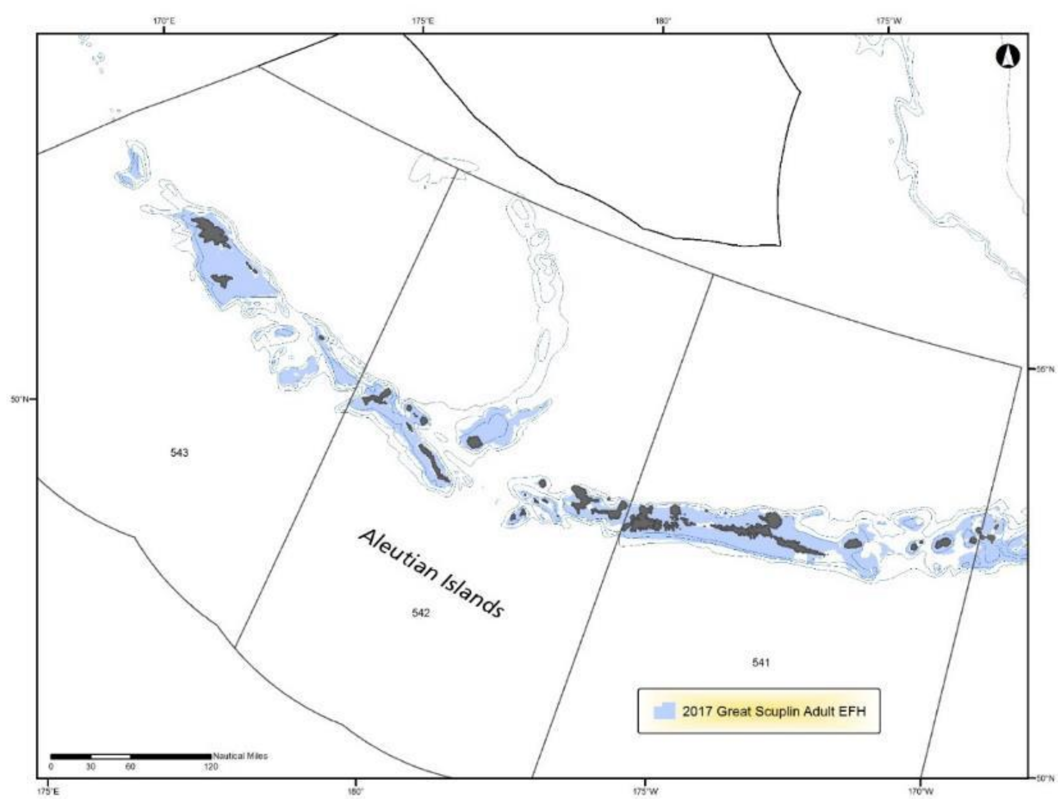
519
2017 Great Sculpin Adult EFH
Nautical Miles


Aleutian Islands
543
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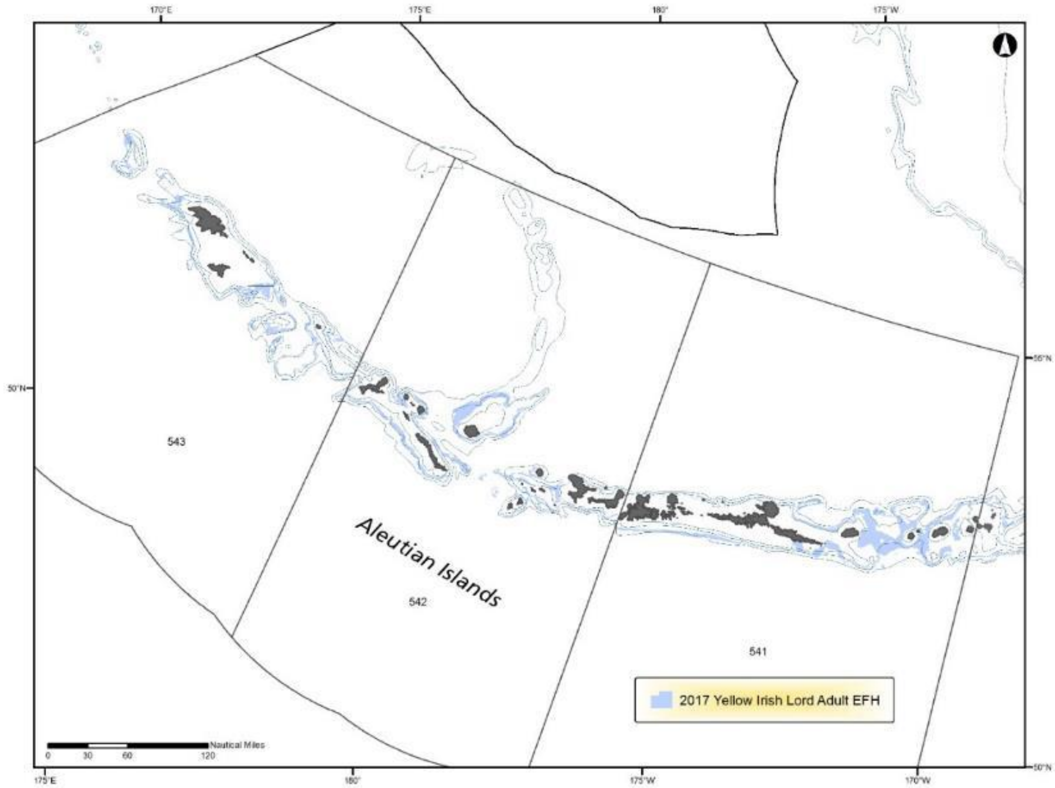
541
2017 Great Sculpin Adult EFH
Nautical Miles



Aleutian Islands
543
542
541
2017 Yellow Irish Lord Adult EFH
Nautical Miles
0 30 60 120

Skates

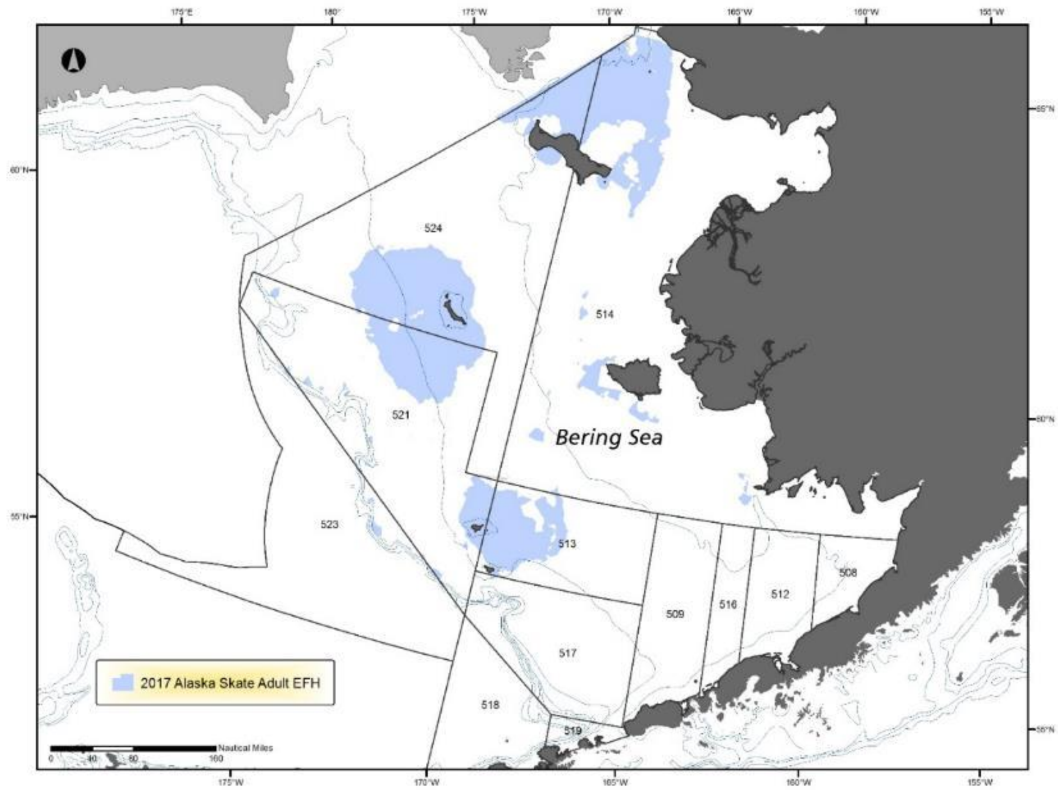
Eggs: EFH for skate egg cases is the general distribution area for this life stage, located on the seafloor below the shelf-slope interface in the eastern Bering Sea, in depths from 140 to 360 m.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: EFH for early juvenile skates is the general distribution area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock.

Late Juveniles: EFH for late juvenile skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock.

Adults: EFH for adult skates is the habitat-related density area for this life stage, located in the lower portion of the water column on the shelf (0 to 200 m) and the upper slope (200 to 500 m) throughout the BSAI wherever there are of substrates of mud, sand, gravel, and rock.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Bering Sea
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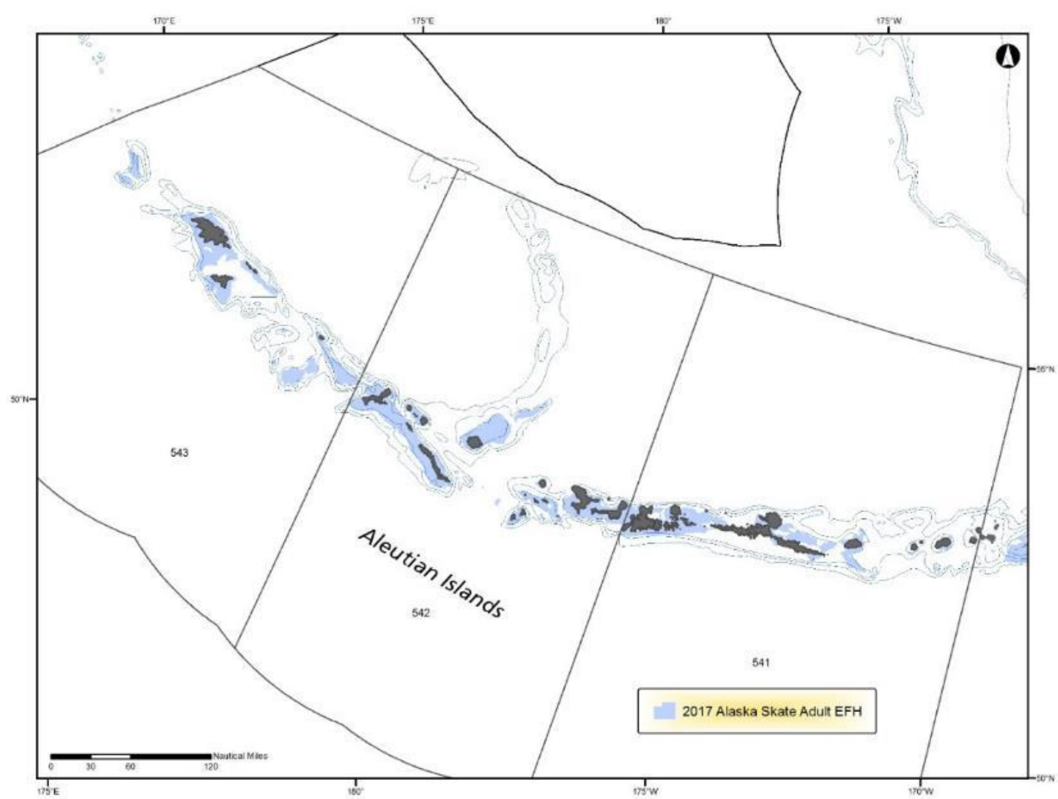
2017 Alaska Skate Adult EFH
Nautical Miles


543
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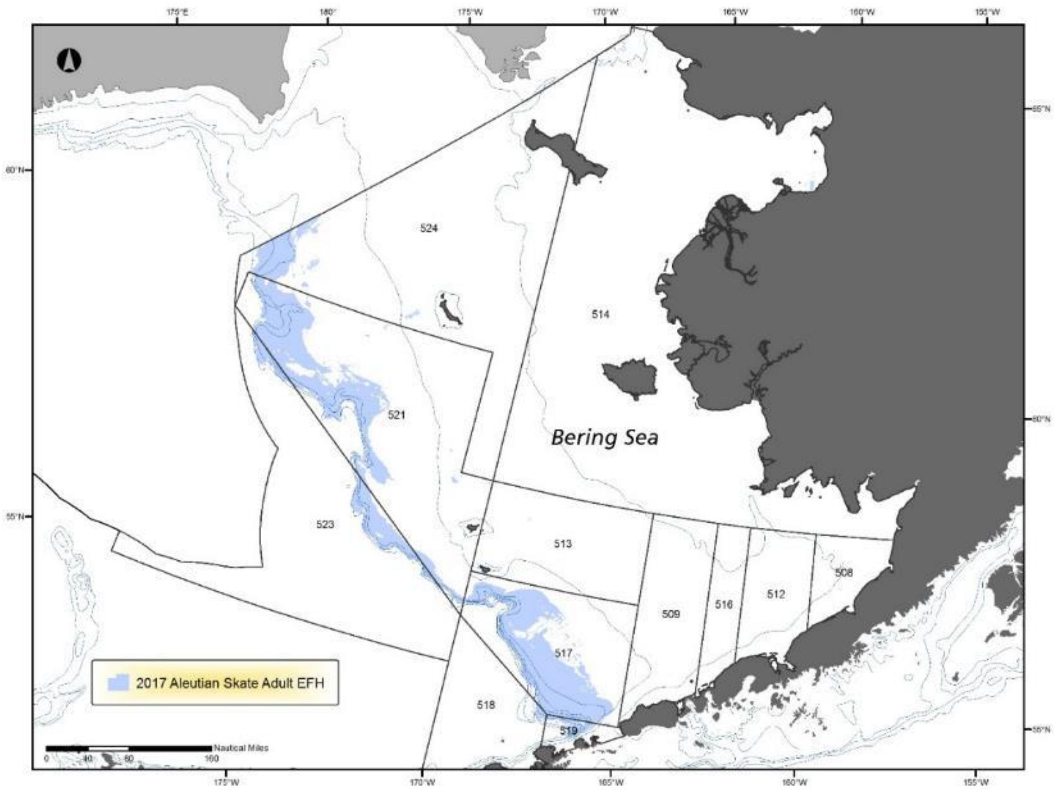
Aleutian Islands
2017 Alaska Skate Adult EFH
Nautical Miles



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Bering Sea
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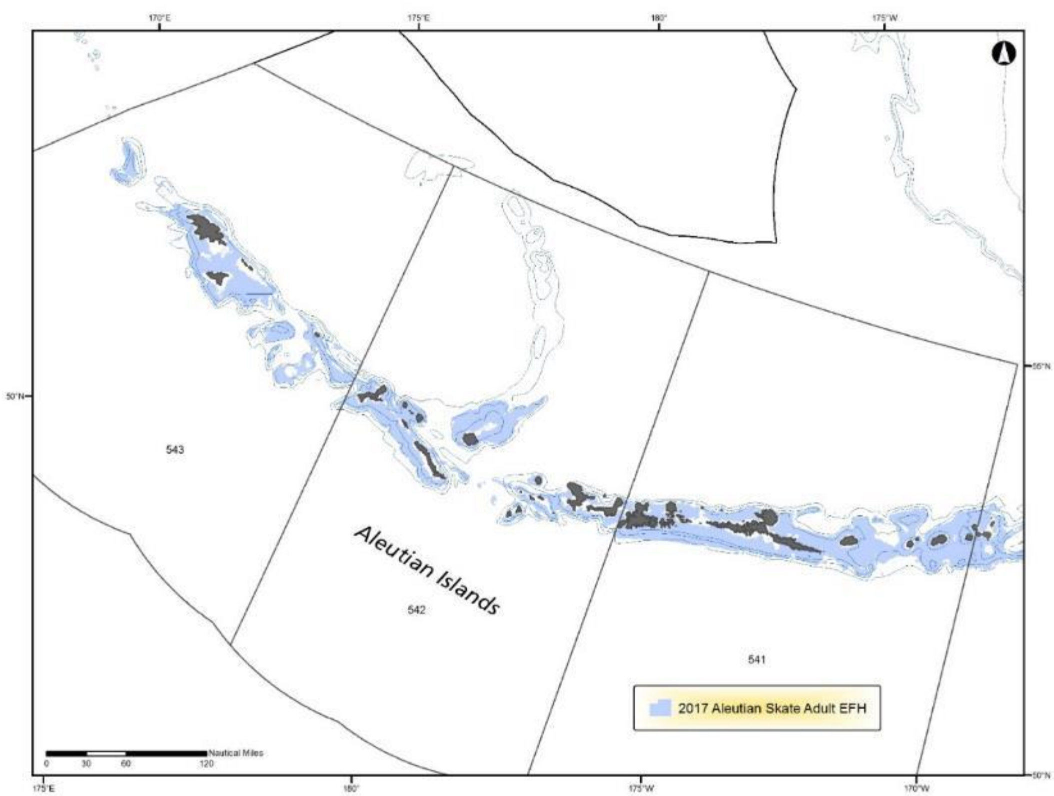
2017 Aleutian Skate Adult EFH
Nautical Miles



543
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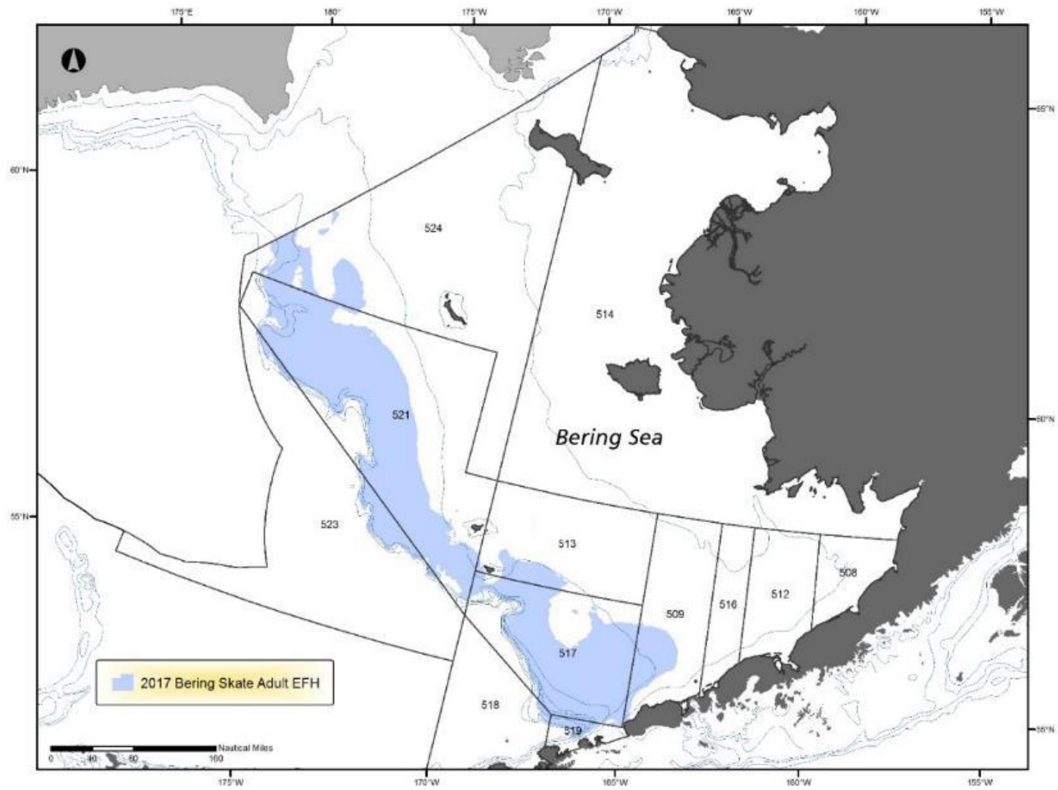
541
Aleutian Islands
2017 Aleutian Skate Adult EFH
Nautical Miles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Bering Sea
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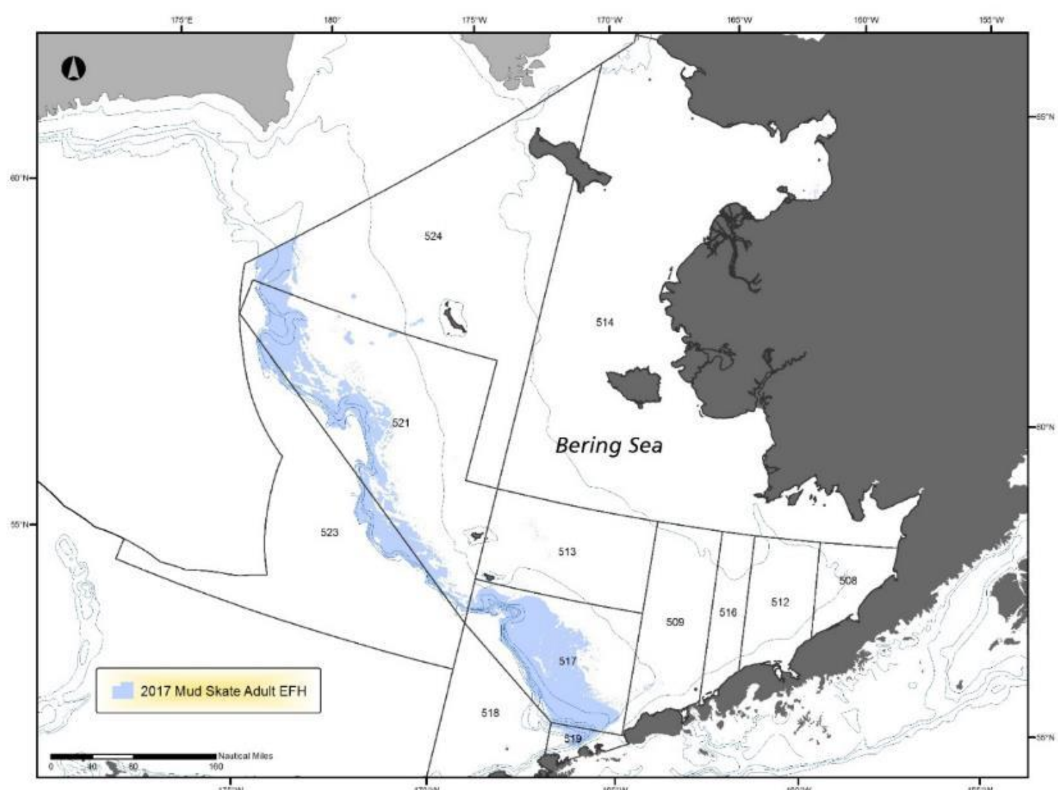
519
2017 Bering Skate Adult EFH
Nautical Miles


524
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Bering Sea
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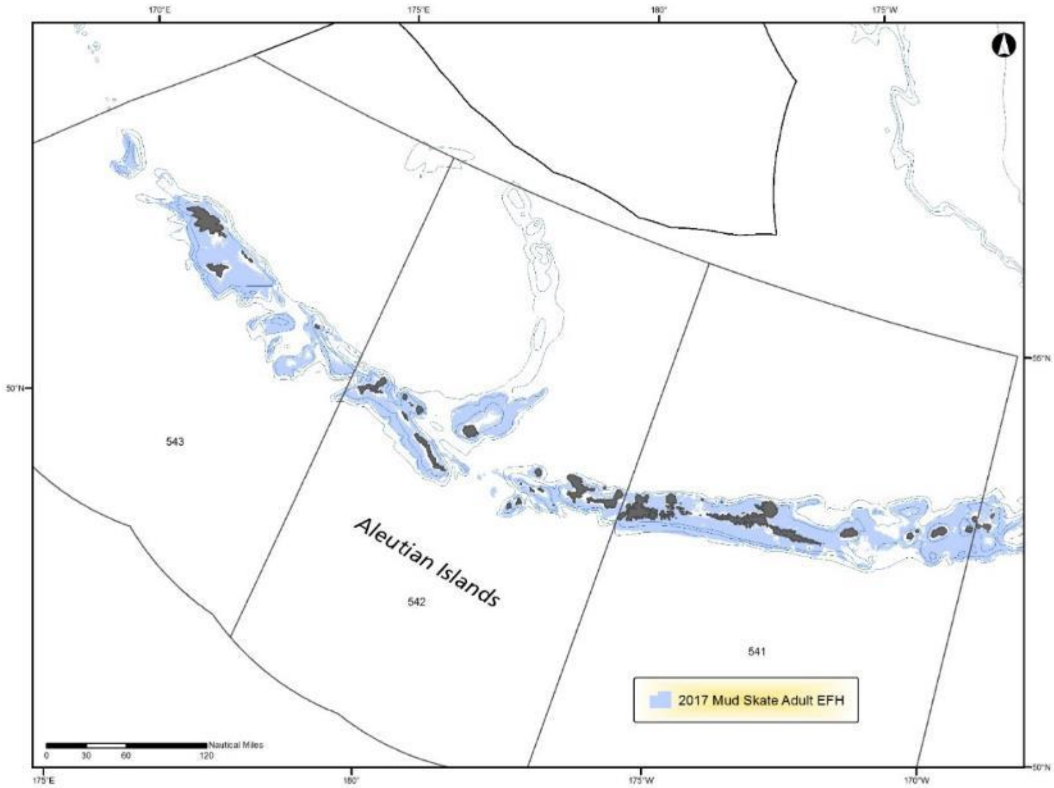
519
2017 Mud Skate Adult EFH
Nautical Miles


Aleutian Islands
543
542
541
2017 Mud Skate Adult EFH
Nautical Miles

Sharks

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: No EFH description determined. Insufficient information is available.

Adults: No EFH description determined. Insufficient information is available.

Octopus

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: No EFH description determined. Insufficient information is available.

Adults: EFH for adult octopus is the habitat-related density area for this life stage, located in demersal habitat throughout the intertidal, subtidal, shelf (0 to 200 m) and slope (200 to 2,000 m).

Octopus

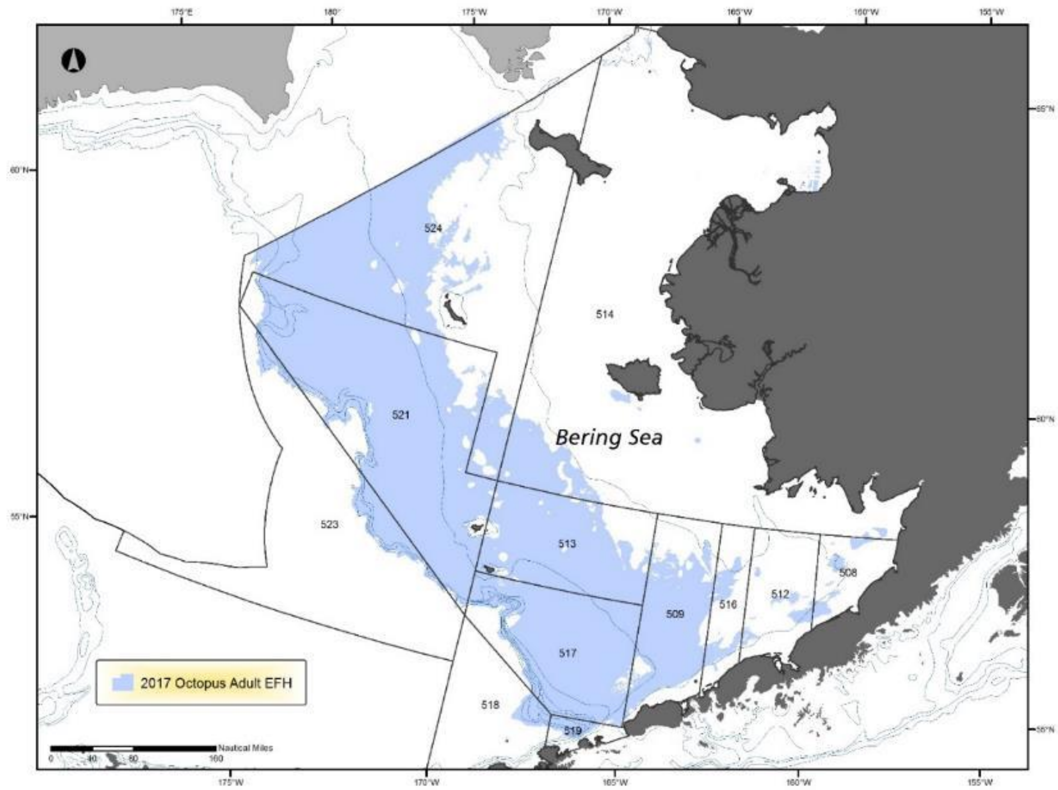
Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: No EFH description determined. Insufficient information is available.

Adults: EFH for adult octopus is the habitat-related density area for this life stage, located in demersal habitat throughout the intertidal, subtidal, shelf (0 to 200 m) and slope (200 to 2,000 m).


Bering Sea
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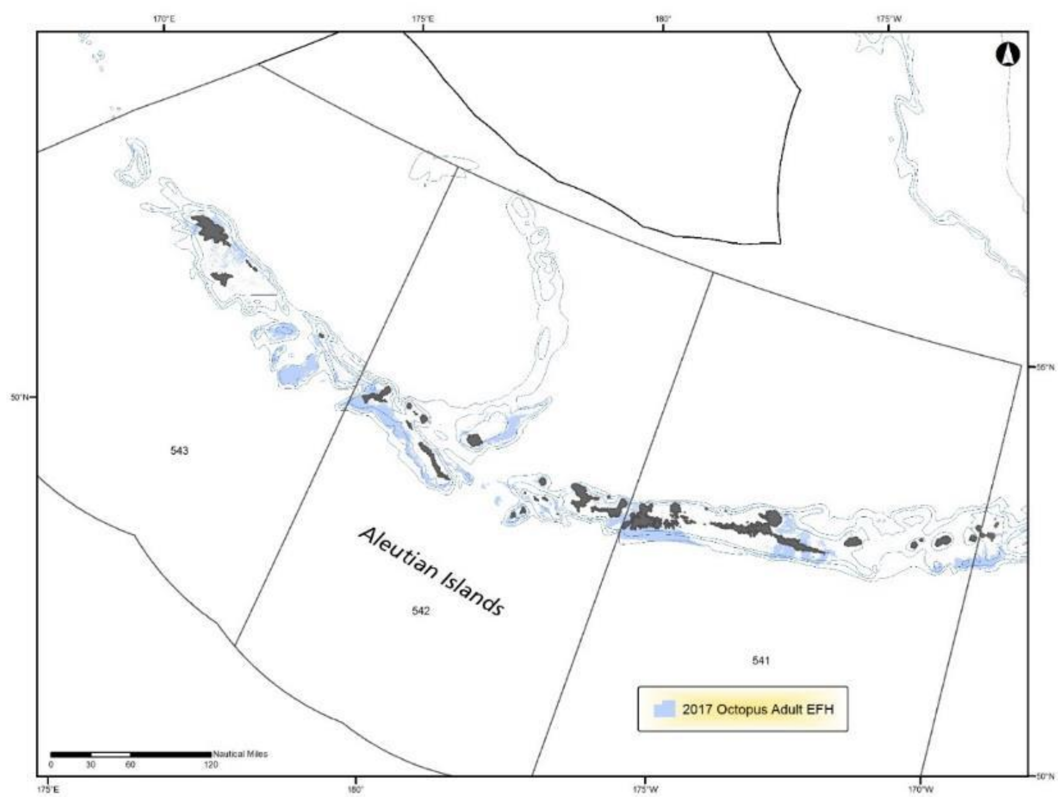
519
2017 Octopus Adult EFH
Nautical Miles


Aleutian Islands
543
542
541
2017 Octopus Adult EFH
Nautical Miles

Forage Fish Complex

The forage fish complex consists of species including eulachon, capelin, sand lance, sand fish, euphausiids, myctophids, pholids, gonostomatids.

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: No EFH description determined. Insufficient information is available.

Adults: No EFH description determined. Insufficient information is available.

Grenadiers

Eggs: No EFH description determined. Insufficient information is available.

Larvae: No EFH description determined. Insufficient information is available.

Early Juveniles: No EFH description determined. Insufficient information is available.

Late Juveniles: No EFH description determined. Insufficient information is available.

Adults: No EFH description determined. Insufficient information is available.

Table 2 Summary of habitat associations for BSAI groundfish.

BSAI Groundfish / Species	Life Stage	Nearshore: Freshwater	Nearshore: Estuarine	Nearshore: Intertidal	Nearshore: Subtidal	Shelf: Inner 1-50m	Shelf: Middle 51-100m	Shelf: Outer 101-200m	Slope: Upper 201-300m	Slope: Upper 301-500m	Slope: Intermediate 501-700m	Slope: Intermediate 701-1000m	Slope: Lower 1001-3000m	Slope: Basin >3000m	Stratum Reference: Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Location: Surfce	Near surface	Semi-demersal	Demersal	Pelagic: 1-200m (epi)	Pelagic: 201-1000m (meso)	Pelagic: >1000m (bathy)	Physical Oceanography: Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Substrate: Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Structure: Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Community Associations: Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Oceanographic Properties: Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Walleye Pollock	M					x	x	x	x				x		x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x																									**2-10**			M
	J					x	x	x							x	x	x	x	x	x		x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x																									**2-10**			J
	L						x	x							x	x	x	x	x	x		x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x																												L
	E						x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x		x			x	x	x	x																																								E
Pacific Cod	M					x	x	x	x	x					x	x	x	x	x	x	x			x	x										x	x	x	x	x	x	x	x	x	x	x																												M
	LJ					x	x	x	x	x					x	x	x	x	x	x	x			x	x										x	x	x	x	x	x	x	x	x	x	x																				x							LJ
	EJ				x	x	x	x							x	x	x	x	x	x	x			x	x										x	x	x	x	x	x	x	x	x	x																													EJ
	L					x	x	x							x	x	x	x	x	x	x					x																																														L
	E																										x																																														**3-6**	**13-23**	**2-3**	E
Sablefish	M									x	x	x	x	x				x				x				x				x							x	x	x								x	x							x																		M
	LJ								x	x	x	x							x				x				x				x							x	x	x								x	x																									LJ
	EJ					x	x	x										x							x	x	x		x																																										EJ
	L						x	x	x	x	x	x	x	x								x	x						x																																											L
	E									x	x	x	x	x	x												x	x		x																																											E
Yellowfin Sole	M					x	x																		x													x	x				x																																		M
	LJ					x	x																		x													x	x				x																																		LJ
	EJ					x																			x													x	x				x																																		EJ
	L					x	x																			x																																																		L
	E					x	x																			x																																																		E
Greenland Turbot	M							x	x	x	x	x	x								x	x				x													x	x	x		x																																		M
	LJ					x	x																		x													x	x			x																																		LJ
	EJ																										x													x	x			x																																		EJ
	L					x	x	x	x	x																x					x																																										L
	E					x	x	x	x	x																x																																														E
Arrowtooth Flounder	M					x	x	x	x	x	x														x													x	x	x			x																																		M
	LJ					x	x	x																	x													x	x	x			x																																		LJ
	EJ					x	x																		x													x	x	x			x																																		EJ
	L					x	x	x	x	x															x					x																																										L
	E					x	x	x	x	x														x																																																E
Kamchatka Flounder	M						x	x	x	x	x	x														x													x	x	x			x																																		M
	LJ						x	x	x	x															x													x	x	x			x																																		LJ
	EJ						x	x																	x													x	x	x			x																																		EJ
	L						x	x	x	x																x																																														L
	E						x	x	x	x																																																																			E
Northern Rock Sole	M					x	x	x																	x													x	x				x																																		M
	LJ					x	x																		x													x	x				x																																		LJ
	EJ					x																			x													x	x				x																																		EJ
	L					x	x	x																		x					x																																										L
	E					x	x	x																	x																																																E
Flathead Sole	M					x	x	x	x																x									x		x	x	x			x		x																																M
	LJ					x	x	x																	x													x	x	x			x		x																																LJ
	EJ					x	x																		x														x	x																																						EJ
	L					x	x	x																		x					x											x																																				L
	E					x	x	x																		x																																																		E

Table 2. Continued

BSAI Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceano-graphy					Substrate													Structure										Community Associations												Oceano-graphic Properties			
						Inner	Middle	Outer	Upper		Intermediate		Lower	Basin												Pelagic																																															
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamounts	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Alaska Plaice	M					x	x	x																	x										x	x				x																																M
	LJ					x	x	x																	x										x	x				x																																LJ
	EJ					x	x																		x										x	x				x																																EJ
	L					x	x	x																		x					x																																										L
	E					x	x	x																		x																																															E
Rex Sole	M					x	x	x	x	x															x										x	x				x																																M
	LJ					x	x	x	x																x										x	x				x																																LJ
	EJ					x	x																		x										x	x				x																																EJ
	L					x	x	x	x																	x									x	x																																				L
	E					x	x	x	x																	x																																														E
Dover Sole	M					x	x	x	x	x	x	x													x										x	x			x																																	M
	LJ					x	x	x	x	x															x										x	x			x																																	LJ
	EJ					x	x																		x										x	x			x																																	EJ
	L					x	x	x	x	x																x					x																																										L
	E					x	x	x	x	x																x																																														E
Pacific Ocean Perch	M							x	x	x								x	x	x	x			x	x	x			x								x								x	x														x													M
	LJ					x	x	x	x																																																																	LJ
	EJ					x	x	x																x	x	x	x	x	x								x								x	x																											EJ
	L																						x	x		x	x		x																																													L
Northern Rockfish	M						x	x										x							x																				x	x																												M
	LJ						x	x										x	x						x																				x	x																												LJ
	EJ																									x																																																EJ
	L																																																																									L
Shortraker Rockfish	M								x	x										x					x								x		x	x	x	x	x	x	x	x	x	x	x	x							x								x												M
	LJ																								x																																																	LJ
	EJ						x	x	x	x	x	x	x	x									x																																																		EJ
	L																										x																																														L
Blackspotted/ Rougheye Rockfish	M								x	x										x					x								x		x	x	x	x	x	x	x	x	x	x	x	x							x								x												M
	LJ																								x																																																LJ
	EJ						x	x	x	x	x	x	x	x									x																																																		EJ
	L																										x																																														L
Light Dusky Rockfish	M							x	x									x		x	x				x												x								x	x																											M
	LJ						x	x										x		x					x																																				x												LJ
	EJ																																																																									EJ
	L																																																																									L
Thornyhead Rockfish	M								x	x	x	x	x												x												x								x	x							x																					M
	LJ						x	x	x																x												x									x																											LJ
	EJ																									x																																																EJ
	L																									x																																																L
	E																									x																																																E
Atka Mackerel	M					x	x	x	x							x							x	x	x				x			x	x			x	x								x	x								x							x			x					3-5	>17		M
	J																					x	x																																															3-12			J
	L																					x	x																																															2-12			L
	E					x	x	x								x									x												x								x	x																		x					3-10			E

Table 2. Continued

BSAI Groundfish

Species	Life Stage	Nearshore: Freshwater	Nearshore: Estuarine	Nearshore: Intertidal	Nearshore: Subtidal	Shelf (Inner): 1-50m	Shelf (Middle): 51-100m	Shelf (Outer): 101-200m	Slope (Upper): 201-300m	Slope (Intermediate): 301-500m	Slope (Intermediate): 501-700m	Slope (Intermediate): 701-1000m	Slope (Lower): 1001-3000m	Slope (Basin): >3000m	Stratum Reference: Shallows	Stratum Reference: Island Pass	Stratum Reference: Bay/Fjord	Stratum Reference: Bank	Stratum Reference: Flat	Stratum Reference: Edge	Stratum Reference: Gully	Location: Surafce	Location: Near surface	Location: Semi-demersal	Location: Demersal	Location (Pelagic): 1-200m (epi)	Location (Pelagic): 201-1000m (meso)	Location (Pelagic): >1000m (bathy)
Squids	M				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	LJ																											
	EJ																											
	L																											
	E																											
Octopuses	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x				x	x	x	
	LJ																											
	EJ																											
	L																											
	E																											
Sharks	M			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
	LJ																											
	EJ																											
	L																											
	E																											
Sculpins	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x			
	LJ																											
	EJ																											
	L																											
	E																											
Skates	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x			
	LJ																											
	EJ																											
	L																											
	E							x	x																			
Eulachon	M						x	x	x								x									x		
	LJ						x	x																		x		
	EJ					x	x																			x		
	L	x	x			x	x										x						x					
	E	x																										
Capelin	M						x	x									x									x		
	LJ						x	x																		x		
	EJ					x	x																			x		
	L		x			x	x										x						x					
	E			x											x													
Sand Lance	M			x	x	x									x		x					x	x	x	x	x		
	LJ			x	x	x									x		x					x	x	x	x	x		
	EJ		x		x	x									x		x					x	x			x		
	L		x			x									x		x					x	x			x		
	E			x													x											
Grenadiers	M				x					x	x	x	x							x	x				x			
	LJ				x					x	x	x	x							x	x				x			
	EJ																											
	L																											
	E																											

Species	Life Stage	Physical Oceanography: Upwelling areas	Physical Oceanography: Gyres	Physical Oceanography: Thermo/pycnocline	Physical Oceanography: Fronts	Physical Oceanography: Edges (ice, bath)	Substrate: Organic Debris	Substrate: Mud	Substrate: Sand	Substrate: Gravel	Substrate: Mud & sand	Substrate: Mud & gravel	Substrate: Sand & mud	Substrate: Gravel & mud	Substrate: Gravel & sand	Substrate: Gravel & sand & mud	Substrate: Gravel & mud & sand	Substrate: Cobble	Substrate: Rock
Squids	M																		
	LJ																		
	EJ																		
	L																		
	E																		
Octopuses	M																		
	LJ																		
	EJ																		
	L																		
	E																		
Sharks	M						x	x	x	x	x	x	x	x	x	x	x	x	x
	LJ																		
	EJ																		
	L																		
	E																		
Sculpins	M																		
	LJ																		
	EJ																		
	L																		
	E																		
Skates	M																		
	LJ																		
	EJ																		
	L																		
	E																		
Eulachon	M	x			x	x													
	LJ	x			x	x													
	EJ	x			x														
	L																		
	E																		
Capelin	M	x			x	x													
	LJ	x			x	x													
	EJ	x			x														
	L																		
	E								x	x					x				
Sand Lance	M								x	x					x				
	LJ								x	x					x				
	EJ																		
	L																		
	E																		
Grenadiers	M							x	x	x	x	x	x	x	x	x	x	x	x
	LJ							x	x	x	x	x	x	x	x	x	x	x	x
	EJ																		
	L																		
	E																		

Species	Life Stage	Structure: Bars	Structure: Sinks	Structure: Slumps\Rockfalls\Debris	Structure: Channels	Structure: Ledges	Structure: Pinnacles	Structure: Seamounts	Structure: Reefs	Structure: Vertical Walls	Structure: Man-made	Community Associations: Algal Cover	Community Associations: Anenomes	Community Associations: Enchinoderms	Community Associations: Soft Coral	Community Associations: Hard Coral	Community Associations: Mollusca	Community Associations: Drift Algae\Kelp	Community Associations: Kelp	Community Associations: Polychaetes	Community Associations: Sea Grasses	Community Associations: Sea Onions	Community Associations: Tunicates	Oceanographic Properties: Temperature (Celsius)	Oceanographic Properties: Salinity (ppt)	Oceanographic Properties: Oxygen Conc (ppm)	Life Stage
Squids	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Octopuses	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Sharks	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Sculpins	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Skates	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Eulachon	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																							4-8			E
Capelin	M																							-2-3			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																							5-9			E
Sand Lance	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Grenadiers	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E

Table 3 **Summary of biological associations for BSAI groundfish**

BSAI Groundfish	Life Stage	Reproductive Traits																										
		Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season											
		Female		Male																								
Species		50%	100%	50%	100%	External	Internal	Oviparous	Aplacental	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May	June	July	August	September	October	November	December
Walleye Pollock	M	3-4		3-4		x						x						x	x	x	x							
Pacific Cod	M	5	11	5	11	x						x						x	x	x								
Sablefish	M	57-61cm				x						x					x	x	x									
Yellowfin Sole	M	10.1				x					x										x	x	x					
Greenland Turbot	M	5-10				x						x					x	x	x							x	x	x
Arrowtooth Flounder	M	5		4		x											x	x	x	x							x	x
Kamchatka Flounder	M	10		10		x											x	x	x								x	x
Northern Rock Sole	M	9				x					x						x	x	x									
Flathead Sole	M	9.7				x					x						x	x	x	x								
Alaska Plaice	M	6-7				x													x	x	x							
Rex Sole	M	35cm				x												x	x	x	x	x	x					
Dover Sole	M	33cm				x											x	x	x	x	x	x	x	x				
Pacific Ocean Perch	M	10.5					x			x	x							x	x	x	x							
Northern Rockfish	M	13					x			x	x																	
Shortraker Rockfish	M						x			x	x							x	x	x	x	x	x	x				
Blackspotted/Rougheye Rockfish	M						x			x	x						x	x	x	x								
Thornyhead Rockfish	M	12									x							x				x						
Light Dusky Rockfish	M	11					x			x	x																	
Atka Mackerel	M	3.6		3.6		x					x			x	x							x	x	x	x	x		
Squid	M						x				x																	
Octopus	M						x				x			x	x													
Sharks	M	35		21			x	x	x	x			x			x	x	x	x						x	x	x	x
Sculpins	M					x									x													
Skates	M						x	x					x															
Eulachon	M	3	5	3	5	x		x			x									x	x	x						
Capelin	M	2	4	2	4	x		x			x										x	x	x	x				
Sand Lance	M	1	2	1	2	x		x			x						x	x									x	x
Grenadiers	M	23	#			x					x	x					x	x	x	x	x	x	x	x	x	x	x	x

Table 4		Summary of predatory prey associations for BSAI groundfish (next three pages)

BSAI Groundfish

Predator to

Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Shrimps, Panaeid	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut	Deepsea smelt
Walleye Pollock	M				x			x			x			x						x		x	x	x	x		x			x	x	x	
	LJ				x			x			x			x						x		x	x	x	x		x			x	x	x	
	EJ				x			x			x									x		x	x										
	L				x			x			x																						
	E																																
Pacific Cod	M				x		x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	LJ				x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	EJ				x			x		x	x		x	x		x	x	x	x	x		x		x	x	x	x	x		x	x	x	
	L																																
	E																																
Sablefish	M							x	x	x	x		x	x				x		x			x	x		x	x		x	x	x		
	LJ							x	x	x	x		x	x				x		x			x	x		x	x		x	x	x		
	EJ							x		x	x		x	x	x			x		x				x					x				
	L				x						x																						
	E																																
Yellowfin Sole	M							x		x			x			x		x		x						x					x		
	LJ							x		x			x			x		x		x						x							
	EJ				x																												
	L	x		x																													
	E																																
Greenland Turbot	M							x				x	x	x		x	x	x	x	x		x	x	x	x				x	x	x		
	LJ							x				x	x	x		x	x	x	x	x		x	x	x	x				x	x	x		
	EJ				x																												
	L	x		x																													
	E																																
Arrowtooth Flounder	M												x	x				x	x	x				x	x						x		
	LJ												x					x	x	x				x	x						x		
	EJ				x																												
	L	x		x																													
	E																																
Kamchatka Flounder	M							x		x			x	x				x		x											x		
	LJ							x		x			x					x		x													
	EJ				x																												
	L	x		x																													
	E																																
Northern Rock Sole	M									x			x			x	x																
	LJ									x			x			x	x																
	EJ				x																												
	L	x		x																													
	E																																
Flathead Sole	M							x		x	x		x			x	x	x	x			x	x								x		
	LJ							x		x	x		x			x	x	x	x												x		
	EJ				x								x			x			x												x		
	L	x		x																													
	E																																
Rex Sole	M							x		x			x					x															
	LJ							x		x			x					x															
	EJ																																
	L	x		x																													
	E																																
Dover Sole	M												x				x	x															
	LJ												x				x	x															
	EJ																																
	L	x		x																													
	E																																

Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	Salmon Shark	Pacific sleeper shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Baird's beaked shale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Walleye Pollock	M								x						x	x	x		x	x	x												
	LJ							x	x						x	x			x	x	x				x				x	x	x		
	EJ							x	x						x	x			x	x	x				x				x	x	x		
	L							x	x						x	x									x				x	x	x		
	E																																
Pacific Cod	M															x	x		x		x		x	x	x								
	LJ								x						x	x	x		x		x		x	x	x								
	EJ							x	x						x	x	x		x		x		x	x	x					x			
	L							x	x						x																		
	E																																
Sablefish	M																																
	LJ						x									x											x						
	EJ																																
	L																																
	E																																
Yellowfin Sole	M																																
	LJ								x							x																	
	EJ								x							x																	
	L																																
	E																																
Greenland Turbot	M								x																								
	LJ																																
	EJ							x	x					x																			
	L																																
	E																																
Arrowtooth Flounder	M																																
	LJ							x	x																								
	EJ																																
	L																																
	E																																
Kamchatka Flounder	M																																
	LJ							x	x						x	x																	
	EJ																																
	L																																
	E																																
Northern Rock Sole	M																																
	LJ							x	x					x		x																	
	EJ																																
	L																																
	E																																
Flathead Sole	M								x				x		x	x																	
	LJ																																
	EJ																																
	L																																
	E																																
Rex Sole	M								x						x																		
	LJ								x						x																		
	EJ																																
	L																																
	E																																
Dover Sole	M								x						x																		
	LJ								x						x																		
	EJ																																
	L																																
	E																																

BSAI Groundfish — Predator to

Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Shrimps, Panaeid	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut	Deepsea smelt
Pacifc Ocean	M							x																									
Perch	LJ							x			x																						
	EJ																																
	L			x	x																												
Northern Rockfish	M							x			x																						
	LJ																																
	EJ																																
	L																																
Shortraker	M													x						x					x								
Rockfish	LJ																																
	EJ																																
	L																																
Blackspotted/	M													x						x					x								
Rougheye Rockfish	LJ																																
	EJ																																
	L																																
Light Dusky Rockfis	M							x																									
	LJ																																
	EJ																																
	L																																
Thornyhead	M																			x						x							
Rockfish	LJ																																
	EJ																																
	L																																
	E																																
Atka Mackerel	M							x			x														x								
	J							x			x																						
	L										x																						
	E																																
Squid	M							x			x									x		x	x	x									
	LJ																																
	EJ																																
	L																																
	E																																
Octopus	M															x	x	x	x	x		x				x		x		x		x	
	LJ																																
	EJ																																
	L		x	x							x																						
	E																																
Sharks	M							x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	
	LJ																																
	EJ																																
	L																																
	E																																
Sculpins	M				x			x	x	x	x	x	x		x	x	x	x	x	x		x	x	x		x	x		x	x			
	LJ																																
	EJ																																
	L																																
	E																																
Skates	M									x		x	x					x		x		x		x		x	x	x	x	x	x	x	
	LJ																																
	EJ																																
	L																																
	E																																

BSAI Groundfish — Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	Salmon Shark	Pacific sleeper shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Baird's beaked shale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Pacifc Ocean	M															x																	
Perch	LJ																																
	EJ						x																										
	L																																
Northern Rockfish	M																																
	LJ																																
	EJ																																
	L																																
Shortraker	M																																
Rockfish	LJ																																
	EJ																																
	L																																
Blackspotted/	M																																
Rougheye Rockfish	LJ																																
	EJ																																
	L																																
Light Dusky Rockfis	M																																
	LJ																																
	EJ																																
	L																																
Thornyhead	M																																
Rockfish	LJ																																
	EJ																																
	L																																
	E																																
Atka Mackerel	M								x						x	x			x	x	x	x			x								
	J																		x		x								x	x			
	L																																
	E																																
Squid	M	x					x	x	x	x	x	x	x			x			x	x	x	x	x		x				x	x	x		
	LJ																																
	EJ																																
	L																																
	E																																
Octopus	M							x	x	x	x		x	x		x			x	x	x		x										
	LJ																																
	EJ																																
	L																																
	E																																
Sharks	M									x						x	x																
	LJ																																
	EJ																																
	L																																
	E																																
Sculpins	M										x		x		x	x			x	x	x	x	x										
	LJ																																
	EJ																																
	L																																
	E																																
Skates	M																																
	LJ																																
	EJ																																
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BSAI Groundfish — Predator to

Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Shrimps, Panaeid	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut	Deepsea smelt
Eulachon	M				X			X			X																						
	LJ				X			X			X																						
	EJ				X			X			X																						
	L			X	X	X		X			X																						
	E																																
Capelin	M				X			X			X		X							X													
	LJ				X			X			X																						
	EJ				X			X			X																						
	L			X	X	X		X			X																						
	E																																
Sand Lance	M				X			X		X	X																						
	LJ				X			X		X	X																						
	EJ				X			X		X	X																						
	L			X	X	X		X		X	X																						
	E																																
Grenadiers	M													X						X	X				X								X
	LJ													X						X	X				X								X
	EJ																																
	L																																
	E																																

BSAI Groundfish — Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	Salmon Shark	Pacific sleeper shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Baird's beaked shale	Sperm whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrerstrial Mammals
Eulachon	M						X	X	X							X			X	X	X	X							X	X			X
	LJ						X	X	X							X			X	X	X	X							X	X			
	EJ					X	X	X	X							X																	
	L					X	X	X	X							X																	
	E																																
Capelin	M						X	X	X						X	X			X	X	X	X							X	X			
	LJ						X	X	X						X	X			X	X	X	X							X	X			
	EJ					X	X	X	X						X	X																	
	L					X	X	X	X						X	X																	
	E																																
Sand Lance	M						X	X	X						X	X			X	X	X	X							X	X			
	LJ						X	X	X						X	X			X	X	X	X							X	X			
	EJ					X	X	X	X						X	X																	
	L					X	X	X	X						X	X																	
	E																																
Grenadiers	M																	X								X	X						
	LJ																	X								X	X						
	EJ																																
	L																																
	E																																

Habitat Information

The following sections describe the habitat of the BSAI management area and defines essential fish habitat for each of the managed species. In each individual section, a species-specific table summarizes habitat. The following abbreviations are used in these habitat tables to specify location, position in the water column, bottom type, and other oceanographic features.

Location

BCH	=	beach (intertidal)
ICS	=	inner continental shelf (1-50 m)
MCS	=	middle continental shelf (50-100 m)
OCS	=	outer continental shelf (100-200 m)
USP	=	upper slope (200-1000 m)
LSP	=	lower slope (1000-3000 m)
BSN	=	basin (>3000 m)
BAY	=	nearshore bays, with depth if appropriate (e.g., fjords)
IP	=	island passes (areas of high current), with depth if appropriate

Water column

D	=	demersal (found on bottom)
SD/SP	=	semi-demersal or semi-pelagic, if slightly greater or less than 50% on or off bottom
P	=	pelagic (found off bottom, not necessarily associated with a particular bottom type)
N	=	neustonic (found near surface)

General

U	=	unknown
NA	=	not applicable

Bottom Type

M	=	mud
S	=	sand
MS	=	muddy sand
R	=	rock
SM	=	sandy mud
CB	=	cobble
G	=	gravel
C	=	coral
K	=	kelp
SAV	=	subaquatic vegetation (e.g., eelgrass, not kelp)

Oceanographic Features

UP	=	upwelling
G	=	gyres
F	=	fronts
CL	=	thermo- or pycnocline
E	=	edges

Walleye pollock (Theragra calcogramma)

The eastern Bering Sea and Aleutian Islands pollock stocks are managed under the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area (FMP). Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian exclusive economic zone (EEZ), international waters of the central Bering Sea, and into the Chukchi Sea.

Life History and General Distribution

Pollock is the most abundant species within the eastern Bering Sea comprising 75 to 80 percent of the catch and 60 percent of the biomass. In the Gulf of Alaska, pollock is the second most abundant groundfish stock comprising 25 to 50 percent of the catch and 20 percent of the biomass.

Four stocks of pollock are recognized for management purposes: Gulf of Alaska, eastern Bering Sea, Aleutian Islands, and Aleutian Basin. For the contiguous sub-regions (i.e., areas adjacent to their management delineation), there appears to be some relationship among the eastern Bering Sea, Aleutian Islands, and Aleutian Basin stocks. Some strong year classes appear in all three places suggesting that pollock may expand from one area into the others or that discrete spawning areas benefit (in terms of recruitment) from similar environmental conditions. There appears to be stock separation between the Gulf of Alaska stocks and stocks to the north.

The most abundant stock of pollock is the eastern Bering Sea stock which is primarily distributed over the eastern Bering Sea outer continental shelf between approximately 70 m and 200 m. Information on pollock distribution in the eastern Bering Sea comes from commercial fishing locations, annual bottom trawl surveys and regular (every two or three years) echo-integration mid-water trawl surveys. There are also ancilliary surveys for different life stages including those of the BASIS program (typically conducted in late summer and early fall) and some cooperative surveys with the Russian Federation scientists (typically covering the region a few hundred miles within the US zone from the Convention line).

The Aleutian Islands stock extends through the Aleutian Islands from 170° W. to the end of the Aleutian Islands (Attu Island), with the greatest abundance in the eastern Aleutian Islands (170° W. to Seguam Pass). Most of the information on pollock distribution in the Aleutian Islands comes from regular (every two or three years) bottom trawl surveys. These surveys indicate that pollock are primarily located on the Bering Sea side of the Aleutian Islands, and have a spotty distribution throughout the Aleutian Islands chain, particularly during the summer months when the survey is conducted. Thus, the bottom trawl data may be a poor indicator of pollock distribution because a significant portion of the pollock biomass is likely to be unavailable to bottom trawls. Also, many areas of the Aleutian Islands shelf are untrawlable due to the rough bottom.

The Aleutian Basin stock appears to be distributed throughout the Aleutian Basin which encompasses the U.S. EEZ, Russian EEZ, and international waters in the central Bering Sea. This stock appears throughout the Aleutian Basin apparently for feeding, but concentrates near the continental shelf for spawning. The principal spawning location is thought to be near Bogoslof Island in the eastern Aleutian Islands, but data from pollock fisheries in the first quarter of the year indicate that there are other concentrations of deepwater spawning concentrations in the central and western Aleutian Islands. The Aleutian Basin spawning stock appears to be derived from migrants from the eastern Bering Sea shelf stock, and possibly some western Bering Sea pollock. Recruitment to the stock occurs generally around age 5 with younger fish being rare in the Aleutian Basin. Most of the pollock in the Aleutian Basin appear to originate from strong year classes also observed in the Aleutian Islands and eastern Bering Sea shelf region.

The Gulf of Alaska stock extends from southeast Alaska to the Aleutian Islands (170° W.), with the greatest abundance in the western and central regulatory areas (147° W. to 170° W.). Most of the information on pollock distribution in the Gulf of Alaska comes from annual winter echo-integration mid-water trawl surveys and regular (every two or three years) bottom trawl surveys. These surveys indicate that pollock are distributed throughout the shelf regions of the Gulf of Alaska at depths less than 300 m. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and unavailable to bottom trawls. The principal spawning location is in Shelikof Strait, but other spawning concentrations in the Shumagin Islands, the east side of Kodiak Island, and near Prince William Sound also contribute to the stock.

Peak pollock spawning occurs on the southeastern Bering Sea and eastern Aleutian Islands along the outer continental shelf around mid-March. North of the Pribilof Islands spawning occurs later (April and May) in smaller spawning aggregations. The deep spawning pollock of the Aleutian Basin appear to spawn slightly earlier, late February and early March. In the Gulf of Alaska, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area appears to be 2 to 3 weeks earlier than in Shelikof Strait.

Spawning occurs in the pelagic zone and eggs develop throughout the water column (70 to 80 m in the Bering Sea shelf, 150 to 200 m in Shelikof Strait). Development is dependent on water temperature. In the Bering Sea, eggs take about 17 to 20 days to develop at 4 °C in the Bogoslof area and 25.5 days at 2 °C on the shelf. In the Gulf of Alaska, development takes approximately 2 weeks at ambient temperature (5 °C). Larvae are also distributed in the upper water column. In the Bering Sea the larval period lasts approximately 60 days. The larvae eat progressively larger naupliar stages of copepods as they grow and then small euphausiids as they approach transformation to juveniles (approximately 25 mm standard length). In the Gulf of Alaska, larvae are distributed in the upper 40 m of the water column and their diet is similar to Bering Sea larvae. Fisheries-Oceanography Coordinated Investigations survey data indicate larval pollock may utilize the stratified warmer upper waters of the mid-shelf to avoid predation by adult pollock which reside in the colder bottom water.

At age 1 pollock are found throughout the eastern Bering Sea both in the water column and on the bottom depending on temperature. Age 1 pollock from strong year-classes appear to be found in great numbers on the inner shelf, and further north on the shelf than weak year classes which appear to be more concentrated on the outer continental shelf. From age 2 to 3 pollock are primarily pelagic and then are most abundant on the outer and mid-shelf northwest of the Pribilof Islands. As pollock reach maturity (age 4) in the Bering Sea, they appear to move from the northwest to the southeast shelf to recruit to the adult spawning population. Strong year-classes of pollock persist in the population in significant numbers until about age 12, and very few pollock survive beyond age 16. The oldest recorded pollock was age 31.

Growth varies by area with the largest pollock occurring on the southeastern shelf. On the northwest shelf the growth rate is slower. A newly maturing pollock is around 40 cm.

The upper size limit for juvenile pollock in the eastern Bering Sea and Gulf of Alaska is about 38 to 42 cm. This is the size of 50 percent maturity. There is some evidence that this has changed over time.

Relevant Trophic Information

Juvenile pollock through newly maturing pollock primarily utilize copepods and euphausiids for food. At maturation and older ages pollock become increasingly piscivorous, with pollock (cannibalism) a major food item in the Bering Sea. Most of the pollock consumed by pollock are age 0 and 1 pollock, and recent research suggests that cannibalism can regulate year-class size. Weak year-classes appear to be those located within the range of adults, while strong year-classes are those that are transported to areas outside the range of adult abundance.

Being the dominant species in the eastern Bering Sea, pollock is an important food source for other fish, marine mammals, and birds. On the Pribilof Islands hatching success and fledgling survival of marine birds has been tied to the availability of age 0 pollock to nesting birds.

Habitat and Biological Associations

Egg-Spawning: Pelagic on outer continental shelf generally over 100 to 200 m depth in Bering Sea. Pelagic on continental shelf over 100 to 200 m depth in Gulf of Alaska.

Larvae: Pelagic outer to mid-shelf region in Bering Sea. Pelagic throughout the continental shelf within the top 40 m in the Gulf of Alaska.

Juveniles: Age 0 appears to be pelagic, as is age 2 and 3. Age 1 pelagic and demersal with a widespread distribution and no known benthic habitat preference.

Adults: Adults occur both pelagically and demersally on the outer and mid-continental shelf of the Gulf of Alaska, eastern Bering Sea and Aleutian Islands. In the eastern Bering Sea few adult pollock occur in waters shallower than 70 m. Adult pollock also occur pelagically in the Aleutian Basin. Adult pollock range throughout the Bering Sea in both the U.S. and Russian waters; however, the maps provided for this document detail distributions for pollock in the U.S. EEZ and the Aleutian Basin.

Habitat and Biological Associations: Walleye Pollock

Stage - EFH Level	Duration or Age	Diet/Prey	Season / Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14 days at 5 °C	None	Feb–Apr	OCS, USP	P	NA	G?	
Larvae	60 days	copepod naupli and small euphausiids	Mar–Jul	MCS, OCS	P	NA	G? F	pollock larvae with jellyfish
Juveniles	0.4 to 4.5 years	pelagic crustaceans, copepods and euphausiids	Aug. +	OCS, MCS, ICS	P, SD	NA	CL, F	
Adults	4.5–16 years	pelagic crustaceans and fish	spawning Feb–Apr	OCS, BSN	P, SD	UNK	F UP	increasingly demersal with age.

Literature

A'mar, Z. T., Punt, A. E., and Dorn, M. W. 2009. The evaluation of two management strategies for the Gulf of Alaska walleye pollock fishery under climate change. – ICES Journal of Marine Science, 66: 000–000.

Aydin, K. Y., et al. A comparison of the Eastern Bering and western Bering Sea shelf and slope ecosystems through the use of mass-balance food web models. U.S. Department of Commerce, Seattle, WA. (NOAA Technical Memorandum NMFS-AFSC-130) 78p.

Bacheler, N.M., L. Ciannelli, K.M. Bailey, and J.T. Duffy-Anderson. 2010. Spatial and temporal patterns of walleye pollock (*Theragra chalcogramma*) spawning in the eastern Bering Sea inferred from egg and larval distributions. Fish. Oceanogr. 19:2. 107-120.

Bailey, K.M. 2000. Shifting control of recruitment of walleye pollock *Theragra chalcogramma* after a major climatic and ecosystem change. Mar. Ecol. Prog. Ser 198:215-224.

Bailey, K.M., P.J. Stabeno, and D.A. Powers. 1997. The role of larval retention and transport features in mortality and potential gene flow of walleye pollock. J. Fish. Biol. 51(Suppl. A):135-154.

Bailey, K.M., S.J. Picquelle, and S.M. Spring. 1996. Mortality of larval walleye pollock (*Theragra chalcogramma*) in the western Gulf of Alaska, 1988-91. Fish. Oceanogr. 5 (Suppl. 1):124-136.

Bailey, K.M., T.J. Quinn II, P. Bentzen, and W.S. Grant. 1999. Population structure and dynamics of walleye pollock, *Theragra chalcogramma*. Advances in Mar. Biol. 37: 179-255.

Bakkala, R.G., V.G. Wespestad and L.L. Low. 1987. Historical trends in abundance and current condition of walleye pollock in the eastern Bering Sea. Fish. Res.,5:199-215.

Barbeaux, S. J., and M. W. Dorn. 2003. Spatial and temporal analysis of eastern Bering Sea echo integration-trawl survey and catch data of walleye pollock, *Theragra chalcogramma*. NOAA Technical Memorandum NMFS-AFSC-136

Barbeaux, S. J., and D. Fraser. 2009. Aleutian Islands cooperative acoustic survey study for 2006. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-198, 91 p.

Barbeaux, S.J., Horne, J., Ianelli, J. 2014. A novel approach for estimating location and scale specific fishing exploitation rate of eastern Bering Sea walleye pollock (*Theragra chalcogramma*). Fish. Res. 153 p. 69 – 82.

Bates, R.D. 1987. Ichthyoplankton of the Gulf of Alaska near Kodiak Island, April-May 1984. NWAFC Proc. Rep. 87-11, 53 pp.

Bond, N.A., and J.E. Overland 2005. The importance of episodic weather events to the ecosystem of the Bering Sea shelf. Fisheries Oceanography, Vol. 14, Issue 2, pp. 97-111.

Brodeur, R.D. and M.T. Wilson. 1996. A review of the distribution, ecology and population dynamics of age-0 walleye pollock in the Gulf of Alaska. Fish. Oceanogr. 5 (Suppl. 1):148-166.

Brown, A.L. and K.M. Bailey. 1992. Otolith analysis of juvenile walleye pollock *Theragra chalcogramma* from the western Gulf of Alaska. Mar. Bio. 112:23-30.

Canino, M.F., P.T. O'Reilly, L. Hauser, and P. Bentzen. 2005. Genetic differentiation in walleye pollock (*Theragra chalcogramma*) in response to selection at the pantophysin (*Pan* I) locus. Can. J. Fish. Aquat. Sci. 62:2519-2529.

Coyle, K. O., Eisner, L. B., Mueter, F. J., Pinchuk, A. I., Janout, M. A., Cieciel, K. D., … Andrews, A. G. (2011). Climate change in the southeastern Bering Sea: Impacts on pollock stocks and implications for the oscillating control hypothesis. *Fisheries Oceanography*, *20*(2), 139–156. doi:10.1111/j.1365-2419.2011.00574.x

De Robertis, A., and K. Williams. 2008. Weight-length relationships in fisheries studies: the standard allometric model should be applied with caution. Trans. Am. Fish. Soc. 137:707-719.

De Robertis, A., McKelvey, D.R., and Ressler, P.H. 2010. Development and application of empirical multi-frequency methods for backscatter classification in the North Pacific. Can. J. Fish. Aquat. Sci. 67: 1459-1474.

De Robertis, A., Wilson, C. D., Williamson, N. J., Guttormsen, M. A., & Stienessen, S. (2010). Silent ships sometimes do encounter more fish. 1. Vessel comparisons during winter pollock surveys. *ICES Journal of Marine Science*, *67*(5), 985–995. doi:10.1093/icesjms/fsp299

Dorn, M., S. Barbeaux, M. Guttormsen, B. Megrey, A. Hollowed, E. Brown, and K. Spalinger. 2002. Assessment of Walleye Pollock in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Grant, W.S. and F.M. Utter. 1980. Biochemical variation in walleye pollock *Theragra chalcogramma*: population structure in the southeastern Bering Sea and Gulf of Alaska. Can. J. Fish. Aquat. Sci. 37:1093-1100.

Grant, W. S., Spies, I., and Canino, M. F. 2010. Shifting-balance stock structure in North Pacific walleye pollock (*Gadus chalcogrammus*). – ICES Journal of Marine Science, 67:1686-1696.

Guttormsen , M. A., C. D. Wilson, and S. Stienessen. 2001. Echo integration-trawl survey results for walleye pollock in the Gulf of Alaska during 2001. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510. North Pacific Fisheries Management Council, Anchorage, AK.

Heintz, R. a., Siddon, E. C., Farley, E. V., & Napp, J. M. (2013). Correlation between recruitment and fall condition of age-0 pollock (Theragra chalcogramma) from the eastern Bering Sea under varying climate conditions. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, 150–156. doi:10.1016/j.dsr2.2013.04.006

Hinckley, S. 1987. The reproductive biology of walleye pollock, *Theragra chalcogramma*, in the Bering Sea, with reference to spawning stock structure. Fish. Bull. 85:481-498.

Hinckley, S., Napp, J. M., Hermann, a. J., & Parada, C. (2009). Simulation of physically mediated variability in prey resources of a larval fish: a three-dimensional NPZ model. *Fisheries Oceanography*, *18*(4), 201–223. doi:10.1111/j.1365-2419.2009.00505.x

Hollowed, A.B., J.N. Ianelli, P. Livingston. 2000. Including predation mortality in stock assessments: a case study for Gulf of Alaska pollock. ICES J. Mar. Sci. 57:279-293.Hughes, S. E. and G. Hirschhorn. 1979. Biology of walleye pollock, *Theragra chalcogramma*, in Western Gulf of Alaska. Fish. Bull., U.S. 77:263-274.Ianelli, J.N. 2002. Bering Sea walleye pollock stock structure using morphometric methods. Tech. Report Hokkaido National Fisheries Research Inst. No. 5, 53-58.

Honkalehto, T, and A. McCarthy. 2015. Results of the Acoustic-Trawl Survey of Walleye Pollock (*Gaddus chalcogrammus*) on the U.S. and Russian Bering Sea Shelf in June - August 2014. AFSC Processed Rep. 2015-07, 62 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115. Available from: http://www.afsc.noaa.gov/Publications/ProcRpt/ PR2015-07.pdf

Hulson, P.-J.F., Miller, S.E., Ianelli, J.N., and Quinn, T.J., II. 2011. Including mark–recapture data into a spatial age-structured model: walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 68(9): 1625–1634. doi:10.1139/f2011-060.

Hulson, P. F., Quinn, T. J., Hanselman, D. H., Ianelli, J. N. (2013). Spatial modeling of Bering Sea walleye pollock with integrated age-structured assessment models in a changing environment. Canadian Journal of Fisheries & Aquatic Sciences, 70(9), 1402-1416. doi:10.1139/cjfas-2013-0020.

Ianelli, J. N., Hollowed, A. B., Haynie, A. C., Mueter, F. J., & Bond, N. A. (2011). Evaluating management strategies for eastern Bering Sea walleye pollock (Theragra chalcogramma) in a changing environment. *ICES Journal of Marine Science*, *68*(6), 1297–1304. doi:10.1093/icesjms/fsr010

Ianelli, J.N., S. Barbeaux, T. Honkalehto, G. Walters, and N. Williamson. 2002. Bering Sea-Aleutian Islands Walleye Pollock Assessment for 2003. In Stock assessment and fishery evaluation report for the groundfish resources of the Eastern Bering Sea and Aleutian Island Region, 2002. North Pacific Fishery Management Council, Box 103136, Anchorage, AK 99510. 88p.

Ianelli, J.N., T. Honkalehto, S. Barbeaux, S. Kotwicki, K. Aydin, andWilliamson, 2015. Assessment of the walleye pollock stock in the Eastern Bering Sea, pp. 51-156. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions for 2015. North Pacific Fishery Management Council, Anchorage, AK. Available from http://www.afsc.noaa.gov/REFM/docs/2015/EBSpollock.pdf

Kendall, A.W., Jr. and S.J. Picquelle. 1990. Egg and larval distributions of walleye pollock *Theragra chalcogramma* in Shelikof Strait, Gulf of Alaska. U.S. Fish. Bull. 88(1):133-154.

Kim, S. and A.W. Kendall, Jr. 1989. Distribution and transport of larval walleye pollock (*Theragra chalcogramma*) in Shelikof Strait, Gulf of Alaska, in relation to water movement. Rapp. P.-v. Reun. Cons. int. Explor. Mer 191:127-136.

Kotenev B.N., and A.I. Glubokov. 2007. Walleye pollock *Theragra chalcogramma* from the Navarin region and adjacent waters of the Bering sea: ecology, biology and stock structure.– M.: VNIRO Publishing, 2007.

Kotwicki, S., T.W. Buckley, T. Honkalehto, and G. Walters. 2005. Variation in the distribution of walleye pollock (*Theragra chalcogramma*) with temperature and implications for seasonal migration. U.S. Fish. Bull. 103:574-587.

Kotwicki, S., A. DeRobertis, P vonSzalay, and R. Towler. 2009. The effect of light intensity on the availability of walleye pollock (Theragra chalcogramma) to bottom trawl and acoustic surveys. Can. J. Fish. Aquat. Sci. 66(6): 983–994

Kotwicki, S. and Lauth R.R. 2013. Detecting temporal trends and environmentally-driven changes in the spatial distribution of groundfishes and crabs on the eastern Bering Sea shelf. Deep-Sea Research Part II: Topical Studies in Oceanography. 94:231-243.

Kotwicki, S., Ianelli, J. N., & Punt, A. E. 2014. Correcting density-dependent effects in abundance estimates from bottom-trawl surveys. *ICES Journal of Marine Science*, *71*(5), 1107–1116.

Kotwicki, S. JN Ianelli, and André E. Punt. In press. Correcting density-dependent effects in abundance estimates from bottom trawl surveys. ICES Journal of Marine Science.

Lang, G.M., Livingston, P.A., Dodd, K.A., 2005. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1997 through 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-158, 230p. http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-158.pdf

Lang, G. M., Brodeur, R. D., Napp, J. M., & Schabetsberger, R. (2000). Variation in groundfish predation on juvenile walleye pollock relative to hydrographic structure near the Pribilof Islands, Alaska. *ICES Journal of Marine Science*, *57*(2), 265–271. doi:10.1006/jmsc.1999.0600

Livingston, P.A. 1991. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1884-1986. U. S. Dept. Commerce, NOAA Tech Memo. NMFS F/NWC-207.

Meuter, F.J. and B.L. Norcross. 2002. Spatial and temporal patterns in the demersal fish community on the shelf and upper slope regions of the Gulf of Alaska. Fish. Bull. 100:559-581.

Mueter, F.J., C. Ladd, M.C. Palmer, and B.L. Norcross. 2006. Bottom-up and top-down controls of walleye pollock (*Theragra chalcogramma*) on the Eastern Bering Sea shelf. Progress in Oceanography, Volume 68, 2:152-183.

Moss, J.H., E.V. Farley, Jr., and A.M. Feldmann, J.N. Ianelli. 2009. Spatial Distribution, Energetic Status, and Food Habits of Eastern Bering Sea Age-0 Walleye Pollock. Transactions of the American Fisheries Society 138:497–505.

Mulligan, T.J., Chapman, R.W. and B.L. Brown. 1992. Mitochondrial DNA analysis of walleye pollock, *Theragra chalcogramma*, from the eastern Bering Sea and Shelikof Strait, Gulf of Alaska. Can. J. Fish. Aquat. Sci. 49:319-326.

Olsen, J.B., S.E. Merkouris, and J.E. Seeb. 2002. An examination of spatial and temporal genetic variation in walleye pollock (*Theragra chalcogramma*) using allozyme, mitochondrial DNA, and microsatellite data. Fish. Bull. 100:752-764.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Proc. Rep. 90-01, 162 pp.

Stram, D. L., and J. N. Ianelli. 2009. Eastern Bering Sea pollock trawl fisheries: variation in salmon bycatch over time and space. *In* C. C. Krueger and C. E. Zimmerman, editors. Pacific salmon: ecology and management of western Alaska's populations. American Fisheries Society, Symposium 70, Bethesda, Maryland.

Shima, M. 1996. A study of the interaction between walleye pollock and Steller sea lions in the Gulf of Alaska. Ph.D. dissertation, University of Washington, Seattle, WA 98195.

Siddon, E. C., Heintz, R. a., & Mueter, F. J. (2013). Conceptual model of energy allocation in walleye pollock (Theragra chalcogramma) from age-0 to age-1 in the southeastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, 140–149. doi:10.1016/j.dsr2.2012.12.007

Smart, T. I., Siddon, E. C., & Duffy-Anderson, J. T. (2013). Vertical distributions of the early life stages of walleye pollock (Theragra chalcogramma) in the Southeastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, 201–210. doi:10.1016/j.dsr2.03.030

Stabeno, P.J., J.D. Schumacher, K.M. Bailey, R.D. Brodeur, and E.D. Cokelet. 1996. Observed patches of walleye pollock eggs and larvae in Shelikof Strait, Alaska: their characteristics, formation and persistence. Fish. Oceanogr. 5 (Suppl. 1): 81-91.

Takahashi, Y, and Yamaguchi, H. 1972. Stock of the Alaska pollock in the eastern Bering Sea. Bull. Jpn. Soc. Sci. Fish. 38:418-419.

von Szalay PG, Somerton DA, Kotwicki S. 2007. Correlating trawl and acoustic data in the Eastern Bering Sea: A first step toward improving biomass estimates of walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*)? Fisheries Research 86(1) 77-83.

Walline, P. D. 2007. Geostatistical simulations of eastern Bering Sea walleye pollock spatial distributions, to estimate sampling precision. ICES J. Mar. Sci. 64:559-569.

Wespestad V.G. and T.J. Quinn. II. 1997. Importance of cannibalism in the population dynamics of walleye pollock. In: Ecology of Juvenile Walleye Pollock, *Theragra chalcogramma*. NOAA Technical Report, NMFS 126.

Wespestad, V.G. 1993. The status of Bering Sea pollock and the effect of the “Donut Hole” fishery. Fisheries 18(3)18-25.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 pp.

Pacific cod (Gadus macrocephalus)

Life History and General Distribution

Pacific cod is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species’ distribution is about 34° N. latitude, with a northern limit of about 63° N. latitude. Adults are largely demersal and form aggregations during the peak spawning season, which extends approximately from February through April. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 16 to 28 days. Pacific cod larvae undergo metamorphosis at about 25 to 35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 10 cm in the eastern Bering Sea. Pacific cod can grow to be more than a meter in length, with weights in excess of 10 kg. The instantaneous rate of natural mortality is currently estimated to be 0.34 in the Bering Sea and Aleutian Islands (BSAI). Approximately 50 percent of Pacific cod are mature by age 5 in the BSAI. The maximum recorded age of a Pacific cod is 17 years in the BSAI.

Some studies of Pacific cod in the Gulf of Alaska and also some studies of Atlantic cod suggest that young-of-the-year individuals are dependent on eelgrass, but this does not appear to be the case in the EBS. In contrast to other parts of the species’ range, where sheltered embayments are key nursery grounds, habitat use of age 0 Pacific cod in the EBS seems to occur along a gradient from coastal-demersal (bottom depths < 50 m) to shelf-pelagic (bottom depths 60-80 m), although densities near the coastal waters of the Alaska peninsula are much higher than elsewhere. Evidence of density-dependent habitat selection at the local scale has been found, but no consistent shift in distribution of juvenile Pacific cod in response to interannual climate variability.

Adult Pacific cod are widely distributed across the EBS, to depths of 500 m, and are routinely captured in every stratum of the annual EBS shelf bottom trawl survey. However, adult Pacific cod do display temperature preferences, and EBS shelf bottom trawl survey catch rates in excess of 50 kg/ha are seldom observed inside the 0 degree bottom temperature isotherm. On average, adult Pacific cod are strongly associated with the seafloor. However, diel vertical migration has also been observed, with patterns varying significantly by location, bottom depth, and time of year (daily depth changes averaging 8 m).

Pacific cod in the EBS form large spawning aggregations. Spawning concentrations have been north of Unimak Island, in the vicinity of the Pribilof Islands, at the shelf break near Zhemchug Canyon, and adjacent to islands in the central and western Aleutian Islands along the continental shelf. It has been speculated that variations in spawning time may be temperature-related, and temperature impacts on survival and hatching of eggs and development of embryos and larvae have been demonstrated.

Relevant Trophic Information

Age 0 (juvenile) Pacific cod in the EBS have been shown to consume primarily age 0 walleye pollock, euphausiids, large copepods, snow and Tanner crab larvae, sea snails, and arrow worms. This diet may vary with temperature, with high proportions of age 0 walleye pollock during warm years and a shift to euphausiids and large copepods during cool years. For comparison to other parts of the species' range, age 0 Pacific cod in the Gulf of Alaska have been found to prey mainly on small calanoid copepods, mysids, and gammarid amphipods; and near the Kuril Islands and Kamchatka, age 0 walleye pollock have been found to play a major role in the diet of juvenile Pacific cod.

Adult Pacific cod in the EBS have been shown to be significant predators of snow and Tanner crab in the eastern Bering Sea. Based on stomach contents of adult Pacific cod sampled in annual EBS shelf bottom trawl surveys from 1997-2001, hermit crab, snow crab, Tanner crab, walleye pollock, eelpout, and fishery offal all contributed at least 5% of the diet by weight in at least one survey year, with walleye pollock being by far the most important prey item by weight (average across years = 45%). For comparison to other parts of the species' range, adult Pacific cod in the western Gulf of Alaska have been shown to consume primarily eelpouts, Tanner crab, crangonid shrimp, hermit crab, and polychaetes.

Predators of Pacific cod include halibut, salmon shark, northern fur seals, sea lions, harbor porpoises, various whale species, and tufted puffin.

Habitat and Biological Associations

Egg/Spawning: Spawning takes place in the sublittoral-bathyal zone (40 to 290 m) near the bottom. Eggs sink to the bottom after fertilization, and are somewhat adhesive. Optimal temperature for incubation is 3 to 6 °C, optimal salinity is 13 to 23 ppt, and optimal oxygen concentration is from 2 to 3 ppm to saturation. Little is known about the optimal substrate type for egg incubation.

Larvae: Larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, moving downward in the water column as they grow.

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 60 to150 m.

Adults: Adults occur in depths from the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand.

Habitat and Biological Associations: Pacific cod

Stage - EFH Level	Duration or Size	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	16-28 days	NA	winter–spring	U	D	M, SM, MS ,S	U	optimum 3–6°C optimum salinity 13–23 ppt
Larvae	U77-132 days, to 3.5 cm	NA	winter–spring	MCS, OCS	P	M, SM, MS, S	U	
Early Juveniles	to 9 cm	small calanoid copepods, mysids, gammarid amphipods	winter-spring	MCS, OCS	D	M, SM, MS, S	U	
Late Juveniles	to 46 cm	invertebrates, pollock, flatfish, fishery discards,	all year	ICS, MCS, OCS	D	M, SM, MS, S, CB, G, SAV	U	
Adults	>46 cm	pollock, flatfish, fishery discards, crab	spawning (Feb-Apr)	ICS, MCS, OCS	D	M, SM, MS, S, CB, G	U	
			non-spawning (May-Jan)	ICS, MCS, OCS				

Literature

Abookire, A.A., J.F. Piatt, and B.L. Norcross. 2001. Juvenile groundfish habitat in Kachemak Bay, Alaska, during late summer. Alaska Fishery Research Bulletin 8(1):45-56.

Abookire, A.A., J.T. Duffy-Anderson, and C.M. Jump. 2007. Habitat associations and diet of young-of-the-year Pacific cod (*Gadus macrocephalus*) near Kodiak, Alaska. Marine Biology 150:713-726.

Albers, W.D., and P.J. Anderson. 1985. Diet of Pacific cod, *Gadus macrocephalus*, and predation on the northern pink shrimp, *Pandalus borealis*, in Pavlof Bay, Alaska. Fish. Bull., U.S. 83:601-610.

Alderdice, D.F., and C.R. Forrester. 1971. Effects of salinity, temperature, and dissolved oxygen on early development of the Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 28:883-902.

Bakkala, R.G. 1984. Pacific cod of the eastern Bering Sea. Int. N. Pac. Fish. Comm. Bull. 42:157-179.

Bakkala, R.G.,Westrheim, S. Mishima, C. Zhang, and E. Brown. 1984. Distribution of Pacific cod (*Gadus macrocephalus*) in the North Pacific Ocean. Int. N. PacComm42:111-115.

Bian, X., X. Zhang, Y. Sakurai, X. Jin, T. Gao, R. Wan, and J. Yamamoto. 2014. Temperature-mediated survival, development and hatching variation of Pacific cod *Gadus macrocephalus* eggs. J.Biol. 84:85-105.

Bian, X., X. Zhang, Y. Sakurai, X. Jin, R. Wan, T. Gao, and J. Yamamoto. 2016. Interaction effects of incubation temperature and salinity on the early life stages of pacific cod Gadus macrocephalus. Deep-Sea Research II 124:117-128.

Brodeur, R.D., and W. C. Rugen. 1994. Diel vertical distribution of ichthyoplankton in the northern Gulf of Alaska. Fish. Bull., U.S. 92:223-235.

Conners, M.E., and P. Munro. 2008. Effects of commercial fishing on local abundance of Pacific cod (Gadus macrocephalus) in the Bering SeaBull. 106:281-292.

Doyle, M.J., S.J. Picquelle, K.L. Mier, M.C. Spillane, and N.A. Bond. 2009. Larval fish abundance and physical forcing in the Gulf of Alaska, 1981-2003. Prog. Oceanogr. 2009:163-187.

Dunn, J.R., and A.C. Matarese. 1987. A review of the early life history of northeast Pacific gadoid fishes. Fish. Res. 5:163-184.

Farley, E.V. Jr., R.A. Heintz, A.G. Andrews, and T.P. Hurst. In press. Size, diet, and condition of age-0 Pacific cod (*Gadus macrocephalus*) during warm and cool climate states in the eastern Bering Sea. Deep-Sea Res. II.

Forrester, C.R., and D.F. Alderdice. 1966. Effects of salinity and temperature on embryonic development of Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 23:319-340.

Hirschberger, W.A., and G.B. Smith. 1983. Spawning of twelve groundfish species in Alaska and Pacific Coast regions, 1975-81. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS F/NWC-44. 50 p.

Hurst, T.P., D.W. Cooper, J.T. Duffy-Anderson, and E.V. Farley. 2015. Contrasting coastal and shelf nursery habitats of Pacific cod in the southeastern Bering Sea. ICES J. Scie. 75:515-527.

Hurst, T.P., D.W. Cooper, J.S. Scheingross, E.M. Seale, B.J. Laurel, and M.L. Spencer. 2009. Effects of ontogeny, temperature, and light on vertical movements of larval Pacific cod (*Gadus macrocephalus).* Fisheries Oceanography 18:301-311.

Hurst, T.P., B.J. Laurel, and L. Ciannelli 2010. Ontogenetic patterns and temperature-dependent growth rates in the early life stages of Pacific cod (*Gadus macrocephalus*).108:382-392.

Hurst, T.P., J.H. Moss, and J.A. Miller. 2012. Distributional patterns of 0-group Pacific cod (*Gadus macrocephalus*) in the eastern Bering Sea under variable recruitment and thermal conditions. ICES J. Mar69:163-174.

Hurst, T.P., S.B. Munch, K.A. Lavelle. 2012. Thermal reaction norms for growth vary among cohorts of Pacific cod (*Gadus macrocephalus*). Mar. Biol. 159:2173-2183.

Ketchen, K.S. 1961. Observations on the ecology of the Pacific cod (*Gadus macrocephalus*) in Canadian waters. J. Fish. Res. Board Can. 18:513-558.

Laman, E.A., C.N. Rooper, S. Rooney, K. Turner, D. Cooper, and M. Zimmermann. In press. Model-based essential fish habitat definitions for eastern Bering Sea groundfish species. xxx.

Lang, G.M., P.A. Livingston, and K.A. Dodd. 2005. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1997 through 2001. NOAA .

Laurel, B.J., L.A. Copeman, and C.C. Parrish. 2012. Role of temperature on lipid/fatty acid composition in Pacific cod (*Gadus macrocephalus*) eggs and unfed larvae. Mar. Biol. 159:2025-2034.

Laurel, B.J., T.P. Hurst, and L. Ciannelli. 2011. An experimental examination of temperature interactions in the match-mismatch hypothesis for Pacific cod larvae. Can. J. Fish. Aquat. Sci. 68:51-61.

Laurel, B.J., T.P. Hurst, L.A. Copeman, and M. W. Davis. 2008. The role of temperature on the growth and survival of early and late hatching Pacific cod larvae (*Gadus macrocephalus*). Journal of Plankton Research 30:1051-1060.

Laurel, B.J., C.H. Ryer, B. Knoth, and A.W. Stoner. 2009. Temporal and ontogenetic shifts in habitat use of juvenile Pacific cod (*Gadus macrocephalus*). Journal of Experimental Marine Biology and Ecology 377:28-35.

Laurel, B.J., A.W. Stoner, C.H. Ryer, T.P. Hurst, and A.A. Abookire. 2007. Comparative habitat associations in juvenile Pacific cod and other gadids using seines, baited cameras and laboratory techniques. 2007. Journal of Experimental Marine Biology and Ecology 351:42-55.

Livingston, P.A. 1989. Interannual trends in Pacific cod, *Gadus macrocephalus*, predation on three commercially important crab species in the eastern Bering Sea. Fish. Bull., U.S. 87:807-827.

Livingston, P.A. 1991. Pacific cod. *In* P.A. Livingston (editor), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1984 to 1986, p. 31-88. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS F/NWC-207.

Matarese, A.C., A.W. Kendall Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dept. Commerce, NOAA Tech. Rep. NMFS 80. 652 p.

Moiseev, P.A. 1953. Cod and flounders of far eastern waters. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 40. 287 p. (Transl. from Russian: Fish. Res. Board Can. Transl. Ser. 119.)

Moss, J.H., M.F. Zaleski, R.A. Heintz. In press. Distribution, diet, and energetic condition of age-0 walleye pollock (Gadus chalcogrammus) and Pacific cod (*Gadus macrocephalus*) inhabiting the Gulf of Alaska. Deep-Sea Res. II.

National Oceanic and Atmospheric Administration (NOAA). 1987. Bering, Chukchi, and Beaufort Seas--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service.

National Oceanic and Atmospheric Administration (NOAA). 1990. West coast of North America--Coastal and ocean zones strategic assessment: Data Atlas. U.S. Dept. Commerce, NOAA, National Ocean Service and National Marine Fisheries Service.

Neidetcher, S.K., T.P. Hurst, L. Ciannelli, and E.A. Logerwell. 2014. Spawning phenology and geography of Aleutian Islands and eastern Bering Sea Pacific cod (*Gadus macrocephalus*). Deep-Sea Res. II 109:204-214.

Nichol, D.G., T. Honkalehto, and G.G. Thompson. Proximity of Pacific cod to the sea floor: Using archival tags to estimate fish availability to research bottom trawls. Fish. Res. 86:129-135.

Nichol, D.G., S. Kotwicki, and M. Zimmerman. 2013. Diel vertical migration of adult Pacific cod *Gadus macrocephalus* in Alaska. J. Fish Biol. 83:170-189.

Parker-Stetter, S.L., J.K. Horne, E.V. Farley, D.H. Barbee, A.G. Andrews III, L.B. Eisner, and J.M. Nomura. Summer distributions of forage fish in the eastern Bering Sea. Deep-Sea Res. II 94:211-230.

Phillips, A.C., and J.C. Mason. 1986. A towed, self-adjusting sled sampler for demersal fish eggs and larvae. Fish. Res. 4:235-242.

Poltev, Yu.N. 2007. Specific features of spatial distribution of Pacific cod Gadus macrocephalus in waters off the eastern coast of the northern Kuril Islands and the southern extremity of Kamchatka. Journal of Ichthyology 47:726-738.

Poltev, Yu.N., and D.Yu. Stominok. 2008. Feeding habits of the Pacific cod Gadus macrocephalus in oceanic waters of the northern Kuril Islands and southeast Kamchatka. Russ. J. Mar. Biol. 34:316-324.

Rugen, W.C., and A.C. Matarese. 1988. Spatial and temporal distribution and relative abundance of Pacific cod (*Gadus macrocephalus*) larvae in the western Gulf of Alaska. NWAFC Proc. Rep. 88-18. Available from Alaska Fish. Sci. Center, 7600 Sand Point Way NE., Seattle, WA 98115-0070.

Sakurai, Y., and T. Hattori. 1996. Reproductive behavior of Pacific cod in captivity. Fish.Sci. 62:222-228.

Savin, A.B. 2008. Seasonal distribution and migrations of Pacific cod *Gadus macrocephalus* (Gadidae) in Anadyr Bay and adjacent waters. Journal of Ichthyology 48:610-621.

Shi, Y., D. R. Gunderson, P. Munro, and J. D. Urban. 2007. Estimating movement rates of Pacific cod (*Gadus macrocephalus*) in the Bering Sea and the Gulf of Alaska using mark-recapture methods. NPRB Project 620 Final Report. North Pacific Research Board, 1007 West 3rd Avenue, Suite 100, Anchorage, AK 99501.

Shimada, A.M., and D.K. Kimura. 1994. Seasonal movements of Pacific cod, *Gadus macrocephalus*, in the eastern Bering Sea and adjacent waters based on tag-recapture data. Fish. Bull. 92:800-816.

Spies, I. 2012. Landscape genetics reveals population subdivision in Bering Sea and Aleutian Islands Pacific cod. TSoci. 141:1557-1573.

Stark, J.W.Geographic and seasonal variations in maturation and growth of female Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska and Bering Sea. Fish. Bull. 105:396-407.

Stone, R.P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25:229-238.

Strasburger, W.W., N. Hillgruber, A.I. Pinchuk, and F.J. MueterFeeding ecology of age-0 walleye pollock (*Gadus chalcogrammus*) and Pacific cod (*Gadus macrocephalus*) in the southeastern Bering Sea. Deep-Sea Res. II 109:172-180.

Thompson, G.G., and W.A. Palsson. 2015. Assessment of the Pacific cod stock in the Aleutian Islands. In Plan Team for Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 471-613. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G.G. 2015. Assessment of the Pacific cod stock in the Eastern Bering Sea. *In* Plan Team for Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 251-470. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thomson, J.A. On the demersal quality of the fertilized eggs of Pacific cod, *Gadus macrocephalus* Tilesius. 1963. J. Fish. Res. Board Can. 20:1087-1088.

Turner, K., C.N. Rooper, S. Rooney, E. Laman, D. Cooper, and M. Zimmermann. In press. Model-based essential fish habitat definitions for Aleutian Islands groundfish species. NOAA Tech. Memo. NMFS-AFSC-xxx.

Westrheim, S.J. 1996. On the Pacific cod (*Gadus macrocephalus*) in British Columbia waters, and a comparison with Pacific cod elsewhere, and Atlantic cod (*G. morhua*). Can. Tech. Rep. Fish. Aquat. Sci. 2092. 390 p.

Yang, M.-S. 2004. Diet changes of Pacific cod (*Gadus macrocephalus*) in Pavlof Bay associated with climate changes in the Gulf of Alaska between 1980 and 1995. Fish. Bull. 102:400-405.

Yeung, C., and R.A. McConnaughey. 2008. Using acoustic backscatter from a sidescan sonar to explain fish and invertebrate distributions: a case study in Bristol Bay, Alaska. ICES Journal of Marine Science 65:242-254.

Sablefish (Anoplopoma fimbria)

Life History and General Distribution

Sablefish are distributed from Mexico through the GOA to the Aleutian Chain, Bering Sea, along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatka Peninsula. Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords such as Prince William Sound and southeast Alaska, at depths generally greater than 200 m. Adults are assumed to be demersal because they are caught in bottom trawls and with bottom longline gear. Spawning or very ripe sablefish are observed in late winter or early spring along the continental slope. Eggs are released near the bottom where they incubate. After hatching and yolk adsorption, the larvae rise to the surface, where they have been collected with neuston nets. Larvae are oceanic through the spring and by late summer, small pelagic juveniles (10 to 15 cm) have been observed along the outer coasts of Southeast Alaska, where they move into shallow waters to spend their first winter. During most years, there are only a few places where juveniles have been found during their first winter and second summer. It is not clear if the juvenile distribution is highly specific or appears so because sampling is sparse. During the occasional times of large year-classes, the juveniles are easily found in many inshore areas during their second summer. They are typically 30 to 40 cm long during their second summer, after which they leave the nearshore bays. One or two years later, they begin appearing on the continental shelf and move to their adult distribution as late juvniles or mature adults (Hanselman et al. 2015).

Pelagic ocean conditions appear to determine when strong young-of-the-year survival occurs. Water mass movements and temperature appear to be related to recruitment success (Sigler et al. 2001). Above-average young of the year survival was somewhat more likely with northerly winter currents and much less likely for years when the drift was southerlyRecruitment success also appeared related to water temperature and the position of the North Pacific Polar Front in the fall before spawning (Shotwell et al.

2014). Another study linked recent recruitment variability to high chlorophyll *a* and juvenile pink salmon abundance in Southeast Alaska (Martinson et al.2015). Recruitment success did not appear to be directly related to the presence of El Niño or eddies, but these phenomena could potentially influence recruitment indirectly in years following their occurrence (Sigler et al. 2001).

While pelagic oceanic conditions determine the egg, larval, and juvenile survival through their first summer, juvenile sablefish spend 3 to 4 years in demersal habitat along the shorelines and continental shelf before they recruit to their adult habitat, primarily along the upper continental slope, outer continental shelf, and deep gullies. As juveniles in the inshore waters and on the continental shelf, they are subject to myriad factors that determine their ability to grow, compete for food, avoid predation, and otherwise survive to adults. Perhaps increased competition from predators of juveniles such as the large increases of arrowtooth flounder, have limited the ability of the large year classes that, though abundant at the young-of-the-year stage, survive to adults.

The size at 50 percent maturity is 65 cm for males in the Bering Sea, and 67 cm for females. In the Aleutian Islands, size at 50 percent maturity is 61 cm for males, and 65 cm for females; and in the Gulf of Alaska, it is 57 cm for males, and 65 cm for females. At the end of the second summer (approximately 1.5 years old) they are 35 to 40 cm in length.

Relevant Trophic Information

Larval sablefish feed on a variety of small zooplankton ranging from copepod nauplii to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids).

Gao et al. (2004) studied stable isotopes in otoliths of juvenile sablefish from Oregon and Washington and found that as the fish increased in size they shifted from midwater prey to more benthic prey. In nearshore southeast Alaska, juvenile sablefish (20-45 cm) diets included fish such as Pacific herring and smelts and invertebrates such as krill, amphipods and polychaete worms (Coutré et al. 2015). In late summer, juvenile sablefish also consumed post-spawning pacific salmon carcass remnants in high volume revealing opportunistic scavenging (Coutré et al. 2015). Young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the Southeast Alaska troll fishery during the late summer.

In their demersal stage, juvenile sablefish less than 60 cm feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson 2000, Yang et al. 2006) while sablefish greater than 60 cm feed more on fish. Both juvenile and adult sablefish are considered opportunistic feeders. Fish most important to the sablefish diet include pollock, eulachon, capelin, Pacific herring, Pacific cod, Pacific sand lance, and some flatfish, with pollock being the most predominant (10 to 26 percent of prey weight, depending on year). Squid, euphausiids, pandalid shrimp, Tanner crabs, and jellyfish were also found, squid being the most important of the invertebrates (Yang and Nelson 2000, Yang et al. 2006). Feeding studies conducted in Oregon and California found that fish made up 76 percent of the adult sablefish diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids were the dominant prey (Tanasichuk 1997). Among other groundfish in the GOA, the diet of sablefish overlaps mostly with that of large flatfish, arrowtooth flounder and Pacific halibut (Yang and Nelson 2000).

Nearshore residence during their second year provide the opportunity to feed on salmon fry and smolts during the summer months, while young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the southeast Alaska troll fishery during the late summer.

Habitat and Biological Associations

The estimated productivity and sustainable yield of the combined GOA, Bering Sea, and Aleutian Islands sablefish stock have declined steadily since the late 1970s. This is demonstrated by a decreasing trend in recruitment and subsequent estimates of biomass reference points and the inability of the stock to rebuild to the target biomass levels despite the decreasing level of the targets and fishing rates below the target fishing rate. There were episodic years of strong recruitment in the current physical regime starting in 1977. Since 2000, there has only been one year class that has exceeded the average level. This period of low-recruitment appears to be related to environmental conditions in the larval to settlement stages of the sablefish early life history.

Habitat and Biological Associations: Sablefish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	14–20 days	NA	late winter–early spring: Dec–Apr	USP, LSP, BSN	P, 200–3,000 m	NA	U	
Larvae	up to 3 months	copepod nauplii, small copepodites	spring–summer: Apr–July	MCS, OCS, USP, LSP, BSN	N, neustonic near surface	NA	U	
Early Juveniles	to 3 yrs	small prey fish, sandlance, salmon, herring, polychaete worms, krill, and salmon caracasess near stream mouths		OCS, MCS, ICS, during first summer, then observed in BAY, IP, till end of 2nd summer; not observed till found on shelf	P when offshore during first summer, then D, SD/SP when inshore	NA when pelagic. The bays where observed were soft bottomed, but not enough observed to assume typical.	U	
Late Juveniles	3–5 yrs	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	all year	continental slope, and deep shelf gulleys and fjords.	caught with bottom tending gear. presumably D	varies	U	
Adults	5 yrs to 35+	opportunistic: other fish, shellfish, worms, squid, jellyfish, fishery discards	apparently year round, spawning movements (if any) are undescribed	continental slope, and deep shelf gulleys and fjords.	caught with bottom tending gear. presumably D	varies	U	

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and Zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commer., NOAAS Tech. Rept. NMFS 66, 151 p.

Boehlert, G.W., and M.M. Yoklavich. 1985. Larval and juvenile growth of sablefish, Anoplopoma fimbria, as determined from otolith increments. Fish. Bull. 83:475-481.

Coutré, K. M., A.H. Beaudreau, and P.W. Malecha. 2015. Temporal Variation in Diet Composition and Use of Pulsed Resource Subsidies by Juvenile Sablefish. Transactions of the American Fisheries Society, 144(4), 807-819.

Fredin, R. A. 1987. History of regulation of Alaska groundfish fisheries. NWAFC Processed Report 87_07.

Gao, Y., S.H. Joner, R.A. Svec, and K.L. Weinberg. 2004. Stable isotopic comparison in otoliths of juvenile sablefish (Anoplopoma fimbria) from waters off the Washington and Oregon coast. Fisheries Research, 68(1), 351-360.

Grover, J.J., and B.L. Olla. 1986. Morphological evidence for starvation and prey size selection of sea-caught larval sablefish, Anoplopoma fimbria. Fish. Bull. 84:484-489.

Grover, J.J., and B.L. Olla. 1987. Effects of and El Niño event on the food habits of larval sablefish, Anoplopoma fimbria, off Oregon and Washington. Fish. Bull. 85: 71-79.

Grover, J.J., and B.L. Olla. 1990. Food habits of larval sablefish, Anoplopoma fimbria from the Bering Sea. Fish Bull. 88:811-814.

Hanselman, D.H., J. Heifetz, K.B. Echave, and S.C. Dressel. 2015. Move it or lose it: Movement and mortality of sablefish tagged in Alaska. Canadian Journal of Fish and Aquatic Sciences. http://www.nrcresearchpress.com/doi/abs/10.1139/cjfas-2014-0251

Hanselman, D.H., C. Lunsford, and C. Rodgveller. 2015. Assessment of the sablefish stock in Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Hunter, J.R., B.J. Macewiccz, and C.A. Kimbrell. 1989. Fecundity and other aspects of the reproduction of Sablefish, Anoplopoma fimbria, in Central California Waters. Calif. Coop. Fish. Invst. Rep. 30: 61-72.

Kendall, A.W., Jr., and A.C. Matarese. 1984. Biology of eggs, larvae, and epipelagic juveniles of sablefish, Anoplopoma fimbria, in relation to their potential use in management. Mar. Fish. Rev. 49(1):1-13.

Laidig, T. E., P. B. Adams, and W. M. Samiere. 1997. Feeding habits of sablefish, *Anoplopoma fimbria*, off the coast of Oregon and California. *In* M. Saunders and M. Wilkins (eds.). Proceedings of the International Symposium on the Biology and Management of Sablefish. pp 65-80. NOAA Tech. Rep. 130. Mason, J.C. , R.J. Beamish, and G.A. McFralen. 1983. Sexual maturity, fecundity, spawning, and early life history of sablefish (Anoplopoma fimbria) off the Pacific coast of Canada. Can. J. Fish. Aquat. Sci. 40:2121-2134.

McFarlane, G.A., and R.J. Beamish. 1992. Climatic influence linking copepod production with strong year-classes in sablefish, Anoplopoma fimbria. Can J. Fish. Aquat. Sci. 49:743-753.

Moser, H.G., R.L. Charter, P.E. Smith, N.C.H. Lo., D.A. Ambrose, C.A. Meyer, E.M. Sanknop, and W. Watson. 1994. Early life history of sablefish, Anoplopoma fimbria, off Washington, Oregon, and California with application to biomass estimation. Calif. Coop. Oceanic Fish. Invest. Rep. 35:144-159.

NOAA (National Oceanic and Atmospheric Administration). 1990. Sablefish, Anoplopoma fimbria. Pl 3.2.22. In: West Coast of North America Coastal and Ocean Zones Strategic Assessment Data Atlas. Invertebrate and Fish Volume. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessment Division, Strategic Assessment Branch.

Rodgveller, C.J., Stark, J.W., Echave, K.B. and Hulson, P.J.F., 2016. Age at maturity, skipped spawning, and fecundity of female sablefish (Anoplopoma fimbria) during the spawning season. Fishery Bulletin, 114(1).

Rutecki, T.L. and E.R. Varosi. 1993. Distribution, age, and growth of juvenile sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Rutecki, T.L. and E.R. Varosi. 1993. Migrations of Juvenile Sablefish in Southeast Alaska. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sasaki, T. 1985. Studies on the sablefish resources in the North Pacific Ocean. Bulletin 22, (1-108), Far Seas Fishery Laboratory. Shimizu, 424, Japan.

Shotwell, S.K., D.H. Hanselman, and I.M. Belkin. 2014. Toward biophysical synergy: Investigating advection along the Polar Front to identify factors influencing Alaska sablefish recruitment. Deep-Sea Res. II, http://dx.doi.org/10.1016/j.dsr2.2012.08.024.

Sigler, M.F., E.R. Varosi, and T.R. Rutecki. 1993. Recruitment curve for sablefish in Alaska based on recoveries of fish tagged as juveniles. Paper presented at International Symposium on the Biology and Management of Sablefish. Seattle, Wash. April 1993.

Sigler, M. F., T. L. Rutecki, D. L. Courtney, J. F. Karinen, and M.-S.Yang. 2001. Young-of-the-year sablefish abundance, growth, and diet. Alaska Fisheries Research Bulletin 8(1): 57-70.

Smith, G.B., G.E. Walters, P.A. Raymore, Jr., and W.A, Hischberger. 1984. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part I, Three-year comparisons. NOAA Tech. Memo. NMFS F/NWC-59. 100p.Tanasichuk, R. W. 1997. Diet of sablefish, *Anoplopoma fimbria*, from the southwest coast of Vancouver Island. *In* M. Saunders and M. Wilkins (eds.). Proceedings of the International Symposium on the Biology and Management of Sablefish. pp 93-98. NOAA Tech. Rep. 130.

Tanasichuk, R. W. 1997. Diet of sablefish, Anoplopoma fimbria, from the southwest coast of Vancouver Island. In M. Saunders and M. Wilkins (eds.). Proceedings of the International Symposium on the Biology and Management of Sablefish. pp 93-98. NOAA Tech. Rep. 130.

Umeda, Y., T. Sample, and R. G. Bakkala. 1983. Recruitment processes of sablefish in the EBS. In Proceedings of the International Sablefish Symposium March 1983, Anchorage, Alaska. Alaska Sea Grant Report 83-8.

Walters, G.E., G.B. Smith, P.A. Raymore, and W.A. Hirschberger. 1985. Studies of the distribution and abundance of juvenile groundfish in the northwestern Gulf of Alaska, 1980-82: Part II, Biological characteristics in the extended region. NOAA Tech. Memo. NMFS F/NWC-77. 95 p.

Wing, B.L. 1985. Salmon Stomach contents from the Alaska Troll Logbook Program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91, 41 p.

Wing, B.L. 1997. Distribution of sablefish, Anoplopoma fimbria, larvae in the eastern Gulf of Alaska: Neuston-net tows versus oblique tows. In: M. Wilkins and M. Saunders (editors), Proc. Int. Sablefish Symp., April 3-4, 1993, p. 13-25.. U.S. Dep. Commer., NOAA Tech. Rep. 130.

Wing, B.L. and D.J. Kamikawa. 1995. Distribution of neustonic sablefish larvae and associated ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-53, 48 p.

Wing, B.L., C. Derrah, and V. O'Connell. 1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-376, 42 p.

Witherell, D. 1997. A brief history of bycatch management measures for EBS groundfish fisheries. Marine Fisheries ReviewWolotera, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. NOAA Tech. Memo. NMFS-AFSC-22. 150 p.

Yang, M-S. and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the GOA in 1990, 1993, and 1996. NOAA Technical Memorandum NMFS-AFSC-112.

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. NOAA Technical Memorandum NMFS-AFSC-164.

Yasumiishi, E., Shotwell, S.K., Hanselman, D.H., Orsi, J., and Ferguson, E. 2015. Using Salmon Survey and Commercial Fishery Data to Index Nearshore Rearing Conditions and Recruitment of Alaskan Sablefish. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 7: 312-324.

Yellowfin sole *(Limanda aspera)*

Life History and General Distribution

Yellowfin sole are distributed in North American waters from off British Columbia, Canada, (approximately latitude 49° N.) to the Chukchi Sea (about latitude 70° N.) and south along the Asian coast to about latitude 35° N. off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water. Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 25 to 45 cm long. Eggs have been found to the limits of inshore ichthyoplankton sampling over a widespread area to at least as far north as Nunivak Island. Larvae have been measured at 2.2 to 5.5 mm in July and 2.5 to 12.3 mm in late August and early September. The age or size at metamorphosis is unknown. Upon settlement in nearshore areas, juveniles preferentially select sediment suitable for feeding on meiofaunal prey and burrowing for protection. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. The estimated age of 50 percent maturity is 10.5 years (approximately 29 cm) for females based on samples collected in 1992 and 1993 and 10.14 from an updated study using 2012 collections. Natural mortality rate is believed to range from 0.12 to 0.16.

The approximate upper size limit of juvenile fish is 27 cm.

Relevant Trophic Information

Groundfish predators include Pacific cod, skates, and Pacific halibut, mostly on fish ranging from 7 to 25 cm standard length.

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, usually inhabiting shallow areas.

Adults: Summertime spawning and feeding on sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding mainly on bivalves, polychaete, amphipods, and echiurids. Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures, feeding diminishes.

Habitat and Biological Associations: Yellowfin sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	summer	BAY, BCH	P			
Larvae	2–3 months?	U phyto/zoo plankton?	summer autumn?	BAY, BCH ICS	P			
Early Juveniles	to 5.5 yrs	polychaete bivalves amphipods echiurids	all year	BAY, ICS OCS	D	S, SM		
Late Juveniles	5.5 to 10 yrs	polychaete bivalves amphipods echiurids	all year	BAY, ICS OCS	D	S, SM, MS		
Adults	10+ years	polychaete bivalves amphipods echiurids	spawning/ feeding May–August non-spawning Nov–April	BAY BCH ICS, MCS OCS	D	S, SM, MS, M	ice edge	

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Bakkala, R.G., V.G. Wespestad, and L.L. Low. 1982. The yellowfin sole (*Limanda aspera*) resource of the eastern Bering Sea—Its current and future potential for commercial fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-33, 43 p.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the Bering Sea and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA as TT 67-51206.

Kashkina, A.A. 1965. Reproduction of yellowfin sole (*Limanda aspera*) and changes in its spawning stocks in the eastern Bering Sea. Tr. Vses. Nauchno-issled, Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Rbn. Khoz. Okeanogr. 53):191-199. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 182-190. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part IV. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51206.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Moles, A., and B. L. Norcross. 1995. Sediment preference in juvenile Pacific flatfishes. Netherlands J. Sea Res. 34(1-3):177-182 (1995).

Musienko, L.N. 1963. Ichthyoplankton of the Bering Sea (data of the Bering Sea expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P.A.

Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P.A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Nichol, D.G. 1994. Maturation and Spawning of female yellowfin sole in the Eastern Bering Sea. Preceding of the International North Pacific Flatfish Symposium, Oct. 26-28, 1994, Anchorage, AK. Alaska Sea Grant Program.

TenBrink, T., and T. Wilderbuer. 2015. Updated maturity estimates for flatfishes (Pleuronectidae) in the Eastern Bering Sea, with implications for fisheries management. Mar. Coast. Fish. Dynam, Manage, Ecosys. Sci. DOI: 10.1080/19425120.2015.1091411.

Wakabayashi, K. 1986. Interspecific feeding relationships on the continental shelf of the eastern Bering Sea, with special reference to yellowfin sole. Int. N. Pac. Fish. Comm. Bull. 47:3-30.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The eastern Bering Sea shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

Wilderbuer, T.K., G.E. Walters, and R.G. Bakkala. 1992. Yellowfin sole, Pleuronectes asper, of the Eastern Bering Sea: Biological Characteristics, History of Exploitation, and Management. Mar. Fish. Rev. 54(4) p 1-18.

Wilderbuer, T.K., D.G. Nichol, and J. Ianelli. 2010. Yellowfin sole. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 565-644.

Yeung, C, and M. Yang. 2014. Habitat and infauna prey availability for flatfishes in the northern Bering Sea. Polar. Biol (2014) 37:1669-1784.

Yeung, C, M. Yang, S. Jewett, A. Naidu. 2013. Polychaete assemblage as surrogate for prey availability in assessing southeastern Bering Sea flatfish habitat. J. Sea Res. 76(2013)211-221.

Greenland turbot (Reinhardtius hippoglossoides)

Life History and General Distribution

Greenland turbot has an amphiboreal distribution, occurring in the North Atlantic and North Pacific. In the North Pacific, species abundance is centered in the eastern Bering Sea and, secondly, in the Aleutian Islands. On the Asian side, they occur in the Gulf of Anadyr along the Bering Sea coast of Russia, in the Okhotsk Sea, around the Kurile Islands, and south to the east coast of Japan to northern Honshu Island (Hubbs and Wilimovsky 1964, Mikawa 1963, Shuntov 1965). Adults exhibit a benthic lifestyle, living in deep waters of the continental slope but are known to have a tendency to feed off the sea bottom. During their first few years as immature fish, they inhabit relatively shallow continental shelf waters (less than 200 m) until about age 4 or 5 before joining the adult population (200 to 1,000 m or more, Templeman 1973). Adults appear to undergo seasonal shifts in depth distribution moving deeper in winter and shallower in summer (Chumakov 1970, Shuntov 1965). Spawning is reported to occur in winter in the eastern Bering Sea and may be protracted starting in September or October and continuing until March with an apparent peak period in November to February (Shuntov 1965, Bulatov 1983). Females spawn relatively small numbers of eggs with fecundity ranging from 23,900 to 149,300 for fish 83 cm and smaller in the Bering Sea (D’yakov 1982).

Eggs and early larval stages are benthypelagic (Musienko 1970). In the Atlantic Ocean, larvae (10 to 18 cm) have been found in benthypelagic waters which gradually rise to the pelagic zone in correspondence to absorption of the yolk sac which is reported to occur at 15 to 18 mm with the onset of feeding (Pertseva-Ostroumova 1961). The period of larval development extends from April to as late as August or September (Jensen 1935) which results in an extensive larval drift and broad dispersal from the spawning waters of the continental slope. Metamorphosis occurs in August or September at about 7 to 8 cm in length at which time the demersal life begins. Juveniles are reported to be quite tolerant of cold temperatures to less than 0 °C (Hognestad 1969) and have been found on the northern part of the Bering Sea shelf in summer trawl surveys (Alton et al. 1988).

The age of 50 percent maturity is estimated to range from 5 to 10 years (D'yakov 1982, 60 cm used in stock assessment) and a natural mortality rate of 0.112 has been used in the most recent stock assessments (Barbeaux et al. 2015). The approximate upper size limit of juvenile fish is 59 cm.

Relevant Trophic Information

Groundfish predators include Pacific cod, pollock, and yellowfin sole, mostly on fish ranging from 2 to 5 cm standard length (probably age 0).

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for up to 9 months until metamorphosis occurs, usually with a widespread distribution inhabiting shallow waters. Juveniles live on the continental shelf until about age 4 or 5 feeding primarily on euphausiids, polychaetes, and small walleye pollock.

Adults: Inhabit continental slope waters with annual spring/fall migrations from deeper to shallower waters. In the Bering Sea diet consists of primarily walleye pollock, squid, crustaceans, and other miscellaneous fish species. In the Aleutian Islands although there is walleye pollock in the diet, there is a higher proportion of squid and Atka mackerel.

Habitat and Biological Associations: Greenland turbot

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS, MCS	SD, SP			
Larvae	8–9 months	U phyto/zoo plankton?	spring summer	OCS, ICS MCS	P			
Juveniles	1–5 yrs	euphausiids polychaetes small pollock	all year	ICS, MCS OCS, USP	D, SD	MS, M		
Adults	5+ years	pollock small fish	spawning Nov–February	OCS, USP LSP	D, SD	MS, M		
			non-spawning March–Oct	USP, LSP				

Literature

Alton, M.S., R.G. Bakkala, G.E. Walters and P.T. Munro. 1988. Greenland turbot, *Reinhardtius hippoglossoides*, of the Eastern Bering Sea and Aleutian Islands. U.S. Dept. Commer., NOAA Tech. Rpt. NMFS 71, 31 pages.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Barber WE, Smith RL, Vallarino M, Meyer RM (1997) Demersal fish assemblages of the northeastern Chukchi Sea, Alaska. Fish Bull 95:195–209

Bulatov, O.A. 1983. Distribution of eggs and larvae of Greenland halibut, *Reinhardtius hippoglossoides*, (Pleuronectidae) in the eastern Bering Sea. J. Ichthyol. [Engl. Transl. Vopr. Ikhtiol.] 23(1):157-159.

Chiperzakl, D.B., F Aurette, and P Raddi. 1995. First Record of Greenland Halibut (*Reinhardtius hippoglossoides*) in the Beaufort Sea (Arctic Ocean). Arctic 48(4)368-371.

Chumakov, A.K. 1970. The Greenland halibut, *Reinhardtius hippoglossoides*, in the Iceland area-The halibut fisheries and tagging. Tr. Polyarn. Nauchno-Issled. Proektn. Inst. Morsk. Rybn. Khoz. 1970:909-912.

D'yakov, Yu. P. 1982. The fecundity of the Greenland halibut, *Reinhardtius hippoglossoides* (Pleuronectidae), from the Bering Sea. J. Ichthyol. [Engl. Trans. Vopr. Ikhtiol.] 22(5):59-64.

Filina, E. and K. Budnova. 2015. On the Finding of mature individuals of the Greenland halibut *Reinhardtius hippoglossoides* (Pleuronectidae) in the Kara Sea. Journal of Ichthyology. 55: 138–142.

Hognestad, P.T. 1969. Notes on Greenland halibut, *Reinhardtius hippoglossoides*, in the eastern Norwegian Sea. Fiskeridir. Skr. Ser. Havunders. 15(3):139-144.

Hubbs, C.L., and N.J. Wilimovsky. 1964. Distribution and synonymy in the Pacific Ocean and variation of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum). J. Fish. Res. Board Can. 21:1129-1154.

Ianelli, J.N., T.K. Wilderbuer, and D. Nichol. 2010. Greenland turbot. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501.

Jensen, A.S. 1935. (*Reinhardtius hippoglossoides*) its development and migrations. K. dan. Vidensk. Selsk. Skr. 9 Rk., 6:1-32.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way, NE., Seattle, WA 98115.

Mecklenburg , C. W., P. R. Moller, and D. Steinke. 2011. Biodiversity of arctic marine fishes: taxonomy and zoogeography. Marine Biodiversity 41: 109-140

Mikawa, M. 1963. Ecology of the lesser halibut, *Reinhardtius hippoglossoides matsuurae* Jordan and Snyder. Bull. Tohoku Reg. Fish. Res. Lab. 29:1-41.

Musienko, L.N. 1970. Reproduction and Development of Bering Sea. Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 70 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 72)161-224. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1972, p. 161-224. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part V. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT71-50127.

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. Izdatel'stvo Akad. Nauk. SSSR, 483 p. [Transl. By Fish. Res. Board Can., 1967, Transl. Ser. 856, 1003 p.]

Rand, K. M., and E. A. Logerwell, 2011: The first demersal trawl survey of benthic fish and invertebrates in the Beaufort Sea since the late 1970's. Polar Biol., 34, 475-488.

Shuntov, V.P. 1965. Distribution of the Greenland halibut and arrowtooth halibuts in the North Pacific. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53):155-163. [Transl. In Soviet Fisheries Investigation in the Northeastern Pacific, Part IV, p. 147-156, by Israel Prog. Sci. Transl., 1972, avail. Natl. Tech. Inf. Serv., Springfield, VA as TT71-50127.]

Templeman, W. 1973. Distribution and abundance of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), in the Northwest Atlantic. Int. Comm. Northwest Atl. Fish. Res. Bull. 10:82-98.

Arrowtooth flounder (*Atheresthes stomias*)

Life History and General Distribution

Arrowtooth flounder are distributed in North American waters from central California to the eastern Bering Sea on the continental shelf and upper slope.

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the eastern Bering Sea shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and outer shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Total fecundity may range from 250,000 to 2,340,000 oocytes (Zimmerman 1997). Larvae have been found from ichthyoplankton sampling over a widespread area of the eastern Bering Sea shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach the 10 to 15 cm range (Martin and Clausen 1995). The estimated age at 50 percent maturity is 7.6 years (47.6 cm) for females collected from the Bering Sea (Stark 2011). The natural mortality rate used in stock assessments differs by sex and is estimated at 0.2 for females and 0.35 to 0.37 for females (Turnock et al. 2009, Wilderbuer et al. 2010).

The approximate upper size limit of juvenile fish is 27 cm for males and 37 cm for females.

Relevant Trophic Information

Arrowtooth flounder are very important as a large, and abundant predator of other groundfish species.

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs; juveniles usually inhabit shallow areas until about 10 cm in length.

Adults: Widespread distribution mainly on the middle and outer portions of the continental shelf, feeding mainly on walleye pollock and other miscellaneous fish species when arrowtooth flounder attain lengths greater than 30 cm. Wintertime migration to deeper waters of the shelf margin and upper continental slope to avoid extreme cold water temperatures and for spawning.

Habitat and Biological Associations: Arrowtooth flounder

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter, spring?	ICS, MCS, OCS	P			
Larvae	2–3 months?	U phyto/zoo plankton?	spring summer?	BAY, ICS, MCS, OCS	P			
Early Juveniles	to 2 yrs	euphausiids crustaceans amphipods pollock	all year	ICS, MCS	D	GMS		
Late Juveniles	males 2–4 yrs females 2–5 yrs	euphausiids crustaceans amphipods pollock	all year	ICS, MCS, OCS, USP	D	GMS		
Adults	males 4+ yrs females 5+ yrs	pollock misc. fish Gadidae sp. euphausiids	spawning Nov–March	MCS, OCS, USP	D	GMS	ice edge (EBS)	
			non-spawning April–Oct					

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can. Bull. 180, 740 p.

Hosie, M.J. 1976. The arrowtooth flounder. Oregon Dep. Fish. Wildl. Info. Rep. 76-3, 4 p.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U. S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Rickey, M.H. 1994. Maturity, spawning, and seasonal movement of arrowtooth flounder, *Atheresthes stomias*, off Washington. Fish. Bull. 93:127-138 (1995).

Stark, J. 2011. Female maturity, reproductive potential, relative distribution, and growth compared between arrowtooth flounder (*Atheresthes stomias*) and Kamchatka flounder (*A. evermanni*) indicating concerns for management. J. Appl. Ichthyol. 1-5.

Turnock, B.J., T.K. Wilderbuer and E.S. Brown 2009. Arrowtooth flounder. *In* Appendix B Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Waldron, K.D. and B.M. Vinter 1978. Ichthyoplankton of the eastern Bering Sea. U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

Wilderbuer, T.K., D. Nichol, and K. Aydin. 2010. Arrowtooth flounder. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 697-762.

Zimmermann, Mark. 1997. Maturity and fecundity of arrowtooth flounder, *Atheresthes stomias*, from the Gulf of Alaska. Fish Bull. 95:598-611.

Northern rock sole (Lepidopsetta polyxystra)

Life History and General Distribution

Members of the genus *Lepidopsetta* are distributed from California waters north into the Gulf of Alaska and Bering Sea to as far north as the Gulf of Anadyr. The distribution continues along the Aleutian Islands westward to the Kamchatka Peninsula and then southward through the Okhotsk Sea to the Kurile Islands, Sea of Japan, and off Korea. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central Gulf of Alaska, and in the southeastern Bering Sea (Alton and Sample 1976). Two forms were found to exist in Alaska by Orr and Matarese (2000), a southern rock sole (*L. bilineatus*) and a northern rock sole (*L. polyxystra*). Resource assessment trawl surveys indicate that northern rock sole comprise more than 95 percent of the Bering Sea population. Adults exhibit a benthic lifestyle and, in the eastern Bering Sea, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Northern rock sole spawn during the winter and early spring period of December through March. Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' N. and 55°0' N. and approximately 165°2' W. (Shubnikov and Lisovenko, 1964). Rock sole spawning in the eastern and western Bering Sea was found to occur at depths of 125 to 250 m, close to the shelf/slope break. Spawning females deposit a mass of eggs which are demersal and adhesive (Alton and Sample 1976). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11 °C to about 25 days at 2.9 °C (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in eastern Bering Sea plankton surveys (Waldron and Vinter 1978). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1976). Norcross et al. (1996) and Cooper et al. (2014) found newly settled larvae in the 40 to 50 mm size range. Forrester and Thompson (1969) report that by age 1 they are found with adults on the continental shelf during summer, but this has not been observed in the eastern Bering Sea.

In the springtime, after spawning, rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf. This migration has been observed on both the eastern (Alton and Sample 1976) and western (Shvetsov 1978) areas of the Bering Sea. During this time they spread out and form much less dense concentrations than during the spawning period. Summertime trawl surveys indicate most of the population can be found at depths from 50 to 100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,00 eggs for fish 42 cm long. Larvae are pelagic but their occurrence in plankton surveys in the eastern Bering Sea were rare in the early 1960s (Musienko 1963). However, ichthyoplankton surveys conducted since the early 2000s have captured northern rock sole larvae (Lanksbury et al. 2007). Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1969). The estimated age of 50 percent maturity is 9 years (approximately 35 cm) for southern rock sole females and 7 years for northern rock sole females (Stark and Somerton 2002). Natural mortality rate is believed to range from 0.18 to 0.20.

The approximate upper size limit of juvenile fish is 34 cm.

Relevant Trophic Information

Groundfish predators include Pacific cod, walleye pollock, skates, Pacific halibut, and yellowfin sole, mostly on fish ranging from 5 to 15 cm standard length.

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, juveniles inhabit shallow areas at least until age 1.

Adults: Summertime feeding on primarily sandy substrates of the eastern Bering Sea shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding on bivalves, polychaete, amphipods, and miscellaneous crustaceans. Wintertime migration to deeper waters of the shelf margin for spawning and to avoid extreme cold water temperatures, feeding diminishes.

Habitat and Biological Associations: Rock sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	winter	OCS	D			
Larvae	2–3 months?	U phyto/zoo plankton?	winter/spring	OCS, MCS, ICS	P			
Early Juveniles	to 3.5 yrs	polychaete bivalves amphipods misc. crustaceans	all year	BAY, ICS	D	S G		
Late Juveniles	to 9 years	polychaete bivalves amphipods misc. crustaceans	all year	BAY, ICS, MCS, OCS	D	S, SM,MS G		
Adults	9+ years	polychaete bivalves amphipods misc. crustaceans	feeding May–September spawning Dec.–April	MCS, ICS OCS	D	S,SM, MS,M G	ice edge	

Literature

Alton, M.S. and Terry M. Sample 1976. Rock sole (Family Pleuronectidae) p. 461-474. *In*: Demersal fish and shellfish resources in the Bering Sea in the baseline year 1975. Principal investigators Walter T. Pereyra, Jerry E. Reeves, and Richard Bakkala. U.S. Dep. Comm., Natl. Oceanic Atmos. Admin., Natl. Mar. Serv., Northwest and Alaska Fish Center, Seattle, WA. Processed Rep., 619 p.

Armistead, C.E. and D.G. Nichol 1993. 1990 Bottom Trawl Survey of the Eastern Bering Sea Continental Shelf. U.S. Dep. Commer., NOAA Tech. Mem. NMFS-AFSC-7, 190 p.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Cooper, D., J. Duffy-Anderson, B. Norcross, B. Holladay and P. StabenoNursery areas of juvenile northern rock sole (Lepidopsetta polyxystra) in the eastern Bering Sea in relation to hydrography and thermal regimes. ICES J. Mar. Sci.;doi:10.1093/icesjms/fst210.

Forrester, C.R. 1964. Demersal Quality of fertilized eggs of rock sole. J. Fish. Res. Bd. Canada, 21(6), 1964. P. 1531.

Forrester, C.R. and J.A. Thompson 1969. Population studies on the rock sole, *Lepidopsetta bilineata*, of northern Hecate Strait British Columbia. Fish. Res. Bd. Canada, Tech. Rep. No. 108, 1969. 104 p.

Lanksbury, J., J. Duffy-Anderson, M. Busby, P. Stabeno, and K. Meir. 2007. Distribution and transport patterns of northern rock sole larvae, Lepidopsetta polyxystra, in the Southeastern Bering Sea. Prog.Oceanog. 72.1 (2007): 39-62.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Musienko, L.N. 1963. Ichthyoplankton of the Bering Sea (data of the Bering Sea expedition of 1958-59). Tr. Vses Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 50)239-269. [In Russ.] Transl. By Isr. Prog. Sci. Transl., 1968, p. 251-286. In P. A. Moiseev (Editor), Soviet fisheries investigations in the northeastern Pacific, Part I. Avail. Natl. Tech. Inf. Serv., Springfield, VA., as TT67-51203.

Norcross, B.L., B.A. Holladay, S. C. Dressel, and M. Frandsen. 1996 .Recruitment of juvenile flatfishes in Alaska: habitat preference near Kodiak Island. U. Alaska, Coastal Marine Institute, OCS study MMS 96-003. Vol. 1.

Orr, J. M. and A. C. Matarese. 2000. Revision of the genus *Lepidipsetta* Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. Fish. Bull.98:539-582 (2000).

Shubnikov, D.A. and L.A. Lisovenko 1964. Data on the biology of rock sole in the southeastern Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51) : 209-214. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 220-226, by Israel Program Sci. Transl., 1968, available Natl. Tech. Inf. Serv., Springfield, VA, as TT 67-51204).

Shvetsov, F.G. 1978. Distribution and migrations of the rock sole, *Lepidopsetta bilineata*, in the regions of the Okhotsk Sea coast of Paramushir and Shumshu Islands. J. Ichthol., 18 (1), 56-62, 1978.

Stark, J. W. and D. A. Somerton. 2002. Maturation, spawning and growth of rock sole off Kodiak Island in the Gulf of Alaska. J. Fish. Biology (2002)61, 417-431.

Waldron, K.D. And B. M. Vinter 1978. Ichthyoplankton of the eastern Bering Sea. U. S. Dep. Commer., Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv. Seattle, WA, Processed rep., 88 p.

Wilderbuer, T.K. and D.G. Nichol. 2010. Northern Rock sole. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 781-868.

Flathead sole (Hippoglossoides elassodon)

Life History and General Distribution

Flathead sole are distributed from northern California, off Point Reyes, northward along the west coast of North America, and throughout the Gulf of Alaska and the Bering Sea, the Kuril Islands and possibly the Okhotsk Sea (Hart 1973).

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the eastern Bering Sea shelf and in the Gulf of Alaska. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year for feeding. The spawning period may start as early as January but is known to occur in March and April, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75 to 3.75 mm) and females have egg counts ranging from about 72,000 (20 cm fish) to almost 600,000 (38 cm fish). Eggs hatch in 9 to 20 days depending on incubation temperatures within the range of 2.4 to 9.8°C (Forrester and Alderdice 1967) and have been found in ichthyoplankton sampling on the southern portion of the Bering Sea shelf in April and May (Waldron 1981). Larvae absorb the yolk sac in 6 to 17 days but the extent of their distribution is unknown. Size at metamorphosis is 18 to 35 mm (Matarese et al. 2003). Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. Age at 50 percent maturity is 9.7 years (Stark 2004). The natural mortality rate used in recent stock assessments is 0.2 (McGilliard et al. 2015).

Relevant Trophic Information

Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder, and cannibalism by large flathead sole, mostly on fish less than 20 cm standard length (Livingston and DeReynier 1996).

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for an unknown time period until metamorphosis occurs, usually inhabiting shallow areas.

Adults: Winter spawning and summer feeding on sand and mud substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on ophiuroids, tanner crab, osmerids, bivalves, and polychaete (Pacunski 1990).

Habitat and Biological Associations: Flathead sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	9–20 days	NA	winter	ICS, MCS, OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS, MCS, OCS	P			
Early Juveniles	to 2 yrs	polychaete bivalves ophiuroids	all year	MCS, ICS	D	S, M		
Late Juveniles	age 3–9 yrs	polychaete bivalves ophiuroids pollock and Tanner crab	all year	MCS, ICS, OCS	D	S, M	Juveniles	
Adults	age 9–30 yrs	polychaete bivalves ophiuroids pollock and Tanner crab	spawning Jan–April non-spawning May–December	MCS, OCS, ICS	D	S, M	ice edge	

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on sea floor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Forrester, C.R. and D.F. Alderdice. 1967. Preliminary observations on embryonic development of the flathead sole (*Hippoglossoides elassodon*). Fish. Res. Board Can. Tech. Rep. 100: 20 p

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Matarese, A.C., D.M. Blood, S.J. Piquelle and J. Benson. 2003.Atlas of abundance and distribution patterns of ichthyoplankton form the northeast Pacific Ocean and Bering Sea ecosystems based on research conducted by the Alaska Fisheries Science Center (1972-1996). NOAA Prof. Paper NMFS 1. 281 p.

McConnaughey, R.A. and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 57: 2410-2419.

McGilliard, C.R., Nichol, D., Palsson, W., and Stockhausen, W. 2014. 9. Assessment of the Flathead Sole-Bering Flounder Stock in the Bering Sea and Aleutian Islands. In Appendix A: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region.1151-1258. North Pacific Fishery Management Council, 605 W 4th Ave.,Miller, B.S. 1969. Life history observations on normal and tumor bearing flathead sole in East Sound, Orcas Island (Washington). Ph.D. Thesis. Univ. Wash. 131 p.

Pacunski, R.E. 1990. Food habits of flathead sole (*Hippoglossoides elassodon*) in the eastern Bering Sea. M.S. Thesis. Univ. Wash. 106 p.

Stark, J.W. 2004. A comparison of the maturation and growth of female flathead sole in the central Gulf of Alaska and south-eastern Bering Sea. J. Fish. Biol. 64: 876-889.

Waldron, K.D. 1981. Ichthyoplankton. In D.W. Hood and J.A. Calder (Editors), The eastern Bering Sea shelf: Oceanography and resources, Vol. 1, p. 471-493. U.S. Dep. Commer., NOAA, Off. Mar. Poll. Asess., U.S. Gov. Print. Off., Wash., D.C.

Walters, G.E. and T.K. Wilderbuer 1996. Flathead sole. *In* Stock assessment and fishery evaluation Report for the groundfish resources of the Bering Sea/Aleutian Islands Regions. p 279-290. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Alaska plaice (Pleuronectes quadrituberculatus)

Formerly a constituent of the “other flatfish” management category, Alaska plaice were split-out and are now managed as a separate stock.

Life History and General Distribution

Alaska plaice inhabit continental shelf waters of the North Pacific ranging from the Gulf of Alaska to the Bering and Chukchi Seas and in Asian waters as far south as Peter the Great Bay (Pertseva-Ostroumova 1961; Quast and Hall 1972). Adults exhibit a benthic lifestyle and live year round on the shelf and move seasonally within its limits (Fadeev 1965). From over-winter grounds near the shelf margins, adults begin a migration onto the central and northern shelf of the eastern Bering Sea, primarily at depths of less than 100 m. Spawning usually occurs in March and April on hard sandy ground (Zhang 1987). The eggs and larvae are pelagic and transparent and have been found in ichthyoplankton sampling in late spring and early summer over a widespread area of the continental shelf (Waldron and Favorite 1977). Eggs and larvae were primarily collected from depths < 200 m, with the majority occurring over bottom depths ranging 50–100 m. Eggs were present throughout the water column, though densities of preflexion stage larvae were concentrated at depths 10–20 m. There was no evidence of vertical migration for pre-flexion stages (Duffy-Anderson et al. 2010).

Fecundity estimates (Fadeev 1965) indicate female fish produce an average of 56 thousand eggs at lengths of 28 to 30 cm and 313 thousand eggs at lengths of 48 to 50 cm. The age or size at metamorphosis is unknown. The estimated length of 50 percent maturity is 32 cm from collections made in March and 28 cm from April, which corresponds to an age of 6 to 7 years. Natural mortality rate estimates range from 0.19 to 0.22 (Wilderbuer and Zhang 1999).

The approximate upper size limit of juvenile fish is 27 cm.

Relevant Trophic Information

Groundfish predators include Pacific halibut (Novikov 1964) yellowfin sole, beluga whales, and fur seals (Salveson 1976).

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, usually inhabiting shallow areas.

Adults: Summertime feeding on sandy substrates of the eastern Bering Sea shelf. Wide-spread distribution mainly on the middle, northern portion of the shelf, feeding on polychaete, amphipods, and echiurids (Livingston and DeReynier 1996). Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures. Feeding diminishes until spring after spawning.

Habitat and Biological Associations: Alaska plaice

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	spring and summer	ICS, MCS OCS	P			
Larvae	2–4 months?	U phyto/zoo plankton?	spring and summer	ICS, MCS	P			
Juveniles	up to 7 years	polychaete amphipods echiurids	all year	ICS, MCS	D	S, SM, MS, M		
Adults	7+ years	polychaete amphipods echiurids	spawning March–May non-spawning and feeding June–February	ICS, MCS ICS, MCS	D	S, SM,MS,M	ice edge	

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Bailey, K. Brown, E. S., Duffy-Anderson, J. 2003. Aspects of distribution, transport and recruitment of Alaska plaice (Pleurones quadrituberculatus) in the Gulf of Alaska and Eastern Bering Sea: comparison of larval and central populations. J. Sea.50 (2003) 87-95.

Duffy-Anderson, J., Doyle, M, J., Meier, K.L., Stabeno, P.J., Wilderbuer, T.K. 2010. Early life ecology of Alaska plaice (Pleuronectes quadrituberculatus) in the eastern Bering Sea: Seasonality, distribution and dispersal. J. Sea Res., 64,1-2:3-14.

Fadeev, N.W. 1965. Comparative outline of the biology of fishes in the southeastern part of the Bering Sea and condition of their resources. [In Russ.] Tr. Vses. Nauchno-issled. Inst.Morsk. Rybn. Khoz. Okeanogr. 58 (Izv.Tikhookean. Nauchno-issled Inst. Morsk. Rybn. Khoz. Okeanogr. 53):121-138. (Trans. By Isr. Prog. Sci. Transl., 1968), p 112-129. In P.A. Moiseev (Editor), Soviet Fisheries Investigations in the northeastern Pacific, Pt. IV. Avail. Natl. Tech. Inf. Serv., Springfield, Va. As TT 67-51206.

Livingston, P.A. and Y. DeReynier. 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC processed Rep. 96-04, 51 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115.

Novikov, N.P. 1964. Basic elements of the biology of the Pacific Halibut (*Hippoglossus stenolepis* Schmidt) in the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-isslled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):167-204. (Transl. In Soviet Fisheries Investigations in the Northeast Pacific, Part II, p.175-219, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv. Springfield, VA, as TT67-51204.)

Pertseva-Ostroumova, T.A. 1961. The reproduction and development of far eastern flounders. (Transl. By Fish. Res. Bd. Can. 1967. Transl. Ser. 856, 1003 p.).

Quast, J.C. and E.L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. U.S. Dep. Commer. NOAA, Tech. Rep. NMFS SSRF-658, 48p.

Salveson, S.J. 1976. Alaska plaice. In Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975 (eds. W.T. Pereyra, J.E. Reeves, and R.G. Bakkala). Processed Rep., 619 p. NWAFC, NMFS, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Waldron, K.D. and F. Favorite. 1977. Ichthyoplankton of the eastern Bering Sea. In Environmental assessment of the Alaskan continental shelf, Annual reports of principal investigators for the year ending March 1977, Vol. IX. Receptors-Fish, littoral, benthos, p. 628-682. U.S. Dep. Comm., NOAA, and U.S. Dep. Int., Bur. Land. Manage.

Wilderbuer, T.K. and C.I. Zhang. 1999. Evaluation of the population dynamics and yield characteristics of Alaska plaice (*Pleuronectes quadrituberculatus*) in the eastern Bering Sea Fisheries Research 41 (1999) 183-200.

Wilderbuer, T.K., D.G. Nichol, and P.D. Spencer. 2010. Alaska Plaice. *In* Stock Assessment and Fishery Evaluation Report for Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306, Anchorage, Alaska 99501. Pp. 969-1020.

Zhang, C.I. 1987. Biology and Population Dynamics of Alaska plaice, *Pleuronectes quadriterculatus*, in the Eastern Bering Sea. PhD. dissertation, University of Washington: p.1-225.

Rex sole (Glyptocephalus zachirus)

Rex sole are a constituent of the "other flatfish" management category in the Bering Sea and Aleutian Islands where they are less abundant than in the Gulf of Alaska.

Other members of the "other flatfish" category include:

Dover sole (*Microstomus pacificus*)
Starry flounder (*Platichthys stellatus*)
Longhead dab (*Pleuronectes proboscidea*)
Butter sole (*Pleuronectes isolepis*)

Life History and General Distribution

Rex sole are distributed from Baja California to the Bering Sea and western Aleutian Islands (Hart 1973, Miller and Lea 1972), and are widely distributed throughout the Gulf of Alaska. Adults exhibit a benthic lifestyle and are generally found in water deeper than 300 meters. From over-winter grounds near the shelf margins, adults begin a migration onto the mid- and outer continental shelf in April or May each year. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Spawning in the Gulf of Alaska was observed from February through July, with a peak period in April and May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets mainly in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over midshelf and slope areas (Kendall and Dunn 1985). Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 24 to 59 cm (Hosie and Horton 1977). The age or size at metamorphosis is unknown. Maturity studies from Oregon indicate that males were 50 percent mature at 16 cm and females at 24 cm. Abookire (2006) estimated the female length at 50 percent maturity from Gulf of Alaska samples at 35 cm and 5.6 years. Juveniles less than 15 cm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.17 (Wilderbuer et al. 2010).

The approximate upper size limit of juvenile fish is 15 cm for males and 23 cm for females.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for an unknown time period (at least 8 months from October through May) until metamorphosis occurs; juvenile distribution is unknown.

Adults: Spring spawning and summer feeding on a combination of sand, mud and gravel substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on polychaete, amphipods, euphausids and snow crabs.

Habitat and Biological Associations: Rex sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	Feb–May	ICS? MCS, OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS? MCS, OCS	P			
Juveniles	2 years	polychaete amphipods euphausiids Tanner crab	all year	MCS, ICS, OCS	D	G, S, M		
Adults	2+ years	polychaete amphipods euphausiids Tanner crab	spawning Feb–May non-spawning May–January	MCS, OCS USP MCS, OCS, USP	D	G, S, M		

Literature

Abookire, A.A. 2006. Reproductive biology, spawning season, and growth of female rex sole (*Glyptocephalus zachirus*) in the Gulf of Alaska. Fish. Bull. 104: 350-359.

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hosie, M.J. and H.F. Horton. 1977. Biology of the rex sole, *Glyptocephalus zachirus*, in waters off Oregon. Fish. Bull. Vol. 75, No. 1, 1977, p. 51-60.

Hirschberger, W.A. and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dep. Fish. Game, Fish. Bull. 157, 235 p.

Wilderbuer, T. K., D. G. Nichol and P. D. Spencer. 2010. Other flatfish. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Eastern Bering Sea and Aleutian Islands. Compiled by the Plan Team for the fishery resources of the Bering Sea and Aleutian Islands. North Pacific Fisheries Management Council, Anchorage, AK.

Dover sole (Microstomus pacificus)

Life History and General Distribution

Dover sole are distributed in deep waters of the continental shelf and upper slope from northern Baja California to the Bering Sea and the western Aleutian Islands (Hart 1973, Miller and Lea 1972), and exhibit a widespread distribution throughout the Gulf of Alaska. Adults are demersal and are mostly found in water deeper than 300 meters. The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Spawning in the Gulf of Alaska has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown but the pelagic larval period is known to be protracted and may last as long as two years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported and the young may still be pelagic at 10 cm (Hart 1973). Dover sole are batch spawners and Hunter et al. (1992) concluded that the average 1 kg female spawns its 83,000 advanced yolked oocytes in about nine batches. Maturity studies from Oregon indicate that females were 50 percent mature at 33 cm total length. Juveniles less than 25 cm are rarely found with the adult population from bottom trawl surveys (Martin and Clausen 1995). The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 1996).

The approximate upper size limit of juvenile fish is 32 cm.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Habitat and Biological Associations

<u>*Larvae/Juveniles*</u>: Planktonic larvae for up to 2 years until metamorphosis occurs, juvenile distribution is unknown.

<u>*Adults*</u>: Winter and spring spawning and summer feeding on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution mainly on the

middle to outer portion of the shelf and upper slope, feeding mainly on polychaete, annelids, crustaceans, and molluscs (Livingston and Goiney 1983).

Habitat and Biological Associations: Dover sole

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs		NA	spring summer	ICS? MCS, OCS, UCS	P			
Larvae	up to 2 years	U phyto/ zooplankton?	all year	ICS? MCS, OCS, UCS	P			
Early Juveniles	to 3 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Late Juveniles	3–5 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Adults	5+ years	polychaetes amphipods annelids molluscs	spawning Jan–August non-spawning July–Jan	MCS, OCS, UCS	D	S, M		

Literature

Auster, P.J., Malatesta, R.J., Langton, R.W., L. Watling, P.C. Valentine, C.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. in Fish. Sci. 4(2): 185-202.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Canada, Bull. No. 180. 740 p.

Hunter, J.R., B.J. Macewicz, N.C. Lo and C.A. Kimbrell. 1992. Fecundity, spawning, and maturity of female Dove sole *Microstomus pacificus*, with an evaluation of assumptions and precision. Fish. Bull. 90:101-128(1992).

Hirschberger, W.A. and G.B. Smith. 1983. Spawning of twelve groundfish species in the Alaska and Pacific coast regions. 50 p. NOAA Tech. Mem. NMFS F/NWC-44. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Kendall, A.W. Jr. and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. NOAA Tech. Rep. NMFS 20, U.S. Dep. Commer, NOAA, Natl. Mar. Fish. Serv.

Livingston, P.A. and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. NOAA Tech. Mem. NMFS F/NWC-54, U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv.

Markle, D.F., Harris, P, and Toole, C. 1992. Metamorphosis and an overview of early-life-history stages in Dover sole *Microstomus pacificus*. Fish. Bull. 90:285-301.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska Bottom Trawl Survey. U.S. Dept. Commer., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Mem. NMFS-AFSC-59, 217 p.

Miller, D.J. and R.N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish. Game, Fish. Bull. 157, 235 p.

Turnock, B.J., T.K. Wilderbuer and E.S. Brown. 1996. Flatfish. In Stock assessment and fishery evaluation Report for the groundfish resources of the Gulf of Alaska. p 279-290. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Wilderbuer, T. K., D. G. Nichol and P. D. Spencer. 2010. Other flatfish. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Eastern Bering Sea and Aleutian Islands. Compiled by the Plan Team for the fishery resources of the Bering Sea and Aleutian Islands. North Pacific Fisheries Management Council, Anchorage, AK.

Pacific ocean perch (*Sebastes alutus*)

Life History and General Distribution

Pacific ocean perch has a wide distribution in the North Pacific from southern California around the Pacific rim to northern Honshu Island, Japan, including the Bering Sea. The species appears to be most abundant in northern British Columbia, the Gulf of Alaska, and the Aleutian Islands. Adults are found primarily offshore along the continental slope in depths of 180 to 420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 180 m and 250 m. In the fall, the fish apparently migrate farther offshore to depths of approximately 300 to 420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution. This seasonal pattern is probably related to summer feeding and winter spawning. Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental slope, most of the population occurs in patchy, localized aggregations. Pacific ocean perch is a semipelagic species, and along the EBS slope they have been observed to move into the water column during the day and onto the bottom at night

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species. The species appears to be viviparous, with internal fertilization and the release of live young. Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place approximately 2 months later. The eggs develop and hatch internally, and parturition (release of larvae) occurs in April and May. Information on early life history is very sparse, especially for the first year of life. Positive identification of Pacific ocean perch larvae is not possible at present, but the larvae are thought to be pelagic and to drift with the current. Transformation to an adult form and the assumption of a demersal existence may take place within the first year. Small juveniles probably reside inrelatively shallow areas of mixed sand and boulder substrates, and by age 3 begin to migrate to deeper offshore waters of the continental shelf. As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch has a low population growth rate, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (9 years for females in the Aleutian Islands), and a very old maximum age of 104 years in Aleutian Islands. Despite their viviparous nature, the fish is relatively fecund with number of eggs per female in Alaska ranging from 10,000 to 300,000, depending upon size of the fish.

For the Aleutian Islands, the approximate upper size limit of juvenile fish is 38 cm for females and unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Relevant Trophic Information

All food studies of Pacific ocean perch have shown them to be overwhelmingly planktivorous. Small juveniles eat mostly calanoid copepods, whereas larger juveniles and adults consume euphausiids as their major prey items. Adults, to a much lesser extent, may also eat small shrimp and squids. It has been suggested that Pacific ocean perch and walleye pollock compete for the same euphausiid prey. Consequently, the large removals of Pacific ocean perch by foreign fishermen in the Gulf of Alaska in the 1960s may have allowed walleye pollock stocks to greatly expand in abundance.

Documented predators of adult Pacific ocean perch include Pacific halibut and sablefish, and it is likely that Pacific cod and arrowtooth flounder also prey on Pacific ocean perch. Pelagic juveniles are consumed by salmon, and benthic juveniles are eaten by lingcod and other large demersal fish.

Habitat and Biological Associations

Egg/Spawning: Little information is known. Insemination is thought to occur after adults move to deeper offshore waters in the fall. Parturition is reported to occur from 20 to 30 m off the bottom at depths of 360 to 400 m.

Larvae: Little information is known. Earlier information suggested that after parturition, larvae rise quickly to near surface, where they become part of the plankton. Data from British Columbia indicates that larvae may remain at depths greater than 175 m for some period of time (perhaps two months), after which they slowly migrate upward in the water column.

Juveniles: Again, information is very sparse, especially for younger juveniles. After metamorphosis from the larval stage, juveniles may reside in a pelagic stage for an unknown length of time. They eventually become demersal, and at age 1 through 5 probably live in very rocky shallower areas. Afterward, they move to progressively deeper waters of the continental shelf. Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months. Juvenile Pacific ocean perch are associated with boulders, sponges, and upright coral, and these habitat structures may plan an important role for the juvenile stage of Pacific ocean perch.

Adults: Commercial fishery data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the continental slope. Generally, they are found in shallower depths (180 to 250 m) in the summer, and deeper (300 to 420 m) in the fall, winter, and early spring. In addition, POP on the EBS slope have been observed to move into the water column during the day, and onto the bottom at night. The best information available at present suggests that adult Pacific ocean perch are a semipelagic species that prefer a flat, pebbled substrate along the continental slope.

Habitat and Biological Associations: Pacific ocean perch

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	Internal incubation; ~90 d	NA	Winter	NA	NA	NA	NA	NA
Larvae	U; assumed between 60 and 180 days	U; assumed to be micro-zooplankton	spring–summer	MCS, OCS, USP, LSP, BSN	P	NA	U	U
Juveniles	3–6 months to 10 years	early juvenile: calanoid copepods; late juvenile: euphausiids	All year	MCS, OCS, USP	P? (early juv. only), D	R (<age 3)	U	U
Adults	10–98 years of age	euphausiids	insemination (fall); fertilization, incubation (winter); larval release (spring); feeding in shallower depths (summer)	OCS, USP	SD/SP	CB, G, M?, SM?, MS?	U	U

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commer., NOAA Tech. Rept. NMFS 66, 151 p.

Boldt, J.L. and C.N. Rooper. 2009. Abundance, condition, and diet of juvenile Pacific ocean perch (*Sebastes alutus*) in the Aleutian Islands. Fish Bull. 107:278-285.

Carlson, H.R., and R.E. Haight. 1976. Juvenile life of Pacific ocean perch, *Sebastes alutus*, in coastal fiords of southeastern Alaska: their environment, growth, food habits, and schooling behavior. Trans. Am. Fish. Soc. 105:191-201.

Carlson, H.R., and R.R. Straty. 1981. Habitat and nursery grounds of Pacific rockfish, *Sebastes* spp., in rocky coastal areas of Southeastern Alaska. Mar. Fish. Rev. 43: 13-19.

Doyle, M.J. 1992. Patterns in distribution and abundance of ichthyoplankton off Washington, Oregon, and Northern California (1980-1987). U.S. Dep. Commer. NOAA NMFS AFSC Processed Rept. 92-14, 344 p.

Gillespie, G.E., R.D. Stanley, and B.M. Leaman. 1992. Early life history of rockfishes in British Columbia; preliminary results of the first year of investigation. Proc. 1992 W. Groundfish Conf. Alderbrook Inn Resort, Union, WA, Jan 27-30, 1992.

Gunderson, D.R. 1971. Reproductive patterns of Pacific ocean perch (*Sebatodes alutus*) off Washington and British Columbia and their relation to bathymetric distribution and seasonal abundance. J. Fish. Res. Bd. Can. 28: 417-425.

Gunderson, D.R., and M.O. Nelson. 1977. Preliminary report on an experimental rockfish survey conducted off Monterey, California and in Queen Charlotte Sound, British Columbia during August-September, 1976. Prepared for Feb. 15-16, 1977, Interagency Rockfish Survey Coordinating Committee Meeting, NWAFC, Seattle, WA. Unpubl. manuscr. 82 p.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.229-269. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Ito, D.H. 1982. A cohort analysis of Pacific ocean perch stocks from the Gulf of Alaska and Bering Sea regions. U.S. Dep. Commer., NWAFC Processed Rept. 82-15, 157 p.

Ito, D.H., and J.N. Ianelli. 1996. Pacific ocean perch. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p.331-359. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Kendall, A.W., and W.H. Lenarz. 1986. Status of early life history studies of northeast Pacific rockfishes. Proc. Int. Rockfish Symp. Oct. 1986, Anchorage Alaska; p. 99-117.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull., U.S. 91:87-96.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commer. NOAA Tech. Rept. NMFS 80, 652 p.

Matthews, K.R., J.R. Candy, L.J. Richards, and C.M. Hand. 1989. Experimental gill net fishing on trawlable and untrawlable areas off northwestern Vancouver Island, from the MV Caledonian, August 15-28, 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2046, 78 p.

Mattson, C.R., and B.L. Wing. 1978. Ichthyoplankton composition and plankton volumes from inland coastal waters of southeastern Alaska, April-November 1972. U.S. Dep. Commer., NOAA Tech. Rept. NMFS SSRF-723, 11 p.

Moser, H.G., 1996. SCORPAENIDAE: scorpionfishes and rockfishes. *In*: Moser, H.G., editor. The early stages of fishes in the California Current region, p. 733-795. CalCOFI Atlas No.33. 1505 p.

NOAA (National Oceanic and Atmospheric Administration). 1990. Pacific ocean perch, *Sebastes alutus*. *In*: West coast of North America coastal and ocean zones strategic assessment: data atlas. Invertebrate and fish volume, Plate 3.2.20. U.S. Dep. Commer. NOAA. OMA/NOS, Ocean Assessments Division, Strategic Assessment Branch.

Ronholt, L.L., K. Teshima, and D.W. Kessler. 1994. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-31. 351 p.

Rooper, C.N. 2008. An ecological analysis of rockfish (*Sebates* spp.) assesmblages in the North Pacific Ocean along broad-scale gradients. Fish Bull. 106:1-11.

Rooper, C.N. and J. L. Boldt. 2005. Distribution of juvenile Pacific ocean perch *Sebastes alutus* in the Aleutian Islands in relation to benthic habitat. Alaska Fisheries Research Bulletin 11(2):102-112.

Rooper, C.N., J.L. Boldt, S Batten, and C. Gburski. 2012. Growth and production of Pacific ocean perch (*Sebastes alutus*) in nursery habitats in the Gulf of Alaska. Fish. Oceanog. 21:415-429.

Rooper, C.N. , J. L. Boldt, and M. Zimmermann. 2007. An assessment of juvenile Pacific Ocean perch (Sebastes alutus) habitat use in a deepwater nursery. Estuarine, Coastal and Shelf Science 75:371-380

Rooper, C.N., G.R. Hoff, and A. DeRobertis. 2010. Assessing habitat utilization and rockfish (*Sebastes* spp.) biomass on an isolated rocky ridge using acoustics and stereo image analysis. Can J. Fish. Aquat. Sci. 67:1658-1670. Seeb, L.W. 1993. Biochemical identification of larval rockfishes of the genus *Sebastes*.

Final Report Contract #43ABNF001082. U.S. Dept. Commer. NOAA/NMFS NWAFC/RACE Division, Seattle, WA. 28 p.

Seeb, L.W., and A.W. Kendall, Jr. 1991. Allozyme polymorphisms permit the identification of larval and juvenile rockfishes of the genus *Sebastes*. Environmental Biology of Fishes 30:191-201.

Spencer, P.D., and J.N. Ianelli. 2014. Assessment of the Pacific ocean perch stock in the eastern Bering Sea and Aleutian Islands. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, pp. 1329-1394. North Pacific Fishery Management Council, 605 W. 4th Ave, suite 306. Anchorage, AK 99501.

Stark, J.W., and D.M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S.J. 1970. Survey of rockfishes, especially Pacific ocean perch, in the northeast Pacific Ocean, 1963-66. J. Fish. Res. Bd. Canada 27: 1781-1809.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32: 2399-2411.

Wing, B.L. 1985. Salmon stomach contents from the Alaska troll logbook program, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-91. 41 p.

Wing, B.L., C. Derrah, and V. O'Connell. 1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-376, 42 p.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U. S. Dep. Commer., NOAA Tech. Memo. NMFS - AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S, K. Dodd, R. Hibpshman, and A. Whitehouse. 1996. Food Habits of Groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-164, 199 p.

Northern rockfish (*Sebastes polyspinus*)

Life History and General Distribution

Northern rockfish range from northern British Columbia through the Gulf of Alaska and Aleutian Islands to eastern Kamchatka, including the Bering Sea. The species is most abundant from about Portlock Bank in the central Gulf of Alaska to the western end of the Aleutian Islands. Within this range, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf. The preferred depth range is approximately 75 to 125 m in the Gulf of Alaska, and approximately 100 to 150 m in the Aleutian Islands. The fish appear to be semipelagic, and along the EBS slope they have been observed to move into the water column during the day and onto the bottom at night. In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described. There is no information on when the juveniles become benthic or what habitat they occupy. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat.

Northern rockfish have a low population growth rate, with a low rate of natural mortality (estimated at 0.5), a relatively old age at 50 percent maturity (8.2 years for females in the Aleutian Islands), and an old maximum age of 74 years in the Aleutian Islands. No information on fecundity is available.

For the Aleutian Islands, the upper size limit for juveniles is 34 cm for females and unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Relevant Trophic Information

Although no comprehensive food study of northern rockfish has been done, several smaller studies have all shown euphausiids to be the predominant food item of adults in both the Gulf of Alaska and Bering Sea. Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities.

Predators of northern rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Habitat and Biological Associations

Egg/Spawning: No information known, except that parturition probably occurs in the spring.

Larvae: No information known.

Juveniles: No information known for small juveniles (less than 20 cm), except that juveniles apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. Larger juveniles have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds.

Adults: Commercial fishery and research survey data have indicated that adult northern rockfish are primarily found over hard, rocky, or uneven bottom of offshore banks of the outer continental shelf at depths of 75 to 150 m. Generally, the fish appear to be semipelagic, extending into the water column, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with dusky rockfish.

Habitat and Biological Associations: Northern Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer?	U	P (assumed)	NA	U	U
Early Juveniles	from end of larval stage to ?	U	all year	MCS, OCS	P? (early juvenile only), D	U (juvenile< 20 cm); substrate (juvenile> 20 cm)	U	U
Late Juveniles	to 8 yrs	U	all year	OCS	D	CB, R	U	U
Adults	8 – 57 years of age	euphausiids	U, except that larval release is probably in the spring in the Gulf of Alaska	OCS, USP	SD/SP	CB, R	U	U

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.)

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.229-269. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Jones, D.T, C.D. Wilson, A. De Robertis, C.N. Rooper, T.C. Weber, and J.L. Butler. 2012. Evaluation of rockfish abundance in untrawlable habitat: combining acoustic and complementary sampling tools. Fish Bull. 110:332-343.

Kendall, A.W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc.Rept. 89-21. 46 p.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of Northeast Pacific fishes. U.S. Dep. Commerce NOAA Tech. Rept. NMFS 80, 652 p.

Ronholt, L.L., K. Teshima, and D.W. Kessler. 1994. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-31. 351 p.

Rooper, C.N., G.R. Hoff, and A. DeRobertis. 2010. Assessing habitat utilization and rockfish (*Sebastes* spp.) biomass on an isolated rocky ridge using acoustics and stereo image analysis. Can J. Fish. Aquat. Sci. 67:1658-1670.

Rooper, C.N. M.H. Martin., J.L. Butler, D.T Jones, and M Zimmerman. 2012. Estimating species and size composition of rockfishes to verify targets in acoustic surveys of untrawlable areas. Fish Bull. 110:317-331.

Spencer, P.D., and J.N. Ianelli. 2014. Assessment of the northern rockfish stock in the eastern Bering Sea and Aleutian Islands. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, pp. 1395-14514th Ave, suite 306. Anchorage, AK 99501

Stark, J.W., and D.M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S.J., and H. Tsuyuki. 1971. Taxonomy, distribution, and biology of the northern rockfish, *Sebastes polyspinis*. J. Fish. Res. Bd. Can. 28: 1621-1627.

Yang, M-S, K. Dodd, R. Hibpshman, and A. Whitehouse. 1996. Food Habits of Groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-164, 199 p.

Shortraker rockfish (*Sebastes borealis*)

Life History and General Distribution

Shortraker rockfish are found along the northwest slope of the eastern Bering Sea, throughout the Aleutian Islands and south to Point Conception, California. Information for the larval and juvenile stages of shortraker rougheye is very limited. Shortraker rougheye are viviparous, as females release larvae rather than eggs. Parturition (the release of larvae) can occur from February through August (McDermott 1994). Identification of larvae can be made with genetic techniques (Gray et al. 2006), although this technique has not been used to produce a broad scale distribution of the larval stage. Species identification based on morphological characteristics is difficult because of overlapping characteristics among species, as few rockfishes species in the north Pacific have published descriptions of the complete larval developmental series. However, Kendall (2003) was able to identify archived *Sebastes* ichthyoplankton from the Gulf of Alaska to four distinct morphs. One of the morphs consists solely of shortraker rockfish, although the occurrence of this morph was relatively rare (18 of 3,642 larvae examined). Post-larval and juvenile shortraker rockfish do occur in the Aleutian Islands trawl survey, but these data have not been spatially analyzed with respect to their habitat characteristics. As adults, shortraker rockfish occur primarily at depths from 300 to 500 m.

Though relatively little is known about their biology and life history, shortraker rockfish appear to be *K*-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Age at 50 percent maturity has been estimated at 21.4 years for female shortraker rockfish in the Gulf of Alaska (Hutchinson 2004); maturity information is not available for the Bering Sea and Aleutian Islands (BSAI) management area. Hutchinson (2004) estimated a maximum age of 116 years. Shortraker rockfish are among the largest *Sebastes* species in Alaskan waters; samples as large as 109 cm have been obtained in Aleutian Islands trawl surveys.

Relevant Trophic Information

The limited information available suggests that the diet of shortraker rockfish consists largely of squid, shrimp, and myctophids. From data collected in the 1994 and 1997 Aleutian Islands trawl surveys, Yang (2003) also found that the diet of large shortraker rockfish had proportionally more fish (e.g. myctophids) than small shortrakers, whereas smaller shortrakers consumed proportionally more shrimp It is uncertain what are the main predators of shortraker rockfish.

Habitat and Biological Associations

Egg/Spawning: The timing of reproductive events is apparently protracted. Parturition (the release of larvae) may occur from February through August (McDermott 1994), although Westrheim (1975) found that April was the peak month for parturition.

Larvae: Limited information is available regarding regarding the habitats and biological associations of shortraker rockfish larvae, in part because of the difficulty of using morphological characteristics to identify shortraker rockfish larvae

Juveniles: Very little information is available regarding the habitats and biological associations of juvenile shortraker rockfish.

Adults: Adults are demersal and generally occur at depths between 300 m and 500 m. Krieger (1992) used a submersible to find that shortraker rockfish occurred over a wide range of habitats, with the highest density of fish on sand or sand or mud substrates. Additional submersible work in southeast Alaska indicates that rougheye/shortraker rockfish were associated with habitats containing frequent boulders, steep slopes (more than 20°) and sand-mud substrates (Krieger and Ito 1999). Krieger and Wing (2002) found that large rockfish had a strong association with *Primnoa* spp. coral growing on boulders, and it is likely than many of these large rockfish were shortraker rougheye.

Habitat and Biological Associations: Shortraker and Rougheye Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	NA	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Feb–Aug	U	probably P	NA	U	
Early Juveniles	U	U	U	U, MCS, OCS?	probably N	U	U	
Late Juveniles	Up to ~ 20 years	U	U	U, MCS, OCS?	probably D	U	U	
Adults	> 20 years	shrimp squid myctophids	year-round?	OCS, USP	D	M, S, R, SM, CB, MS, G	U	

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Archibald, C. P., W. Shaw, and B. M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Chilton, D. E., and R. J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Gray, A.K., A.W. Kendall, B.L. Wing, M.G. Carls, J. Heifetz, Z. Li, and A.J. Gharrett. 2006. Identification and first documentation of larval rockfishes in Southeast Alaskan waters was possible using mitochondrial markers but not pigmentation patterns. Trans. Am. Fish. Soc. 135: 1-11.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the 1997 Gulf of Alaska groundfish fishery, p. 230-270. North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage, AK 99501.

Hutchinson, C.E. 2004. Using radioisotopes in the age determination of shortraker (*Sebastes borealis*) and canary (*Sebastes pinniger*) rockfish. Master's Thesis. Univ. Washington, Seattle. 84 p.

Kendall, A.W. 2003. Analysis of *Sebastes* larvae in the Gulf of Alaska based upon the AFSC ichthyoplankton database, and other sources of information. Unpublished manuscript, Alaska Fisheries Science Center, Seattle, WA.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull. 91:87-96.

Krieger, K.J., and D.H. Ito. 1999. Distribution and abundance of shortraker rockfish, *Sebastes borealis*, and rougheye rockfish, *S. aleutianus*, determined from a manned submersible. Fish. Bull. 97: 264-272.

Krieger, K.J., and B.L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the GOA. Hydrobiologia 471: 83-90.

McDermott, S.F. 1994. Reproductive biology of rougheye and shortraker rockfish, *Sebastes aleutianus* and *Sebastes borealis*. Masters Thesis. Univ. Washington, Seattle.76 p.

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32:2399-2411.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S. 2003. Food habits of the important groundfishes in the AI in 1994 and 1999. AFSC Proc. Rep 2003-07. 233 p. (Available from NMFS, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115).

Blackspotted rockfish (*Sebastes melanostictus*) and rougheye rockfish (*S. aleutianus*)

Life History and General Distribution

Fish in Alaska previously referred to as rougheye rockfish have recently been recognized as consisting of two species, the rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*) (Orr and Hawkins 2008). Most of the information on blackspotted/rougheye rockfish was obtained prior to recognition of blackspotted rockfish as a separate species, and thus refers to the two species complex. Love et al. (2002) reports that rougheye rockfish are found along the northwest slope of the eastern Bering Sea, throughout the Aleutian Islands, west to the Kamchatka Peninsula and Japan, and south to Point Conception, California, although this distribution likely reflects the combined blackspotted/rougheye group. Recent trawl surveys indicate that rougheye rockfish are uncommon in the Aleutian Islands, where the two species complex is predominately composed of blackspotted rockfish. Methods for distinguishing the two species from each other are still being refined, but have improved recently (based on verifying field IDs with genetic IDs).

Information for the larval and juvenile stages of blackspotted/rougheye rockfish are very limited. Blackspotted/rougheye rockfish are viviparous, as females release larvae rather than eggs. Parturition (the release of larvae) can occur from December through April (McDermott 1994). Identification of larvae can be made with genetic techniques (Gray et al. 2006), although this technique has not been used to produce a broad scale distribution of the larval stage. Species identification based on morphological characteristics is difficult because of overlapping characteristics among species, as few rockfishes species in the north Pacific have published descriptions of the complete larval developmental series. Length frequency distributions from Aleutian Islands summer trawl survey indicate that small blackspotted/rougheye rockfish (less than 35 cm) are found throughout a range of depths but primarily in shallower water (200 to 300 m) than larger fish. As adults, blackspotted/rougheye rockfish occur primarily at depths from 300 to 500 m.

Though relatively little is known about their biology and life history, blackspotted/rougheye rockfish appear to be *K*-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Age at 50 percent maturity has been estimated at 20.3 years for female blackspotted/rougheye rockfish in the Gulf of Alaska (McDermott 1994); maturity information is not available for the Bering Sea and Aleutian Islands (BSAI) management area. A maximum age of 121 has been reported from sampling in the Aleutian Islands trawl survey.

Relevant Trophic Information

Pandalid and hippolytid shrimp are the largest components of the blackspotted/rougheye rockfish diet (Yang 1993, 1996, Yang and Nelson 2000). In a study of diet data collected from specimens from the Aleutian Islands trawl survey, Yang (2003) found that the diet of large blackspotted/rougheye rockfish had proportionally more fish (e.g., myctophids) than small blackspotted/rougheye, whereas smaller blackspotted/rougheye consumed proportionally more shrimp. It is uncertain what are the main predators of blackspotted/rougheye rockfish.

Habitat and Biological Associations

Egg/Spawning: The timing of reproductive events is apparently protracted. Parturition (the release of larvae) may occur from December to April (McDermott 1994).

Larvae: Limited information is available regarding the habitats and biological associations of blackspotted/rougheye rockfish larvae, in part because of the difficulty of using morphological characteristics to identify blackspotted/rougheye rockfish larvae.

Juveniles: Very little information is available regarding the habitats and biological associations of juvenile blackspotted/rougheye rockfish.

Adults: Adults are demersal and generally occur at depths between 300 m and 500 m. Submersible work in southeast Alaska indicates that blackspotted/rougheye rockfish were associated with habitats containing frequent boulders, steep slopes (more than 20°) and sand-mud substrates (Krieger and Ito 1999). Krieger and Wing (2002) found that large rockfish had a strong association with *Primnoa* spp. coral growing on boulders, and it is likely than many of these large rockfish were blackspotted/rougheye rockfish.

Habitat and Biological Associations: Shortraker and Rougheye Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	NA	NA	NA	NA	NA	NA	NA	
Larvae	U	U	parturition: Dec–Apr	U	probably P	NA	U	
Early Juveniles	U	U	U	U, MCS, OCS?	probably N	U	U	
Late Juveniles	up to ~ 20 years	U	U	U, MCS, OCS?	probably D	U	U	
Adults	> 20 years	shrimp squid myctophids	year-round?	OCS, USP	D	M, S, R, SM, CB, MS, G	U	

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Archibald, C. P., W. Shaw, and B. M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Chilton, D. E., and R. J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Gray, A.K., A.W. Kendall, B.L. Wing, M.G. Carls, J. Heifetz, Z. Li, and A.J. Gharrett. 2006. Identification and first documentation of larval rockfishes in Southeast Alaskan waters was possible using mitochondrial markers but not pigmentation patterns. Trans. Am. Fish. Soc. 135: 1-11.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the 1997 Gulf of Alaska groundfish fishery, p. 230-270. North Pacific Fishery Management Council, 605 W. 4th Avenue, Suite 306, Anchorage, AK 99501.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Krieger, K. 1992. Shortraker rockfish, *Sebastes borealis*, observed from a manned submersible. Mar. Fish. Rev., 54(4): 34-37.

Krieger, K.J. 1993. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fish. Bull. 91:87-96.

Krieger, K.J., and D.H. Ito. 1999. Distribution and abundance of shortraker rockfish, *Sebastes borealis*, and rougheye rockfish, *S. aleutianus*, determined from a manned submersible. Fish. Bull. 97: 264-272.

Krieger, K.J., and B.L. Wing. 2002. Megafauna associations with deepwater corals (*Primnoa* spp.) in the GOA. Hydrobiologia 471: 83-90.

Love, M.S., M. Yoklovich, and L. Thorsteinson. 2002. The rockfishes of the northeast Pacific. University of California Press, Berkeley. 405 p.

McDermott, S.F. 1994. Reproductive biology of rougheye and shortraker rockfish, *Sebastes aleutianus* and *Sebastes borealis*. Masters Thesis. Univ. Washington, Seattle.76 p.

Orr, J.W. and S. Hawkins. 2008. Species of the rougheye rockfish complex: resurrection of *Sebastes melanostictus* (Matsubara 1934) and a redescription of *Sebastes aleutianus* (Jordan and Evermann, 1898) (Teleostei: Scorpaeniformes). Fish. Bull. 106(2):111-134

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S. 2003. Food habits of the important groundfishes in the AI in 1994 and 1999. AFSC Proc. Rep 2003-07. 233 p. (Available from NMFS, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115).

Yang, M.S. and M.W. Nelson. 2000. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990, 1993, and 1996. NOAA Tech. Memo. NMFS-AFSC-112. 174 p.

Other rockfish (Dusky rockfish *Sebastes variabilis*)

Life History and General Distribution

In 2004, Orr and Blackburn described two distinct species that were being labeled as a single species (*Sebastes ciliatus*) with two color varieties: dark and light dusky rockfish. What was labeled as the light dusky rockfish is now considered to be a distinct species *Sebastes variabilis* and is commonly referred to as dusky rockfish. Dusky rockfish range from central Oregon through the North Pacific Ocean and Bering Sea in Alaska and Russia to Japan. The center of abundance for dusky rockfish appears to be the Gulf of Alaska (Reuter 1999). The species is much less abundant in the Aleutian Islands and Bering Sea (Reuter and Spencer 2002). Adult dusky rockfish have a very patchy distribution, and are usually found in large aggregations at specific localities of the outer continental shelf. These localities are often relatively shallow offshore banks. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. Most of what is known about dusky rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the Gulf of Alaska suggest that parturition (larval release) occurs in the spring, and is probably completed by summer. Another, older source, however, lists parturition as occurring “after May.” Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown. There is no information on habitat and abundance of young juveniles (less than 25 cm fork length), as catches of these have been virtually nil in research surveys. Even the occurrence of older juveniles has been very uncommon in surveys, except for one year. In this latter instance, older juveniles were found on the continental shelf, generally at locations inshore of the adult habitat.

Dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 49 to 59 years. No information on age of maturity or fecundity is available.

The approximate upper size limit for juvenile fish is 47 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Relevant Trophic Information

Although no comprehensive food study of dusky rockfish has been done, one smaller study in the Gulf of Alaska showed euphausiids to be the predominate food item of adults. Larvaceans, cephalopods, pandalid shrimp, and hermit crabs were also consumed.

Predators of dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Habitat and Biological Associations

Egg/Spawning: No information known, except that parturition probably occurs in the spring, and may extend into summer.

Larvae: No information known.

Juveniles: No information known for small juveniles less than 25 cm fork length. Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds.

Adults: Commercial fishery and research survey data suggest that adult dusky rockfish are primarily found over reasonably flat, trawlable bottom of offshore banks of the outer continental shelf at depths of 75 to 200 m. Type of substrate in this habitat has not been documented. During submersible dives on the outer shelf (40 to 50 m) in the eastern Gulf, dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where adult dusky rockfishes were observed resting in large vase sponges (V. O'Connell, ADFG, personal communication). Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. Dusky rockfish are the most highly aggregated of the rockfish species caught in Gulf of Alaska trawl surveys. Outside of these aggregations, the fish are sparsely distributed. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. There is no information on seasonal migrations. Dusky rockfish often co-occur with northern rockfish.

Habitat and Biological Associations: Dusky Rockfish

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	spring–summer?	U	P (assumed)	NA	U	U
Early Juveniles	U	U	all year	ICS, MCS, OCS,	U (small juvenile< 25 cm): D? (larger juvenile)	U (juvenile<25 cm); Trawlable substrate? (juvenile>25 cm)	U	U
Late Juveniles	U	U	U	U	U	CB, R, G	U	observed associated with *primnoa* coral
Adults	Up to 49–50 years.	euphausiids	U, except that larval release may be in the spring in the Gulf of Alaska	OCS, USP	SD, SP	CB, R, G	U	observed associated with large vase type sponges

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U. S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Clausen, D.M., and J. Heifetz. 1996. Pelagic shelf rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p.271-288. North Pacific Fishery Management Council, 605 W. 4th. Ave., Suite 306, Anchorage, AK 99501-2252.

Harrison, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-12. 144 p.

Heifetz, J., and D. Ackley. 1997. Bycatch in rockfish fisheries in the Gulf of Alaska. Unpubl. Manuscr. 20 p. (Available from NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801.

Kendall, A.W. 1989. Additions to knowledge of *Sebastes* larvae through recent rearing. NWAFC Proc.Rept. 89-21. 46 p.

Martin, M.H. and D.M. Clausen. 1995. Data report: 1993 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-59. 217 p.

Matarese, A.C., A.W. Kendall, Jr., D.M. Blood, and B.M. Vinter. 1989. Laboratory guide to early life history stages of northeast Pacific fishes. U.S. Dep. Commerce NOAA Tech. Rept. NMFS 80, 652 p.

Orr, J.W., and J.E. Blackburn. 2004. The dusky rockfishes (Teleostei: Scorpaeniformes) of the North Pacific Ocean: resurrection of *Sebastes variabilis* (Pallas, 1814) and a redescription of *Sebastes ciliatus* (Tilesius, 1813). Fish Bull., U.S. 1002:328-348. Online.

Reuter, R.F. 1999. Describing Dusky rockfish (*Sebastes ciliatus*) habitat in the Gulf of Alaska using Historical data. M.S. thesis. California State University, Hayward 83 p.

Reuter, R.F. and P.D. Spencer. 2002. Other rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea and Aleutian Islands, p. 579-608.

Stark, J.W., and D.M. Clausen. 1995. Data report: 1990 Gulf of Alaska bottom trawl survey. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-49. 221 p.

Westrheim, S.J. 1973. Preliminary information on the systematics, distribution, and abundance of the dusky rockfish, *Sebastes ciliatus*. J. Fish. Res. Bd. Can. 30: 1230-1234.

Westrheim, S.J. 1975. Reproduction, maturation, and identification of larvae of some *Sebastes* (Scorpaenidae) species in the northeast Pacific Ocean. J. Fish. Res. Board Can. 32: 2399-2411.

Thornyhead rockfish (*Sebastolobus sp.*)

Life History and General Distribution

Thornyhead rockfish of the northeastern Pacific Ocean are comprised of two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the Bering Sea and Aleutian Islands. The shortspine thornyhead is a demersal species which inhabits deep waters from 93 to 1,460 m from the Bering Sea to Baja California. This species is common throughout the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands. The population structure of shortspine thornyheads, however, is not well defined. Thornyhead rockfish are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 75 cm and 2 kg. Thornyheads spawn buoyant masses of eggs during the late winter and early spring that resemble bilobate "balloons" which float to the surface (Pearcy 1962). Juvenile shortspine thornyhead rockfish have a pelagic period of about 14 to 15 months and settle out on the shelf (100 m) at about 22 to 27 mm (Moser 1974). Fifty percent of female shortspine thornyheads are sexually mature at about 21 cm and 12 to 13 years of age.

The approximate upper size limit of juvenile fish is 27 mm at the pelagic stage, and 60 mm at the benthic stage (see Moser 1974). Female shortspine thornyheads appear to be mature at about 21 to 22 cm (Miller 1985).

Relevant Trophic Information

Shortspine thornyhead rockfish prey mainly on epibenthic shrimp and fish. Yang (1996, 2003) showed that shrimp were the top prey item for shortspine thornyhead rockfish in the Gulf of Alaska; whereas, cottids were the most important prey item in the Aleutian Islands region. Differences in abundance of the main prey between the two areas might be the main reason for the observed diet differences. Predator size might by another reason for the difference since the average shortspine thornyhead in the Aleutian Islands area was larger than that in the Gulf of Alaska (33.4 cm vs 29.7 cm).

Habitat and Biological Associations

Egg/Spawning: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 15 to 61 cm in length, consisting of hollow conical sheaths containing a single layer of eggs in a gelatinous matrix. The masses are transparent and not readily observed in the daylight. Eggs are 1.2 to 1.4 mm in diameter with a 0.2 mm oil globule. They move freely in the matrix. Complete hatching time is unknown but is probably more than 10 days.

Larvae: Three day-old larvae are about 3 mm long and apparently float to the surface. It is believed that the larvae remain in the water column for about 14 to 15 months before settling to the bottom.

Juveniles: Very little information is available regarding the habitats and biological associations of juvenile shortspine thornyheads.

<u>*Adults*</u>: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Groundfish species commonly associated with thornyheads include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish *(Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish (*Sebastes aleutianus*), and grenadiers (family Macrouridae). Two congeneric thornyhead species, the longspine thornyhead (*Sebastolobus altivelis*) and a species common off of Japan , broadbanded thornyhead, *S. macrochir*, are infrequently encountered in the Gulf of Alaska.

Habitat and Biological Associations: Thornyhead Rockfish

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/ Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs	U	U	spawning: late winter and early spring	U	P	U	U	
Larvae	<15 months	U	early spring through summer	U	P	U	U	
Juveniles	> 15 months when settling to bottom occurs (?)	U shrimp, amphipods, mysids, euphausiids?	U	MCS, OCS, USP	D	M, S, R, SM, CB, MS, G	U	
Adults	U	shrimp fish (cottids), small crabs	year-round?	MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, G	U	

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Aton, M. 1981. Gulf of Alaska bottomfish and shellfish resources. U.S. Dep. Commerce Tech. Memo. NMFS F/NWC-10, 51 p.

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfishes (Scorpaenidae) from B.C. coastal waters, 1977-79. Can. Tech. Rep. Fish. Aquat. Sci. 1048, 57 p.

Chilton, D.E., and R.J. Beamish. 1982. Age determination methods for fishes studied by the Groundfish Program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60, 102 p.

Heifetz, J., J.N. Ianelli, and D.M. Clausen. 1996. Slope rockfish. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 230-270. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Ianelli, J.N., D.H. Ito, and M. Martin. 1996. Thornyheads (*Sebastolobus sp*.). *In* Stock Assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 303-330. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Jacobson, L.D. 1993. Thornyheads. *In* Status of living marine resources off the Pacific coast of the United States for 1993. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-26, 35-37 p.

Kramer, D.E., and V.M. O'Connell. 1986. Guide to northeast Pacific rockfishes, Genera *Sebastes* and *Sebastolobus*. Marine Advisory Bulletin No. 25: 1-78. Alaska Sea Grant College Program, University of Alaska.

Low, L.L. 1994. Thornyheads. *In* Status of living marine resources off Alaska, 1993. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-27, 56-57 p.

Miller, P.P. 1985. Life history study of the shortspine thornyhead, *Sebastolobus alascanus*, at Cape Ommaney, south-eastern Alaska. M.S. Thesis, Univ. Alaska, Fairbanks, AK, 61p.

Moser, H.G. 1974. Development and distribution of larvae and juveniles of *Sebastolobus* (Pisces: family Scorpaenidae). Fish. Bull. 72: 865-884.

Pearcy, W.G. 1962. Egg masses and early developmental stages of the scorpaenid fish, *Sebastolobus*. J. Fish. Res. Board Can.19: 1169-1173.

Sigler, M.F., and H.H. Zenger, Jr. 1994. Relative abundance of Gulf of Alaska sablefish and other groundfish based on the domestic longline survey, 1989. NOAA Tech. Memo. NMFS-AFSC-40.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M-S. 2003. Food Habits of the Important Groundfishes in the Aleutian Islands in 1994 and 1997. AFSC processed report 2003-07.

Atka mackerel (Pleurogrammus monopterygius)

Life History and General Distribution

Atka mackerel are distributed along the continental shelf across the North Pacific Ocean and Bering Sea from Asia to North America. On the Asian side they extend from the Kuril Islands to Provideniya Bay; moving eastward, they are distributed throughout the Komandorskiye and Aleutian Islands, north along the eastern Bering Sea shelf, and through the Gulf of Alaska to southeast Alaska. They are most abundant along the Aleutian Islands.

Adult Atka mackerel occur in large localized aggregations usually at depths less than 200 m and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for Aleutian Islands Atka mackerel. Adults are semi-demersal, displaying strong diel behavior with vertical movements away from the bottom occurring almost exclusively during the daylight hours, presumably for feeding, and little to no movement at night (when they are closely associated with the bottom). Atka mackerel are a substrate-spawning fish with male parental care. Single or multiple clumps of adhesive eggs are laid on rocky substrates in individual male territories within nesting colonies where males brood eggs for a protracted period. Nesting colonies are widespread across the continental shelf of the Aleutian Islands and western Gulf of Alaska down to bottom depths of 144 m. Possible factors limiting the upper and lower depth limit of Atka mackerel nesting habitat include insufficient light penetration and the deleterious effects of unsuitable water temperatures, wave surge, or high densities of kelp and green sea urchins. The spawning phase begins in late July, peaks in early September, and ends in mid-October. After spawning ends, territorial males with nests continue to brood egg masses until hatching. Eggs develop and hatch in 40 to 45 days, releasing planktonic larvae which have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel prior to their appearance in trawl surveys and the fishery at about age 2 to 3 years.

Atka mackerel exhibit intermediate life history traits. R-traits include young age at maturity (approximately 50 percent are mature at age 3), fast growth rates, high natural mortality (mortality equals 0.3) and young average and maximum ages (about 5 and 15 years, respectively). K-selected traits include low fecundity (only about 30,000 eggs/female/year, large egg diameters (1 to 2 mm) and male nest-guarding behavior).

The approximate upper size limit of juvenile fish is 35 cm.

Relevant Trophic Information

Atka mackerel are consumed by a variety of piscivores, including groundfish (e.g., Pacific cod, Pacific halibut, and arrowtooth flounder), marine mammals (e.g., northern fur seals and Steller sea lions), and seabirds (e.g., thick-billed murres, tufted puffins, and short-tailed shearwaters). Adult Atka mackerel consume a variety of prey, but principally calanoid copepods and euphausiids. Predation on Atka mackerel eggs by cottids and other hexagrammids is prevalent during the spawning season as is cannibalism by other Atka mackerel.

Habitat and Biological Associations

Egg/Spawning: Adhesive eggs are deposited in nests built and guarded by males on rocky substrates or on kelp in shallow water.

Larvae/Juveniles: Planktonic larvae have been found up to 800 km from shore, usually in upper water column (neuston), but little is known of the distribution of Atka mackerel until they are about 2 years old and appear in fishery and surveys.

Adults: Adults occur in localized aggregations usually at depths less than 200 m and generally over rough, rocky and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for Aleutian Islands Atka mackerel. Adults are semi-demersal/pelagic during much of the year, but the males become demersal during spawning; females move between nesting and offshore feeding areas.

Habitat and Biological Associations: Atka mackerel

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	40–45 days	NA	summer	IP, ICS, MCS	D	G, R, K, CB	U	develop 3–15 °C optimum 3.9–10.5 °C
Larvae	up to 6 mos	U copepods?	fall–winter	U	U, N?	U	U	2–12 °C optimum 5–7 °C
Juveniles	½–2 yrs of age	U copepods & euphausiids?	all year	U	N	U	U	3–5 °C
Adults	3+ yrs of age	copepods euphausiids meso-pelagic fish	spawning (June–Oct) non-spawning (Nov–May)	ICS and MCS, IP MCS and OCS, IP	D (males) SD females SD/D all sexes	G, R, CB, K	F, E	3–5 °C all stages >17 ppt only

		(myctophids)	tidal/diurnal, year-round?	ICS, MCS, OCS, IP	D when currents high/day SD slack tides/night			

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerc., NOAA Tech. Rept. NMFS 66, 151 p.

Aydin, KGaichas, 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. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-178, 298 p.

Boldt, J.L. (Ed). 2005. Ecosystem indicators for the North Pacific and their implications for stock assessment: Proceedings of first annual meeting of NOAA's Ecological Indicators research program. AFSC Processed Rep.2005-04, Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

Canino, M.F, I.B. Spies, M.M. Hollowed, and J.L. GuthridgeMating behavior of Atka mackerel inferred from genetic analysis of egg masses in the wild and in captivity. Marine and Coastal Fisheries.

Cooper, D. W.,F. McDermott and J. N. Ianelli. 2010. Spatial and temporal variability in Atka mackerel female maturity at length and age. Marine and Coastal Fisheries, 2:329-338. http://www.tandfonline.com/doi/abs/10.1577/C09-45.1

Cooper, D., and S. McDermott. 2008. Variation in Atka mackerel, *Pleurogrammus monopterygius*, spatial and temporal distribution by maturity stage. Pages 11-42 *in* S. F. McDermott, M. Canino, N. Hillgruber, D. W. Cooper, I. Spies, J. Guthridge, J. N. Ianelli, P. Woods. 2008. Atka mackerel *Pleurogrammus monopterygius* reproductive ecology in Alaska. North Pacific Research Board Final report, 163p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Dragoo, D.E., G.V. Byrd, and D.B. Irons. 2001. Breeding status, population trends, and diets of seabirds in Alaska, 2000. U.S. Fish and Wildl. Serv. Report AMNWR 01/07.

Francis, R.C., and S.R. Hare. 1994. Decadal scale regime shifts in the large marine ecosystems of the northeast Pacific: A case for historical science. Fish. Oceanogr. 3(1):279-291.

Fritz, L.W. 1993. Trawl locations of walleye pollock and Atka mackerel fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska from 1977-1992. AFSC Processed Report 93-08, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 pp.

Fritz, L.W. and S.A. Lowe. 1998. Seasonal distributions of Atka mackerel (*Pleurogrammus monopterygius*) in commercially-fished areas of the Aleutian Islands and Gulf of Alaska. NOAA Tech. Memo. NMFS-AFSC-92. 29p.

Gorbunova, N.N. 1962. Razmnozhenie I razvite ryb semeistva terpugovykh (Hexagrammidae) Spawning and development of greenlings (family Hexagrammidae). Tr. Inst. Okeanol., Akad. Nauk SSSR 59:118-182. In Russian. (Trans. by Isr. Program Sci. Trans., 1970, p. 121-185 in T.S. Rass (editor), Greenlings: taxonomy, biology, interoceanic transplantation; available from the U.S. Dep. Commerce, Natl. Tech. Inf. Serv., Springfield, VA., as TT 69-55097).

Guthridge, J. L. and N. Hillgruber. 2008. Embryonic development of Atka mackerel (*Pleurogrammus monopterygius*) and the effect of temperature. Pages 43-65 *in* S. F. McDermott, M. Canino, N. Hillgruber,

D. W. Cooper, I. Spies, J. Guthridge, J. N. Ianelli, P. Woods. 2008. Atka mackerel *Pleurogrammus monopterygius* reproductive ecology in Alaska. North Pacific Research Board Final report, 163p.

Hare, S.R., and N.J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Prog. Oceanogr. 47:103-145.

Hollowed, A.B., S.R. Hare, and W.S. Wooster. 2001. Pacific Basin climate variability and patterns of Northeast Pacific marine fish production. Prog. Oceanogr. 49:257-282.

Hunt, G.L. Jr., H. Kato, and S.M. McKinnell [eds.] 2000. Predation by marine birds and mammals in the subarctic north Pacific Ocean. North Pacific Marine Science Organization (PICES) Scientific Report #25. 165 p.

Kajimura, H. 1984. Opportunistic feeding of the northern fur seal *Callorhinus ursinus*, in the eastern north Pacific Ocean and eastern Bering Sea. NOAA Tech. Rept. NMFS SSRF-779. USDOC, NOAA, NMFS, 49 pp.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerc., NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Lauth, R. R., J. Guthridge, D. Nichol, S. W. Mcentire, and N. Hillgruber. 2007a. Timing and duration of mating and brooding periods of Atka mackerel (*Pleurogrammus monopterygius*) in the North Pacific Ocean. Fish. Bull., U.S. 105:560-570. http://fishbull.noaa.gov/1054/lauth.pdf

Lauth, R. R., S. W. Mcentire, and H. H. Zenger, Jr. 2007b. Geographic distribution, depth range, and description of Atka mackerel *Pleurogrammus monopterygius* nesting habitat in Alaska. Alaska Fish. Res. Bull. 12:165-186. http://www.adfg.state.ak.us/pubs/afrb/vol12_n2/lautv12n2.pdf

Lee, J.U. 1985. Studies on the fishery biology of the Atka mackerel *Pleurogrammus monopterygius* (Pallas) in the north Pacific Ocean. Bull. Fish. Res. Dev. Agency, 34, pp.65-125.

Levada, T.P. 1979. Comparative morphological study of Atka mackerel. Pac. Sci. Res. Inst. Fish. Oceanogr. (TINRO), Vladivostok, U.S.S.R., Unpublished manuscript.

Lowe, S., J. Ianelli, M. Wilkins, K. Aydin, R. Lauth, and I. Spies. 2007. Appendix B *In* Stock assessment of Aleutian Islands Atka mackerel. *In* Stock Assessment and Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, Alaska, 99510. http://www.afsc.noaa.gov/refm/docs/2007/BSAIatka.pdf

Malecha, P.W., R.P. Stone, and J. Heifetz. 2005. Living substrate in Alaska: Distribution, abundance, and species associations. Pages 289-299 *in* P.W. Barnes and J.P. Thomas, editors. Benthic habitats and the effects of fishing. American Fisheries Society, Symposium 41, Bethesda, Maryland.

Materese, A.C., D. M. Blood, S. J. Piquelle, and J. L. Benson. 2003. Atlas of abundance and distribution patterns of ichthyoplankton from the Northeast Pacific Ocean and Bering Sea ecosystems based on research conducted by the Alaska Fisheries Science Center (1972-1996). U.S. Dep. Commer., NOAA Professional Paper, NMFS-1, 281 p.

McDermott, S.F. 2003. Improving abundance estimation of a patchily distributed fish, Atka mackerel (*Pleurogrammus monopterygius*). Dissertation, University of Washington, 150 p.

McDermott, S.F. and S.A. Lowe. 1997. The reproductive cycle and sexual maturity of Atka mackerel (*Pleurogrammus monopterygius*) in Alaskan waters. Fishery Bulletin 95: 321-333.

McDermott, S.F., K.E. Pearson and D.R. Gunderson. 2007. Annual fecundity, batch fecundity, and oocyte atresia of Atka mackerel (Pleurogrammus monopterygius) in Alaskan waters. Fish Bull. 105:19-29.

McDermott,K. Rand, M. Levine,Ianelli, and E. Small-scale Atka mackerel population abundance and movement in the central Aleutian Islands, an area of continuing Steller sea lion decline. North Pacific Research Board Final Report:109.

Mel'nikov, I.V. and A. YA. Efimkin. 2003. the young of the northern Atka mackerel *Pleurogrammus monopterygius* in the epipelagic zone over deep-sea areas of the northern Pacific Ocean. J. Ichthyol. 43: 424-437.

Merrick, R.L., M.K. Chumbley, and G.V. Byrd. 1997. Diet diversity of Steller sea lions (*Eumetopias jubatus*) and their population decline in Alaska: a potential relationship. Can. J. Fish. Aquat. Sci. 54:1342-1348.

Morris, B.F. 1981. An assessment of the living marine resources of the central Bering Sea and potential resource use conflicts between commercial fisheries and Petroleum development in the Navarin Basin, Proposed sale No. 83. Anchorage, AK: USDOC, NOAA, NMFS, Environmental Assessment Division.

Musienko, L.N. 1970. Razmnozheine I razvitie ryb Beringova morya (Reproduction and development of Bering Sea fishes). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Koz. Okeanogr. 70: 161-224 In P.A. Moiseev (ed.), Soviet fisheries investigations in the northeastern Pacific, Pt. 5, Avail. Natl. Tech. Info. Serv., Springfield, VA as TT 74-50127.

Nichol D.G., Somerton D.A. 2002. Diurnal vertical migration of the Atka mackerel *Pleurogrammus monopterygius* as shown by archival tags. Mar Ecol Prog Ser 239: 193-207.

NMFS. 1995. Status review of the Unites States Steller sea lion (*Eumetopias jubatus*) population. National Marine Mammal Laboratory, Alaska Fishery Science Center, National Marine Fisheries Service, 7600 Sand Point Way, NE, Seattle, WA 98115.

Orlov, A.M. 1996. The role of mesopelagic fishes in feeding of Atka mackerel in areas of the North Kuril islands. Publ. Abstract in Role of forage fishes in marine ecosystems. Symposium held Nov 1996, AK Sea Grant, U. Alaska, Fairbanks.

Ortiz, I. 2007. Ecosystem Dynamics of the Aleutian Islands. Ph.D. Thesis. University of Washington, Seattle.

Rand, K. M., D. A. Beauchamp, and S. A. LoweLongitudinal growth differences and the influence of diet quality on Atka mackerel of the Aleutian Islands, Alaska: using a bioenergetics model to explore underlying mechanisms. Marine and Coastal Fisheries 2:362-374.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Rutenberg, E.P. 1962. Survey of the fishes family Hexagrammidae. Trudy Instituta Okeanologii Akademiya Nauk SSSR 59:3-100. In Russian. (Translated by the Israel Program for Scientific Translations, 1970. Pages 1-103 in T.S. Rass (editor), Greenlings: taxonomy, biology, interoceanic transplantation; available from the U.S. Department of Commerce, National Technical Information Services, Springfield, Virginia, as TT 69-55097).

Sinclair, E.H., D.S. Johnson, T.K. Zeppelin, and T.S. Gelatt.Decadal variation in the diet of western stock Steller sea lions (*Eumetopias jubatus*). U.S. Dep. Commer., NOAA Tech. Memo., NMFS-AFSC-248, 67 p.

Sinclair E.H. and T.K. Zeppelin 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 83(4).

Springer, A.M., J.F. Piatt, V.P. Shuntov, G.B. Van Vliet, V.L. Vladimirov, A.E. Kuzin, A.S. Perlov. 1999. Prog. in Oceanogr. 43(1999)443-487.

Stone, R.P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25:229-238.Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-84. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. NOAA Technical Memorandum, NMFS-AFSC-60, U.S. Department of Commerce, NOAA. p. 105.

Yang, M-S. 1999. The trophic role of Atka mackerel, *Pleurogrammus monopterygius*, in the Aleutian Islands area. Fishery Bulletin 97(4):1047-1057.

Yang, M-S. 2003. Food habits of the important groundfishes in the Aleutian Islands in 1994 and 1997. AFSC Processed Rep.2003-07, Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115. p. 233.

Zolotov, O.G. 1993. Notes on the reproductive biology of *Pleurogrammus monopterygius* in Kamchatkan waters. J. of Ichthy. 33(4), pp. 25-37.

Squids (Cephalopoda)

The species representatives for squids are:

Gonaditae:	red or magistrate armhook squid (*Berryteuthis magister*)
Onychoteuthidae:	boreal clubhook squid (*Onychoteuthis borealjaponicus)*
	giant or robust clubhook squid (*Moroteuthis robusta*)
Sepiolidae:	eastern Pacific bobtail squid (*Rossia pacifica*)

Life History and General Distribution:

Squids are members of the molluscan class Cephalopoda along with octopus, cuttlefish, and nautiloids. In the Bering Sea and Aleutian Islands (BSAI), gonatid and onychoteuthid squids are generally the most common, along with chiroteuthids. All cephalopods are stenohaline, occurring only at salinities greater than 30 ppt. Fertilization is internal, and for many species development is direct ("larval" stages are only small versions of adults). The eggs of inshore neritic species are often enveloped in a gelatinous matrix attached to rocks, shells, or other hard substrates, while the eggs of some offshore oceanic species are extruded as large, sausage-shaped drifting masses. Little is known of the seasonality of reproduction, but most species probably breed in spring and early summer, with eggs hatching during the summer. Most small squids are generally thought to live only 2 years or less but the giant *Moroteuthis robusta* may live longer.

B. magister is widely distributed in the boreal north Pacific from California, throughout the Bering Sea, to Japan in waters of depth 30 to 1,500 m; adults most often found at mesopelagic depths or near bottom, rising to the surface at night; juveniles are widely distributed across shelf, slope, and abyssal waters in mesopelagic and epipelagic zones, and rise to surface at night. It migrates seasonally, moving northward and inshore in summer, and southward and offshore in winter, particularly in the western north Pacific. In the BSAI, most *B. magister* occur along the continental slope. The maximum size for females is 50 cm mantle length (ML), and for males is 40 cm ML. Spermatophores transferred into the mantle cavity of female, and eggs are laid on the bottom on the upper slope (200 to 800 m). Fecundity is estimated at 10,000 eggs/female. Spawning occurs in February and March in Japan; timing of spawning in Alaska is not known but there appear to be multiple seasonal spawning cohorts each year. Eggs hatch after 1 to 2 months of incubation; development is direct. Adults are thought to die after mating and/or spawning.

O. borealjaponicus, an active, epipelagic species, is distributed in the north Pacific from the Sea of Japan, throughout the Aleutian Islands and south to California, but is absent from the Sea of Okhotsk and not common in the Bering Sea. Juveniles can be found over shelf waters at all depths and near shore. Adults apparently prefer the upper layers over slope and abyssal waters and are diel migrators and gregarious. Development includes a larval stage; maximum size is about 55 cm.

M. robusta, a giant squid, lives near the bottom on the slope, and mesopelagically over abyssal waters; it is rare on the shelf. It is distributed in all oceans, and is found in the Bering Sea, Aleutian Islands, and GOA. Mantle length can be up to 2.5 m long (at least 7 m with tentacles), but most are about 2 m long.

R. pacifica is a small (maximum length with tentacles of less than 20 cm) demersal, neritic and shelf, boreal species, distributed from Japan to California in the North Pacific and in the Bering Sea in waters of about 20 to 300 m depth. It is the only squid observed in abundance on the shelf by bottom trawl surveys. Other *Rossia* species deposit demersal egg masses.

For *B. magister*, the approximate upper size limit of juveniles 20 cm ML for males and 25 cm ML for females; both are at approximately 1 year of age.

Relevant Trophic Information

The principal prey items of squid are small forage fish, pelagic crustaceans (e.g., euphausiids and shrimp), and other cephalopods; cannibalism is not uncommon. After hatching, early juvenile squid eat small zooplankton (e.g. copepods). Squid are preyed upon by marine mammals, seabirds, and to a lesser extent by fish and occupy an important role in marine food webs worldwide. Predation on various species and life stages of squids differs with the size and foraging behavior of the predator, e.g. adult *B. magister* are eaten mainly by marine mammals. In some areas squids may constitute up to 80% of the diets of sperm whales, bottlenose dolphins, and beaked whales, and about half of the diet of Dall's porpoise in the eastern Bering Sea and Aleutian Islands. Seabirds (e.g., kittiwakes, puffins, murres) on island rookeries close to the shelf break (e.g., Buldir Island, Pribilof Islands) are also known to feed heavily on squid. However, squid play a larger role in the diet of salmon.

Habitat and Biological Associations for *Berryteuthis magister*

<u>Egg/Spawning</u>: Eggs are laid on the bottom on the upper slope (200 to 800 m); incubate for 1 to 2 months.

<u>Young Juveniles</u>: Distributed epipelagically (top 100 m) from the coast to open ocean.

<u>Old Juveniles and Adults</u>: Distributed mesopelagically (most from 150 to 500 m), mostly in outer shelf/slope waters (and to an unknown extent out over basin, where very little sampling has been conducted). Migrate to slope waters to mate and spawn demersally.

Habitat and Biological Associations: *B. magister*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	1–2 months	NA	varies	USP, LSP	D	M, SM, MS	U	
Young juveniles	4–6 months	zooplankton	varies	all shelf, slope, BSN	P, N	NA	UP, F?	
Older Juveniles and Adults	1–2 years (may be up to 4 yrs)	euphausiids, shrimp, small forage fish, and other cephalopods	summer winter	OS, USP, LSP, BSN OS, USP, LSP, BSN	SP SP	U U	UP, F? UP, F?	euhaline waters, 2–4 °C

Literature

Arkhipkin, A.I., V.A. Bizikov, V.V. Krylov, and K.N. Nesis. 1996. Distribution, stock structure, and growth of the squid *Berryteuthis magister* (Berry, 1913) (Cephalopoda, Gonatidae) during summer and fall in the western Bering Sea. Fish. Bull. 94: 1-30.

Akimushkin, I.I. 1963. Cephalopods of the seas of the U.S.S.R. Academy of Sciences of the U.S.S.R., Institute of Oceanology, Moscow. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1965. 223 p.

Byrd, G.V., J.C. Williams, and R. Walder. 1992. Status and biology of the tufted puffin in the Aleutian Islands, Alaska, after a ban on salmon driftnets. U. S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, Aleutian Islands Unit, PSC 486, Box 5251, FPO AP 96506-5251, Adak, Alaska.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK.

Hatch, S.A., G.V. Byrd, D.B. Irons, and G.L. Hunt, Jr. 1990. Status and ecology of kittiwakes in the North Pacific. Proc. Pacific Seabird Group Symposium, Victoria, B.C., 21-25 February 1990.

Jorgensen, E.M. 2009. Field guide to squids and octopods of the eastern North Pacific and Bering Sea. Alaska Sea Grant College Program, University of Alaska Fairbanks, Fairbanks, Alaska. 94 p.

Livingston, P.A., and B.J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-54, 81 p.

Nesis, K. N. 1987. Cephalopods of the world. TFH Publications, Neptune City, NJ, USA. 351 pp.

Ormseth, O.A. 2014. Assessment of the squid stock complex in the Bering Sea and Aleutian Islands. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Perez, M. 1990. Review of marine mammal population and prey information for Bering Sea ecosystem studies. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-186, 81 p.

Sobolevsky, Ye. I. 1996. Species composition and distribution of squids in the western Bering Sea. Pp. 135-141 *In* O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Rept 96-01, U. Alaska, Fairbanks, AK 99775.

Springer, A. 1993. Report of the seabird working group. pp. 14-29 *In* Is it food? Addressing marine mammal and seabird declines: a workshop summary. Alaska Sea Grant Report 93-01, Univ. Alaska, Fairbanks, AK, 99775.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Octopuses

There are at least seven species of octopuses currently identified from the Bering Sea (Jorgensen 2009). The species most abundant at depths less than 200m is the giant Pacific octopus *Enteroctopus dofleini* (formerly *Octopus dofleini*). Several species are found primarily in deeper waters along the shelf break and slope, including, *Sasakiopus salebrosus, Benthoctopus leioderma, Benthoctopus oregonensis, Graneledone boreopacifica,* and the cirrate octopus *Opisthoteuthis* cf *californiana. Japetella diaphana* is also reported from pelagic waters of the Bering Sea. Preliminary evidence (Conners and Jorgensen 2008) indicates that octopuses taken as incidental catch in groundfish fisheries are primarily *Enteroctopus dofleini*. This species has been extensively studied in British Columbia and Japan, and is used as the primary indicator for the assemblage. Species identification of octopuses in the Bering Sea and Gulf of

Alaska (GOA) has changed since the previous EFH review and is still developing. The state of knowledge of octopuses in the Bering Sea and Aleutian Islands (BSAI), including the true species composition, is very limited.

Life History and General Distribution

Octopuses are members of the molluscan class Cephalopoda, along with squid, cuttlefish, and nautiloids. The octopuses (order Octopoda) have only eight appendages or arms and unlike other cephalopods, they lack shells, pens, and tentacles. There are two groups of Octopoda, the cirrate and the incirrate. The cirrate have cirri and are by far less common than the incirrate, which contain the more traditional forms of octopus. Octopuses are found in every ocean in the world and range in size from less than 20 cm (total length) to over 3 m (total length); the latter is a record held by *Enteroctopus dofleini*.

In the Bering Sea octopuses are found from subtidal waters to deep areas near the outer slope (Conners et al. 2014). The highest diversity is along the shelf break region where three to four species of octopus can be collected in approximately the same area. The highest diversity is found between 200 m and 750 m. The observed take of octopus from both commercial fisheries and Alaska Fisheries Science Center Resource Assessment and Conservation Engineering Division surveys indicates few octopus occupy federal waters of Bristol Bay and the inner front region. Some octopuses have been observed in the middle front, especially in the region south of the Pribilof Islands. The majority of observed commercial and survey hauls containing octopus are concentrated in the outer front region and along the shelf break, from the horseshoe at Unimak Pass to the northern limit of the federal regulatory area. Octopuses have been observed throughout the western GOA and Aleutian Islands chain. Of the octopus species found in shallower waters, the distribution between state waters (within three miles of shore) and federal waters remains unknown. *Enteroctopus dofleini* in Japan undergo seasonal depth migrations associated with spawning; it is unknown whether similar migrations occur in Alaskan waters.

In general, octopus life spans are either 1 to 2 years or 3 to 5 years depending on species. Life histories of six of the seven species in the Bering Sea are largely unknown. *Enteroctopus dofleini* has been studied in waters of northern Japan and western Canada, but reproductive seasons and age/size at maturity in Alaskan waters are still undocumented. General life histories of the other six species are inferred from what is known about other members of the genus.

E. dofleini samples collected during research in the Bering Sea indicate that *E. dofleini* are reproductively active in the fall with peak spawning occurring in the winter to early spring months. Like most species of octopods, *E. dofleini* are terminal spawners, dying after mating (males) and the hatching of eggs (females) (Jorgensen 2009). *E. dofleini* within the Bering Sea have been found to mature between 10 to 13 kg with 50% maturity values of 12.8 kg for females and 10.8 kg for males (Brewer and Norcross 2013). *E. dofleini* are problematic to age due to a documented lack of beak growth checks and soft chalky statoliths (Robinson and Hartwick 1986). Therefore the determination of age at maturity is difficult for this species. In Japan this species is estimated to mature at 1.5 to 3 years and at similar size ranges (Kanamaru and Yamashita 1967, Mottet1975). Within the Bering Sea, female *E. dofleini* show significantly larger gonad weight and maturity in the fall months (Brewer and Norcross 2013). Due to differences in the timing of peak gonad development between males and females it is likely that females have the capability to store sperm. Fecundity for this species in the Gulf of Alaska ranges from 40,000 to 240,000 eggs per female with an average fecundity of 106,800 eggs per female (Conrath and Conners 2014). Hatchlings are approximately 3.5 mm. Mottet (1975) estimated survival to 6 mm at 4% while survival to 10 mm was estimated to be 1%; mortality at the 1 to 2 year stage is also estimated to be high (Hartwick, 1983). Since the highest mortality occurs during the larval stage it is likely that ocean conditions have the largest effect on the number of *E. dofleini* in the Bering Sea and large fluctuations in numbers of *E. dofleini* should be expected. Based on larval data, *E. dofleini* is the only octopus in the Bering Sea with a planktonic larval stage.

Sasakiopus salebrosus is a small benthic octopus recently identified from the Bering Sea slope in depths ranging from 200 to1200 m (Jorgensen 2010). It was previously identified in surveys as *Benthoctopus sp*. or as *Octopus sp. n.* In recent groundfish surveys of the Bering Sea slope this was the most abundant octopus collected; multiple specimens were collected in over 50% of the tows. *Sasakiopus salebrosus* is a small-sized species with a maximum total length < 25 cm. Mature females collected in the Bering Sea carried 100 to 120 eggs (Laptikhovsky 1999). Hatchlings and paralarvae have not been collected or described (Jorgensen 2009).

Benthoctopus leioderma is a medium sized species, with a maximum total length of approximately 60 cm. Its life span is unknown. It occurs from 250 to 1400 m and is found throughout the shelf break region. It is a common octopus and often occurs in the same areas where *E. dofleini* are found. The eggs are brooded by the female but mating and spawning times are unknown. Members of this genus in the North Pacific Ocean have been found to attach their eggs to hard substrate under rock ledges and crevices (Voight and Grehan 2000). *Benthoctopus* tend to have small numbers of eggs (< 200) that develop into benthic hatchlings.

Benthoctopus oregonensis is larger than *B. leioderma*, with a maximum total length of approximately 1 m. This is the second largest octopus in the Bering Sea and based on size could be confused with *E. dofleini*. We know very little about this species of octopus. Other members of this genus brood their eggs and we would assume the same for this species. The hatchlings are demersal and likely much larger than those of *E. dofleini*. The samples of *B. oregonensis* all come from deeper than 500 m. This species is the least collected incirrate octopus in the Bering Sea and may occur in depths largely outside of the sampling range of AFSC surveys.

Graneledone boreopacifica is a deep water octopus with only a single row of suckers on each arm (the other benthic incirrate octopuses have two rows of suckers). It is most commonly collected north of the Pribilof Islands but occasionally is found in the southern portion of the shelf break region. This species has been shown to occur at hydrothermal vent habitats and prey on vent fauna (Voight 2000). Samples of *G. boreopacifica* all come from deeper than 650 m and this deep water species has not been found on the continental shelf. *Graneledone* species have also been shown to individually attach eggs to hard substrate and brood their eggs throughout development. Recently collected hatchlings of this species were found to be very large (55 mm long) and advanced (Voight 2004) and this species has been shown to employ multiple paternity (Voight and Feldheim 2009).

Opisthoteuthis californiana is a cirrate octopus with fins and cirri (on the arms). It is common in the Bering Sea but would not be confused with *E. dofleini*. It is found from 300 to 1100 m and likely common over the abyssal plain. *Opisthoteuthis californiana* in the northwestern Bering Sea have been found to have a protracted spawning period with multiple small batch spawning events. Potential fecundity of this species was found to range from 1,200 to 2,400 oocytes (Laptikhovsky 1999). There is evidence that *Opisthoteuthis* species in the Atlantic undergo ‘continuous spawning’ with a single, extended period of egg maturation and a protracted period of spawning (Villanueva 1992). Other details of its life history remain unknown.

Japetella diaphana is a small pelagic octopus. Little is known about members of this family. In Hawaiian waters gravid females are found near 1,000 m and brooding females near 800 m. Hatchlings have been observed to be about 3 mm mantle length (Young 2008). This is not a common octopus in the Bering Sea and would not be confused with *E. dofleini*.

Relevant Trophic Information

Octopus are eaten by pinnipeds (principally Steller sea lions, and spotted, bearded, and harbor seals) and a variety of fishes, including Pacific halibut and Pacific cod (Yang 1993). When small, octopods eat planktonic and small benthic crustaceans (mysids, amphipods, copepods). As adults, octopus eat benthic crustaceans (crabs) and molluscs (clams). Large octopuses are also able to catch and eat benthic fishes; the Seattle Aquarium has documented a giant Pacific octopus preying on a 4-foot dogfish. . The pelagic larvae of *E. dofleini* are presumed to prey on planktonic zooplankton.

Habitat and Biological Associations

Egg/Spawning: shelf, *E. dofleini* lays strings of eggs in cave or den in boulders or rubble, which are guarded by the female until hatching. The exact habitat needs and preferences for denning are unknown.

Larvae: pelagic for *Enteroctopus dofleini*, demersal for other octopus species.

Young Juveniles: semi-demersal; widely dispersed on shelf, upper slope

Old Juveniles and Adults: demersal, widely dispersed on shelf and upper slope, preferentially among rocks, cobble, but also on sand/mud.

Habitat and Biological Associations: *Octopus dofleini*, *O. gilbertianus*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U (1–2 months?)	NA	spring–summer?	U, ICS, MCS	P*,D	R, G?	U	euhaline waters
Young juveniles	U	zooplankton	summer–fall?	U, ICS, MCS, OCS, USP	D, SD	U	U	euhaline waters
Older Juveniles and Adults	3–5 yrs for *E.dofleini,* 1–2 yrs for other species	crustaceans, mollusks, fish	all year	ICS, MCS, OCS, USP	D	R, G, S, MS?	U	euhaline waters

Literature

Akimushkin, I.I. 1963. Cephalopods of the seas of the U.S.S.R. Academy of Sciences of the U.S.S.R., Institute of Oceanology, Moscow. Translated from Russian by Israel Program for Scientific Translations, Jerusalem 1965. 223 p.

Alaska Department of Fish and Game. 2004. Annual management report of the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea, and the westward region’s shellfish observer program, 2003. Regional Information Report No. 4K04-43

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2008. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA Tech Memo.

Bowers, F.R., M. Schwenzfeier, K Herring, M Salmon, K Milani, J. Shaishnikoff, H. Barnhart, J. Alas, R. Burt, B. Baechler, and A. Buettner. 2010. Annual management report of the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea, and the westward region’s shellfish observer program, 2008/09. ADF&G Fishery Management Report No 10-24.

Boyle, P. and P. RodhouseCephalopods: Ecology and Fisheries. Blackwell Publishing, Oxford, UK.

Brewer, R.S. and B.L. Norcross. Long-term retention of internal elastomer tags in a wild population of North Pacific giant octopus (Enteroctopus dofleini), Fisheries Research 134-136: 17-20.

Brewer, R.S. and B.L. Norcross. 2013. Seasonal changes in the sexual maturity and body condition of the North Pacific giant octopus (Enteroctopus dofleini).

Caddy, J.F. 1979. Preliminary analysis of mortality, immigration, and emigration on Illex population on the Scotian Shelf. ICNAF Res. Doc. 79/VI/120, Ser. No. 5488.

Caddy, J.F. 1983. The cephalopods: factors relevant to their population dynamics and to the assessment and management of stocks. Pages 416-452 In J.F. Caddy, ed. Advances in assessment of world cephalopod resources. FAO Fisheries Tech. Paper 231.

Caddy, J.F. 2004. Current usage of fisheries indicators and reference points, and their potential application to management of fisheries for marine invertebrates. Can. J Fish. Aquat. Sci. 61:1307-1324.

Caddy, J.F. and P.G. Rodhouse. 1998. Cephalopod and groundfish landings: evidence for ecological change in global fisheries? Rev. Fish Biology and Fisheries 8:431-444.

Charnov e.L. and D. Berrigan. 1991. Evolution of life history parameters in animals with indeterminate growth, particularly fish. Evol. Ecol. 5:63-68.

Conners, M. E., P. Munro, and S. Neidetcher. 2004. Pacific cod pot studies 2002-2003. AFSC Processed Report 2004-04. June 2004

Conners, M.E., C. Conrath, and K. Aydin 2014. Octopus Complex in the Bering Sea and Aleutian Islands. In: Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pac. Mgmt. Council, Anchorage, AK,

Conners, M. E., C. L. Conrath, and R. Brewer. 2012. Field studies in support of stock assessment for the giant Pacific octopus Enteroctopus dofleini. NPRB Project 906 Final Report. North Pacific Research Board, Anchorage, AK.

Conrath, C. and M. E. Conners. 2014, Aspects of the reproductive biology of the giant Pacific octopus, Enteroctopus dofleini, in the Gulf of Alaska. Fishery Bulletin 112(4):253-260.

Fritz, L.W. 1996. Other species In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Fritz, L. 1997. Summary of changes in the Bering Sea Aleutian Islands squid and other species assessment. (in) Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. N. Pacific Fish. Management Council, Anchorage, AK.

Gabe, S.H. 1975. Reproduction in the Giant Octopus of the North Pacific, Octopus dofleini martini. Veliger 18 (2): 146-150.

Gaichas, S. 2004. Other Species (in) Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea / Aleutian Islands regions. N. Pacific Fish. Management Council, Anchorage, AK.

Hatanaka, H. 1979. Studies on the fisheries biology of common octopus off the northwest coast of Africa. Bull Far Seas Reserarch Lab 17:13-94.

Hartwick, B. 1983. *Octopus dofleini*. In Cephalopod Life Cycles Vol. I. P.R. Boyle eds. 277-291.

Hartwick, E.B., R.F. Ambrose, and S.M.C. Robinson. 1984. Dynamics of shallow-water populations of *Octopus dofleini*. Mar. Biol. 82:65-72.

Hartwick, E.B, and I. Barriga. 1997. *Octopus dofleini*: biology and fisheries in Canada (in) Lang, M. A. and F.G. Hochberg (eds.) (1997). Proceedings of the Workshop on the Fishery and market potential of octopus in California. Smithsonian Institutions: Washington. 192 p.

Iverson, S.J., K.J. Frost, and S.L.C. Lang. 2002. Fat content and fatty acid composition of forage fish and invertebrates in Prince William Sound, Alaska: factors contributing to among and within species variability. Marine Ecol. Prog. Ser. 241:161-181.

Kanamaru, S. 1964. The octopods off the coast of Rumoi and the biology of mizudako. Hokkaido Marine Research Centre Monthly Report 21(4&5):189-210.

Kanamaru, S. and Y. Yamashita. 1967. The octopus mizudako. Part 1, Ch. 12. Investigations of the marine resources of Hokkaido and developments of the fishing industry, 1961 – 1965.

Kubodera, T. 1991. Distribution and abundance of the early life stages of octopus, Octopus dofleini Wulker, 1910 in the North Pacific. 49(1-2) 235-243.

Laptikhovsky, V.V. 1999. Fecundity and reproductive strategy of three species of octopods from the Northwest Bering Sea. Russian Journal of Marine Biology 25: 342-346.

Laptikhovsky, V. Fecundity, egg masses and hatchlings of Benthoctopus spp. (Octopodidae) in Falkland waters. J.Biol. Ass. U.K. 81: 267-270.

Livingston, P.L., Aydin, K.Y., J. Boldt., S. Gaichas, J. Ianelli, J. Jurado-Molina, and I. Ortiz. 2003. Ecosystem Assessment of the Bering Sea/Aleutian Islands and Gulf of Alaska Management Regions. In: Stock assessment and fishery evaluation report for the groundfish resources or the Bering Sea/Aleutian Islands regions. North. Pac. Fish. Mgmt. Council, Anchorage, AK.

Merrick, R.L., M.K. Chumbley, and G.V. Byrd, 1997. Diet diversity of Steller sea lions (*Eumetpias jubatus*) and their population decline in Alaska: a potential relationship. Can J. Fish. Aquat. Sci. 54: 1342-1348.

Mottet, M. G. 1975. The fishery biology of *Octopus dofleini*. Washington Department of Fisheries Technical Report No. 16, 39 pp.

National Research Council. 1998. Improving fish stock assessments. National Academy Press, Washington, D.C.

Nesis, K.N. 1987. Cephalopods of the world. TFH Publications, Neptune City, NJ, USA. 351 pp.

Osako, M. and. Murata. 1983. Stock assessment of cephalopod resources in the northwestern Pacific. Pages55-144 In J.F. Caddy, ed. Advances in assessment of world cephalopod resources. FAO Fisheries Tech. Paper 231.

Paust, B.C. 1988. Fishing for octopus, a guide for commercial fishermen. Alaska Sea Grant Report No. 88-3, 48 pp.

Paust, B.C. 1997. *Octopus dofleini*: Commercial fishery in Alaska (in) Lang, M. A. and F.G. Hochberg (eds.) (1997). Proceedings of the Workshop on the Fishery and market potential of octopus in California. Smithsonian Institutions: Washington. 192 p.

Perez, M. 1990. Review of marine mammal population and prey information for Bering Sea ecosystem studies. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS F/NWC-186, 81 p.

Perry, R.I., C.J. Walters, and J.A. Boutillier. 1999. A framework for providing scientific advice for the management of new and developing invertebrate fisheries. Rev. Fish Biology and Fisheries 9:125-150.

Punt, A.E. 1995. The performance of a production-model management procedure. Fish. Res. 21:349-374.

Rikhter, V.A. and V.N. Efanov, 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res.Doc., 79/VI/8, 12p.

Robinson, S.M.C. 1983.Growth of the Giant Pacific octopus, Octopus dofleini martini on the west coast of British Columbia. MSc thesis, Simon Fraser University.

Robinson, S.M.C. and E.B. Hartwick. 1986. Analysis of growth based on tag-recapture of the Giant Pacific octopus Octopus dofleini martini. Journal of Zoology 209: 559-572.

Rooper, C.F.E., M.J. Sweeny, and C.E. Nauen. 1984. FAO Species catalogue vol. 3 cephalopods of the world. FAO Fisheries Synopsis No. 125, Vol. 3.

Sagalkin, N.H. and K Spalinger. Annual management report of the commercial and subsistence shellfish fisheries in the Kodiak, Chignik, and Alaska Peninsula areas, 2010. ADF&G Fishery Management Report No. 11-43.

Sato, K. 1996. Survey of sexual maturation in Octopus dofleini in the coastal waters off Cape Shiriya, Shimokita Peninsula, Aomori Prefecture. Nippon Suisan Gakkaishi 62(3): 355-360.

Sato, R. and H. Hatanaka. 1983. A review of assessment of Japanese distant-water fisheries for cephalopods. Pages 145-203 In J.F. Caddy, ed. Advances in assessment of world cephalopod resources. FAO Fisheries Tech. Paper 231.

Scheel, D. 2002. Characteristics of habitats used by *Enteroctopus dofleini* in Prince William Sound and Cook Inlet, Alaska. Marine Ecology 23(3):185-206.

Sinclair, E.H. and T.K. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). J Mammology 83:973-990.

Toussaint, R.K., D. Scheel, G.K. Sage, and S.L. Talbot. 2012. Nuclear and mitochondrial markers reveal evidence for genetically segregated cryptic speciation in giant Pacific octopuses from Prince William Sound, Alaska. Conservation Genetics. Online First: DOI 10.1007/s10592-012-0392-4.

Villanueva, R. 1992. Continuous spawning in the cirrate octopods Opisthoteuthis agassizii and O. vossi: features of sexual maturation defining a reproductive strategy in cephalopods. Marine Biology 114: 265-275.

Voight, J.R. 2004. Hatchlings of the deep-sea Graneledone boreopacifica are the largest and most advanced known. Journal of Molluscan Studies 70: 400-402.

Voight, J.R. and K.A. Feldheim. 2009. Microsatellite inheritance and multiple paternity in the deep-sea octopus, Graneledone boreopacifica (Mollusca: Cephalopoda). Invertebrate Biology 128:26-30.

Voight, J. R. and A. J. Grehan. 2000. Egg brooding by deep-sea octopuses in the North Pacific Ocean. Biological Bulletin 198: 94–100.

Wakabayashi, K, R.G. Bakkala, and M. S. Alton. 1985. Methods of the U.S.-Japan demersal trawl surveys (in) R.G. Bakkala and K. Wakabayashi (eds.), Results of cooperative U.S. - Japan groundfish investigations in the Bering Sea during May - August 1979. International North Pacific Fisheries Commission Bulletin 44.

Walters, G. E. Report to the fishing industry on the results of the 2004 Eastern Bering Sea Groundfish Survey. AFSC Process Report 2005-03. Feb 2005.

Wilson, J.R. and A.H. Gorham. 1982. Alaska underutilized species Volume II: Octopus. Alaska Sea Grant Report 82-3. May 1982. 64 p.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Young, R.E. 2008. Japetella diaphana (Hoyle 1885). Version 28 April 2008 (under construction). http://tolweb.org/Japetella_diaphana/20224/2008.04.28 in the Tree of Life Web Project, http://tolweb.org/

Young, R.E., and M. Vecchione. 1999. Morphological observations on a hatchling and a paralarva of the vampire squid, *Vampyroteuthis infernalis* Chun (Mollusca: Cephalopoda). Proceedings of the Biological Society of Washington 112:661-666.

Sharks

The species representatives for sharks are:

Lamnidae:	Salmon shark (*Lamna ditropis*)
Squalidae:	Sleeper shark (*Somniosus pacificus*)
	Spiny dogfish (*Squalus suckleyi*)

Life History and General Distribution

Sharks of the order Squaliformes (which includes the two families Lamnidae and Squalidae) are the higher sharks with five gill slits and two dorsal fins. Salmon shark are large (up to 3 m in length), aplacental, viviparous (with small litters of one to four pups and embryos nourished by yolk sac and 5 oophagy), widely migrating sharks, with homeothermic capabilities and highly active predators (salmon and white sharks). Salmon sharks are distributed epipelagically along the shelf (can be found in shallow waters) from California through the Gulf of Alaska (GOA) to the northern Bering Sea and off Japan. In groundfish fishery and survey data, salmon sharks occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near the coast to the outer shelf in the GOA, particularly near Kodiak Island. Salmon sharks are not commonly seen in Aleutian Islands.

The Pacific sleeper shark is distributed from California around the Pacific Rim to Japan and in the Bering Sea principally on the outer shelf and upper slope. However, they do often occur in near shore, and shallow waters in the GOA. Tagging data suggests that they spend a significant amount of time moving vertically thorugh the water column. Adult Pacific sleeper shark have been reported as long as 7 m, however, size at maturity is unknown, as well as reproductive mode. Other members of the Squalidae are aplacental viviparous, and it is likely a safe assumption that Pacific sleeper shark are as well. In groundfish fishery and survey data, Pacific sleeper sharks occur chiefly on outer shelf/upper slope areas in the Bering Sea, but near coast to the outer shelf in the GOA, particularly near Kodiak Island in Shelikof Strait, inside waters of Southeast Alaska and Prince William Sound.

Spiny dogfish are widely distributed throughout the North Pacific Ocean. In the North Pacific, spiny dogfish may be most abundant in the GOA; they also occur in the Bering Sea. Spiny dogfish are pelagic species found at the surface and to depths of 700 m but mostly at 200 m or less on the shelf and the neritic zone; they are often found in aggregations. Spiny dogfish are aplacental viviparous. Litter size is proportional to the size of the female and range from 2 to 23 pups, with 10 average. Gestation may be 22 to 24 months. Young are 24 to 30 cm at birth, with growth initially rapid, then slows dramatically. Maximum adult size is about 1.6 m and 10 kg; maximum age is 80+ years. Fifty percent of females are mature at 97 cm and 36 years old; 50 percent of males are mature at 74 cm and 21 years old. Females give birth in shallow coastal waters, usually in September through January. Tagging experiments indicate local indigenous populations in some areas and widely migrating groups in others. They may move inshore in summer and offshore in winter.

Relevant Trophic Information

Sharks are top level predators in the GOA. The only likely predator would be larger fish or mammals preying on young/small sharks. Spiny dogfish opportunistic generalist feeders, eating a wide variety of foods, including fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus). Salmon shark are believed to eat primarily fish, including salmon, sculpins, and gadids, Pacific sleeper shark are predators of flatfish, cephalopods, rockfish, crabs, seals, and salmon and may also prey on pinnipeds.

Habitat and Biological Associations

Egg/Spawning: Salmon sharks and spiny dogfish are aplacental viviparous; reproductive strategy of Pacific sleeper sharks is not known. Spiny dogfish give birth in shallow coastal waters, while salmon sharks pupping grounds are located in the offshore transitional domain south of the GOA.

Juveniles and Adults: Spiny dogfish are widely dispersed throughout the water column on shelf in the GOA, and along outer shelf in the eastern Bering Sea; apparently not as commonly found in the Aleutian Islands and not commonly at depths greater than 200 m.

Salmon sharks are found throughout the GOA, but less common in the eastern Bering Sea and Aleutian Islands; epipelagic, primarily over shelf/slope waters in GOA, and outer shelf in the eastern Bering Sea. Salmon shark do exihibit seasonal abundances in areas with high density of salmon returns, such as Prince William Sound.

Pacific sleeper sharks are widely dispersed on shelf/upper slope in the GOA, and along outer shelf/upper slope only in the eastern Bering Sea; generally demersal, but may utlize the full water column.

Habitat and Biological Associations: Sharks

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs								
Salmon shark	9 mo gestation		Late spring pupping	Pelagic transition zone	P	NA	U	
Pacific sleeper shark	U		U	U	U	U	U	
Spiny dogfish	18-24 mo gestation		Fall/early winter pupping	Near shore bays	P/D	U	U	
Larvae	NA							
Juveniles and Adults								
Salmon shark	30+ years	fish (salmon, sculpins, and gadids)	all year	ICS, MCS, OCS, USP in GOA; OCS, USP in BSAI	P	NA	U	4-24°C
Pacific sleeper shark	U	omnivorous; flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MCS, OCS, USP in GOA; OCS, USP in BSAI	D	U	U	
Spiny dogfish	80+ years	fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus)	all year	ICS, MCS, OCS in GOA; OCS in BSAI give birth ICS in fall/winter?	P/D	U	U	4–16°C

Literature

Alverson, Dand M. E. Stansby. 1963. The spiny dogfish (*Squalus acanthias*) in the northeastern Pacific. USFWS Spec Sci Rep-Fisheries. 447:25p.

Beamish, R. J., G. A. McFarlane, K. R. Weir, M. S. Smith, J.Scarsbrook, A. J. Cass and C. C. Wood. 1982. Observations on the biology of Pacific hake, walleye pollock and spiny dogfish in the Strait of Georgia, Juan de Fuca Strait and off the west coast of Vancouver Island and United States, July 13-24, 1976. Can MS Rep Fish Aquat Sci. 1651:150p.

Beamish, R.J., and G.A. McFarlane. 1985. Annulus development on the second dorsal spine of the spiny dogfish (*Squalus acanthias*) and its validity for age determination. JAquat. Sci. 42:1799-1805.

Benz, G. W., R. Hocking, A. Kowunna Sr., S. A. Bullard, J.C. George. 2004. A second species of Arctic shark: Pacific sleeper shark *Somniosus pacificus* from Point Hope, Alaska. Polar Biol. 27:250-252.

Bonham, K. 1954. Food of the dogfish *Squalus acanthias*. Fish Res Paper. 1:25-36.

Bright, D.B. 1959. The occurance and food of the sleeper shark, *Sominus pacificus*, in a central Alaskan Bay. Copeia 1959. 76-77.

Campana, S. E., C. Jones, G. A. McFarlane, and S. Myklevoll. 2006. Bomb dating and age validation using the spines of spiny dogfish (*Squalus acanthias*). Environ Biol Fish. 77:327-336.

Conrath, C.L., C.A. Tribuzio, and K.J. Goldman. 2014. Notes on the reproductive biology of female salmon sharks in the eastern North Pacific Ocean. Transactions of the American Fisheries Society. 143:363-368.

Cortes, E. 1999. Standardized diet compositions and trophic levels of sharks. J Mar Sci. 56:707-717.

Cortes, E. 2007. Chondrichthyan demographic modelling: an essay on its use, abuse and future. *Marine and Freshwater Research* **58**, 4-6.

Courtney, D. L. and R. FoyPacific sleeper shark *Somniosus pacificus* trophic ecology in the eastern North Pacific Ocean inferred from nitrogen and carbon stable-isotope ratios and diet. Journal of Fish Biology. 80:1508-1545.

Ebert, D.A., L.J.V. Compagno, and L.J. Natanson. 1987. Biological notes on the Pacific sleeper shark, *Somniosus pacificus (*Chondrichthyes: Squalidae). Calif. Fish and Game 73(2); 117-123.

Ebert, D.A., T.W. White, K.J. Goldman, L.J.V. Compagno, T.S. Daly-Engel and R.D. WardResurrection and redescriptions of *Squalus suckleyi* (Girard, 1854) from the North Pacfici, with comments on the *Squalus acanthias* subgroup (Squaliformes: Squalidae). Zootaxa. 2612:22-40.

Gilmore, R.G. 1993. Reproductive biology of lamnoid sharks. Env. Fish. 38:95-114.

Girard, C.F. 1854. Characterstics of some cartilaginous fishes of the Pacific coast of North America. Proceedings of the Natural Sciences of Philadephia. 7:196-197.

Goldman, K.J., S.D. Anderson, R.J. Latour and J.A. MusickHomeothermy in adult salmon sharks, *Lamna ditropis*. Env. Biol. Fish. December 2004.

Goldman, K.J. and J.A. Musick. 2006. Growth and maturity of salmon sharks in the eastern and western North Pacific, with comments on back-calculation methods. Fish. Bull 104:278-292.

Gotshall, D. W., and T. Jow. 1965. Sleeper sharks (*Somniosus pacificus*) off Trinidad, California, with life history notes. California Fish and Game 51:294 –298.

Hart, JL. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada (Bull. 180), Ottawa, Canada. 749 pp.

Hulbert, L., A. M. Aires-Da-Silva, V. F. Gallucci, and J. S. Rice. 2005. Seasonal foraging behavior and migratory patterns of female *lamna ditropis* tagged in Prince William Sound, Alaska. J. Fish Biol. 67:490-509.

Hulbert, L., M. Sigler, and C. R. Lunsford. 2006. Depth and movement behavior of the Pacific sleeper shark in the north-east Pacific Ocean. J. of Fish Biol. 69:406-425.

Hulson, P-J.F., C.A. Tribuzio, K. Coutre. In review. The use of satellite tags to inform the stock assessment of a data poor species: Spiny Dogfish in the Gulf of Alaska. Proceedings of the 2015 Lowell Wakefield Symposium.

Ketchen, K. S. 1972. Size at maturity, fecundity, and embryonic growth of the spiny dogfish (*Squalus acanthias*) in British Columbia waters. J Fish Res Bd Canada. 29:1717-1723.

McFarlane. G.A., and J.R. King.Migration patterns of spiny dogfish (*Squalus acanthias*) in the North Pacific Ocean. Fishery Bulletin. 101:358-367.

Nagasawa, K. 1998. Predation by salmon sharks (*Lamna ditropis*) on Pacific salmon (*Oncorhynchus spp.*) in the North Pacific Ocean. Bulletin of the North Pacific Anadromous Fish Commission, No. 1:419-433.

Orlov, A.M. 1999. Capture of especially large sleeper shark *Somniosus pacificus* (Squalidae) with some notes on its ecology in Northwestern Pacific. Jornal of Ichthyology. 39: 548-553.

Orlov, A.M., and S.I. Moiseev. Some biological features of Pacific sleeper shark, *Somniosus pacificus* (Bigelow et Schroeder 1944) (Squalidae) in the Northwestern Pacific Ocean. Oceanological Studies. 28: 3-16.

Sano, O.The investigation of salmon sharks as a predator on salmon in the North Pacific, 1960. Bulletin of the Hokkaido Regional Fisheries Research Laboratory, Fisheries Agency 24:148–162 (in Japanese).

Saunders, M.W. and G.A. McFarlane. 1993. Age and length at maturity of the female spiny dogfish (*Squalus acanthias*) in the Strait of Georgia, British Columbia, Canada. Environ Biol Fish 38:49-57.

Schauffler, L. R. Heintz, M. Sigler and L. Hulbert. 2005. Fatty acid composition of sleeper shark (*Somniosus pacificus*) liver and muscle reveals nutritional dependence on planktivores. ICES CM 2005/N:05.

Sigler M.F., L. Hulbert, C. R. Lunsford, N. Thompson, K. Burek, G. Corry-Crowe, and A. Hirons. 2006. Diet of Pacific sleeper shark, a potential Steller sea lion predator, in the north-east Pacific Ocean. J. Fish Biol. 69:392-405.

Tanaka, S. 1980. Biological investigation of *Lamna ditropis* in the north-western waters of the North Pacific. *In* Report of investigation on sharks as a new marine resource (1979). Published by: Japan Marine Fishery Resource Research Center, Tokyo [English abstract, translation by Nakaya].

Taylor, I.G., G.R. Lippert, V.F. Gallucci and G.G. BargmannMovement patterns of spiny dogfish from historical tagging experiments in Washington State. In ' Biology and Management of Dogfish Sharks'. (Eds. V. F. Gallucci, G. A. McFarlane, and G. Bargmann) pp. 67 – 76. (American Fisheries Society: Bethesda, MD)

Tribuzio, C. A., Gallucci, V. F., and Bargmann, G. G. 2009. A survey of demographics and reproductive biology of spiny dogfish (*Squalus acanthias*) in Puget Sound, WA. In ' Biology and Management of Dogfish Sharks'. (Eds. V. F. Gallucci, G. A. McFarlane, and G. Bargmann) pp. 181-194. (American Fisheries Society: Bethesda, MD)

Tribuzio, C.A., K. Echave, C. Rodgveller, and PJ. Hulson. 2014. Assessment of the shark stock complex in the Bering Sea and Aleutian Islands. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Eastern Bering Sea and Aleutian Islands. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. Pgs. 1825-1884.

Tribuzio, C.A., C. Rodgveller, K. Echave and PJ. Hulson. 2015. Assessment of the shark stock complex in the Gulf of Alaska. *In* Stock Assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501. Pgs. 1569-1642.

Tribuzio, C.A., G.H. Kruse and J.T. Fujioka. 2010. Age and growth of spiny dogfish (*Squalus acanthias*) in the Gulf of Alaska: Analysis of alternative growth models. Fishery Bulletin. 102:119-135.

Tribuzio, C.A. and G. H. Kruse. 2012. Life history characteristics of a lightly exploited stock of *Squalus suckleyi*. Journal of Fish Biology. 80:1159-1180.

Weng, K.C., A. Landiera, P.C. Castilho, D.B. Holts, R.J. Schallert, J.M. Morrissette, K.J. Goldman, and B.A. Block. 2005. Warm sharks in polar seas: satellite tracking from the dorsal fins of salmon sharks. Science 310:104-106.

White W.T., P.R. Last, J.D. Stevens, G.K. Yearsley, Fahmi and Dharmadi. 2006 Economically important sharks and rays of Indonesia Australian Centre for International Agricultural Research, Canberra, Australia.

Wood, C. C., Ketchen, K. S., and Beamish, R. J. (1979). Population dynamics of spiny dogfish (*Squalus acanthias*) in British Columbia waters. *Journal of the Fisheries Research Board of Canada* 36, 647-656.

Yang, M., and B.N. Page.Diet of Pacific sleeper shark, *Somniosus pacificus*, in the Gulf of Alaska. Fish. Bull. 97: 406-4-9.

Yano, K., J.D. Stevens, and L.J.V. Compagno.Distribution, reproduction and feeding of the Greenland shark *Somniosus (Somniosus) microcephalus*, with notes on two other sleeper sharks, *Somniosus (Somniosus) pacificus* and *Somniosus (Somniosus) antarticus.* J. Fish. Biol. 70: 374-390.

Sculpins (Cottidae)

The species representatives for sculpins are:

Yellow Irish lord (*Hemilepidotus jordani)*
Warty (*Myoxocephalus verrucosus*)
Bigmouth sculpin (*Hemitripterus bolini*)
Great sculpin (*Myoxocephalus polyacanthocephalus*)
Plain sculpin (*Myoxocephalus jaok*)

Life History and General Distribution

The Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the North Pacific Ocean and Bering Sea. Most species live in shallow water or in tidepools, but some inhabit the deeper waters (to 1,000 m) of the continental shelf and slope. Most species do not attain a large size (generally 10 to 15 cm), but those that live on the continental shelf and are caught by fisheries can be 30 to 50 cm; the cabezon is the largest sculpin and can be as long as 100 cm. Most sculpins spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays demersal eggs amongst rocks where they are guarded by males. Egg incubation duration is unknown; larvae were found across broad areas of the shelf and slope, and were found all year-round, in ichthyoplankton collections from the southeast Bering Sea and Gulf of Alaska (GOA). Larvae exhibit diel vertical migration (near surface at night and at depth during the day). Sculpins generally eat small invertebrates (e.g., crabs, barnacles, mussels), but fish are included in the diet of larger species; larvae eat copepods.

Yellow Irish lords: distributed from subtidal areas near shore to the edge of the continental shelf (down to 200 m) throughout the Bering Sea, Aleutian Islands, and eastward into the GOA as far as Sitka, Alaska; up to 40 cm in length. Larvae from 12 to 26 mm have been collected in spring on the western GOA shelf.

Warty: distributed from rocky, intertidal areas to about 100 m depth on the middle continental shelf (most shallower than 50 m), from California (Monterey Bay) to Kamchatka; throughout the Bering Sea and GOA; rarely over 30 cm in length. Spawns masses of pink eggs in shallow water or intertidally. Larvae were 7 to 20 mm long in spring in the western GOA.

Bigmouth sculpin: distributed in deeper waters offshore, between about 100 m and 300 m in the Bering Sea, Aleutian Islands, and throughout the GOA; up to 70 cm in length.

Great sculpin: distributed from the intertidal to 200 m, but may be most common on sand and muddy/sand bottoms in moderate depths (50 to 100 m); up to 80 cm in length. Found throughout the Bering Sea, Aleutian Islands, and GOA, but may be less common east of Prince William Sound. *Myoxocephalus* spp. larvae ranged in length from 9 to 16 mm in spring ichthyoplankton collections in the western GOA.

Plain sculpin: distributed throughout the Bering Sea and GOA (not common in the Aleutian Islands) from intertidal areas to depths of about 100 m, but most common in shallow waters (less than 50 m); up to 50 cm in length. *Myoxocephalus* spp. larvae ranged in length from 9 to 16 mm in spring ichthyoplankton collections in the western GOA.

The approximate upper size limit of juvenile fish is unknown.

Relevant Trophic Information

Feed on bottom invertebrates (e.g., crabs, barnacles, mussels, and other molluscs); larger species eat fish.

Habitat and Biological Associations

Egg/Spawning: Lay demersal eggs in nests guarded by males; many species in rocky shallow waters near shore.

Larvae: Distributed pelagically and in neuston across broad areas of shelf and slope, but predominantly on inner and middle shelf; have been found all year-round.

Juveniles and Adults: Sculpins are demersal fish, and live in a broad range of habitats from rocky intertidal pools to muddy bottoms of the continental shelf, and rocky, upper slope areas. Most commercial bycatch occurs on middle and outer shelf areas used by bottom trawlers for Pacific cod and flatfish.

Habitat and Biological Associations: Sculpins

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	winter?	BCH, ICS (MCS, OCS?)	D	R (others?)	U	
Larvae	U	copepods	all year?	ICS, MCS, OCS, US	N, P	NA?	U	
Juveniles and Adults	U	bottom invertebrates (crabs, molluscs, barnacles) and small fish	all year	BCH, ICS, MCS, OCS, US	D	R, S, M, SM	U	

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce, NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Ormseth, O.A. and T. TenBrink. 2010. Bering Sea and Aleutian Islands Sculpins. *In* Stock Assessments and Fishery Evaluation Report of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, Anchorage, AK.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

Skates (Rajidae)

The species representatives for skates are:

Alaska skate (*Bathyraja parmifera*)
Aleutian skate (*Bathyraja aleutica*)
Bering skate (*Bathyraja interrupta*)

Life History and General Distribution:

Skates (Rajidae) in the Bering Sea and Aleutian Islands (BSAI) occur in two main taxonomic groups: skates of the genus *Bathyraja* (soft nosed) and those of the genera *Raja* and *Beringraja* (hard nosed). *Bathyraja* skates make up the vast majority of the skate biomass in the BSAI. Skates are oviparous: fertilization is internal and eggs are encased in leathery, horned pouches. Eggcases are then deposited at highly localized nursery sites along the upper continal slope, where the embryos develop for up to 3.5 years. Nursery sites are small, have a high density of eggcases, and appear to be used over many years. Six sites have been designated as Habitat Areas of Particular Concern (HAPC) by the North Pacific Fishery Management Council, although no protections (i.e. fishing gear restrictions) were mandated for the sites. Adults and juveniles are demersal, and feed on bottom invertebrates and fish. The habitat utilized by skates depends on the species. Adult Alaska skates are mostly distributed at a depth of 50 to 200 m on the shelf in eastern Bering Sea (EBS), where they make up ~95% of the biomass, and in the Aleutian Islands (AI). The Aleutian skate is found mainly in the outer shelf and upper slope of the eastern Bering Sea and the Aleutian Islands at depths of 100 to 350 m. The Bering skate is found throughout the eastern Bering Sea and less commonly in the Aleutian Islands at depths of 100 to 350 m. In the EBS, Alaska skates appear to make ontogenetic migrations from the nursery sites on the upper slope to the inner EBS shelf, reaching the inner shelf at approximately the age of maturity (9 years). Adults then likely make long-distance seasonal movements for reproduction and feeding. The biomass of BSAI skates estimated from the survey more than doubled between 1982 and 1996 and has been stable since. The approximate upper size limit of juvenile fish is unknown.

Relevant Trophic Information

Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish. Adult skates have few or no predators, but juvenile skates (particularly those in the 20-30 cm size range) are preyed on by Pacific cod and Pacific halibut.

Habitat and Biological Associations

Egg/Spawning: Deposits eggs in leathery, horned cases in nursery sites along the upper continental slope.

Juveniles and Adults: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown. Adults found across wide areas of shelf and slope and distribution varies by species; surveys found most skates at depths less than 500 m in the eastern Bering Sea, but greater than 500 m in the Aleutian Islands.

Habitat and Biological Associations: Skates

Stage - EFH Level	Duration or Age	Diet/Prey	Season / Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	NA	U	OCS, USP	D	U	U	
Larvae	NA	NA	NA	NA	NA	NA	NA	
Juveniles	U	invertebrates small fish	all year	ICS, MCS, OCS, USP	D	U	U	
Adults	U	invertebrates small fish	all year	MCS, OCS, USP	D	U	U	

Literature

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hoff, G.R. 2006. Investigations of a skate nursery area in the eastern Bering Sea. Final report to the NPRB, project 415. March 7, 2006.

Hoff, G.R. 2007. Reproduction of the Alaska skate (*Bathyraja parmifera*) with regard to nursery sites, embryo development and predation. Ph.D. dissertation, University of Washington, Seattle.

Hoff, G. R. 2008. A nursery site of the Alaska skate (*Bathyraja parmifera*) in the eastern Bering Sea. Fish. Bull., U.S. 106:233-244.

Ormseth, O.A. 2014. Assessment of the skate stock complex in the Bering Sea and Aleutian Islands. *In* Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Stevenson, D. E., J. W. Orr, G. R. Hoff, and J. D. McEachran. 2008. Emerging patterns of species richness, diversity, population density, and distribution in the skates (Rajidae) of Alaska. Fish. Bull., U.S. 106:24-39.

Teshima, K., and T.K. Wilderbuer. 1990. Distribution and abundance of skates in the eastern Bering Sea, Aleutian Islands region, and the Gulf of Alaska. Pp. 257-267 *in* H.L. Pratt, Jr., S.H. Gruber, and T. Taniuchi (eds.), Elasmobranchs as living resources: advances in the biology, ecology, systematics and the status of the fisheries. U.S. Dep. Commerce, NOAA Technical Report 90.

Capelin (Mallotus villosus)

Life History and General Distribution

Capelin is a short-lived , pelagic, schooling fish species with a circumpolar distribution that includes the entire coastline of Alaska and the Bering Sea and extends south along British Columbia to the Strait of Juan de Fuca. In the North Pacific, capelin grow to a maximum of 25 cm and 5 years of age. Capelin, a member of the Osmeridae (smelts), spawn at ages 2 to 4 in spring and summer (May through August; earlier in south, later in north) when about 11 to 17 cm on coarse sand, fine gravel beaches, especially in

Norton Sound, northern Bristol Bay, and along the Alaska Peninsula. Age at 50 percent maturity is 2 years. Each female produces 10,000 to 15,000 eggs. Eggs hatch in 2 to 3 weeks. Most capelin die after spawning. Larvae and juveniles are distributed on the inner mid-shelf in summer (rarely found in waters deeper than about 200 m), and juveniles and adults congregate in fall in mid-shelf waters east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr. Larvae, juveniles, and adults have diurnal vertical migrations following scattering layers; at night they are near surface and at depth during the day. Smelts are captured during trawl surveys, but their small size and patchy distribution reduce the reliability of biomass estimates. The approximate upper size limit of juvenile fish is 13 cm.

Relevant Trophic Information

Capelin are important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance, and juvenile pollock. Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, and beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn. Smelts are also found in the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot, and salmon throughout the North Pacific Ocean and the Bering Sea.

Habitat and Biological Associations

Egg/Spawning: Spawn adhesive eggs (about 1 mm in diameter) on fine gravel or coarse sand (0.5 to 1 mm grain size) beaches intertidally to depths of up to 10 m in May through July in Alaska (later to the north in Norton Sound). Hatching occurs in 2 to 3 weeks. Most intense spawning when coastal water temperatures are 5 to 9 °C.

Larvae: After hatching, 4 to 5 mm larvae remain on the middle-inner shelf in summer; distributed pelagically; centers of distribution are unknown, but have been found in high concentrations north of Unimak Island, in the western Gulf of Alaska, and around Kodiak Island.

Juveniles: In fall, juveniles are distributed pelagically in mid-shelf waters (50 to 100 m depth; -2 to 3 °C), and have been found in highest concentrations east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr.

Adults: Found in pelagic schools in inner-mid shelf in spring-fall, feed along semi-permanent fronts separating inner, mid, and outer shelf regions (approximately 50 and 100 m). In winter, found in concentrations under ice-edge and along mid-outer shelf.

Habitat and Biological Associations: Capelin

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	2–3 weeks to hatch	na	May–August	BCH (to 10 m)	D	S, CB		5–9 °C peak spawning
Larvae	4–8 months?	copepods phytoplankton	summer/fall/ winter	ICS, MCS	N, P	U NA?	U	
Juveniles	1.5+ yrs up to age 2	copepods euphausiids	all year	ICS, MCS	P	U NA?	U F? ice edge in winter	
Adults	2 yrs ages 2–4+	copepods euphausiids polychaetes small fish	spawning (May–August)	BCH (to 10 m)	D, SD	S, CB, G		
			non-spawning (Sep–Apr)	ICS, MCS, OCS	P	NA?	F ice edge in winter	-2 – 3°C peak distributions in EBS?

Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese high seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Doyle, M.J., W.C. Rugen, and R.D. Brodeur. 1995. Neustonic ichthyoplankton in the western Gulf of Alaska during spring. Fishery Bulletin 93: 231-253.

Eschmyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes, North America. Houghton Mifflin Co., Boston. 336 p.

Fritz, L.W. 1996. Other species In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1997. North Pacific Fishery Management Council, 605 West 4th Avenue, Suite 306, Anchorage, AK 99501.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 In Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 In D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and

Resources, Vol. II. U.S. Dept. Commerce, NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce, NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Kendall, A.W., Jr., and J.R. Dunn. 1985. Ichthyoplankton of the continental shelf near Kodiak Island, Alaska. U.S. Dep. Commerce, NOAA Tech. Rept NMFS 20, 89 p.

Kendall, A.W., Jr., J.R. Dunn, and R.J. Wolotira, Jr. 1980. Zooplankton, including ichthyoplankton and decapod larvae, of the Kodiak shelf. NWAFC Processed Rept. 80-8, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 393 p.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce, NOAA, NMFS.

Murphy, E.C., R.H. Day, K.L. Oakley, A.A. Hoover. 1984. Dietary changes and poor reproductive performances in glaucous-winged gulls. Auk 101: 532-541.

Naumenko, E.A. 1996. Distribution, biological condition, and abundance of capelin (*Mallotus villosus socialsis*) in the Bering Sea. Pp. 237-256 In O.A. Mathisen and K.O. Coyle (eds.), Ecology of the Bering Sea: a review of Russian literature. Alaska Sea Grant Report No. 96-01, Alaska Sea Grant College Program, U. Alaska, Fairbanks, AK 99775-5040. 306 p.

Ormseth, O.A., Conners, L., Guttormsen M., and J. Vollenweider. 2008. Forage fishes in the Gulf of Alaska. 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.

Ormseth, O.A. 2015. Status of forage species in the Bering Sea and Aleutian Islands region. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea and Aleutians Islands.

Pahlke, K.A. 1985. Preliminary studies of capelin *Mallotus villosus* in Alaska waters. Alaska Dept. Fish Game, Info. Leaf. 250, 64 p.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Rugen, W.C. 1990. Spatial and temporal distribution of larval fish in the western Gulf of Alaska, with emphasis on the period of peak abundance of walleye pollock (*Theragra chalcogramma*) larvae. NWAFC Processed Rept 90-01, AFSC-NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Sigler, M. *et al*. 2006. Survey strategies for assessment of Bering Sea forage species. NPRB final report, project 401.

Waldron, K.D. 1978. Ichthyoplankton of the eastern Bering Sea, 11 February-16 March 1978. REFM Report, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 33 p.

Waldron, K.D., and B.M. Vinter. 1978. Ichthyoplankton of the eastern Bering Sea. Final Report (RU 380), Environmental Assessment of the Alaskan continental shelf, REFM, AFSC, NMFS, 7600 Sand Point Way, NE, Seattle, WA 98115. 88 p.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Yang, M.-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

Yang, M.-S., K. Aydin, A. Greig,Lang, P. LivingstonHistorical review of capelin (*Mallotus villosus*) consumption in the Gulf of Alaska and eastern Bering SeaCommer.,155, 89 p.

Eulachon (Thaleichthys pacificus)

Life History and General Distribution

Eulachon is a relatively short-lived, anadromous, schooling fish species distributed from the Pribilof Islands in the eastern Bering Sea (EBS), throughout the Gulf of Alaska (GOA), and south to California. Eulachon, a member of the Osmeridae (smelts), are pelagic but often occur near the bottom and are generally found in deep water. In the EBS during summer, their distribution is concentrated in the Bering Canyon area northwest of Unimak Island on the outer shelf and upper slope. In the North Pacific, eulachon grow to a maximum age of 5 years and a maximum size of 23 cm. They spawn at ages 3 to 5 (14-20 cm) in spring and early summer (April through June) in rivers on coarse sandy bottom. Spawning rivers in the EBS are not well known. Age at 50 percent maturity is 3 years. Each female produces approximately 25,000 eggs, which adhere to sand grains and other substrates on the river bottom. Eggs hatch in 30 to 40 days at 4 to 7 °C. Most eulachon die after first spawning. Larvae drift out of rivers and develop at sea. Smelts are captured during trawl surveys, but their small size and patchy distribution reduces the reliability of biomass estimates. The approximate upper size limit of juvenile fish is 14 cm.

Relevant Trophic Information

Eulachon are important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance, and juvenile pollock. Pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise, and fin, sei, humpback, and beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn. Smelts also comprise significant portions of the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot, and salmon throughout the North Pacific Ocean and the Bering Sea.

Habitat and Biological Associations

Egg/Spawning: Anadromous; return to spawn in spring (May through June) in rivers; demersal eggs adhere to bottom substrate (e.g., sand, cobble). Hatching occurs in 30 to 40 days.

Larvae: After hatching, 5 to 7 mm larvae drift out of river and develop pelagically in coastal marine waters; centers of distribution are unknown.

Juveniles and Adults: Distributed pelagically in mid-shelf to upper slope waters (50 to 1000 m water depth), and have been found in highest concentrations between the Pribilof Islands and Unimak Island on the outer shelf, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

Habitat and Biological Associations: Eulachon

Stage - EFH Level	Duration or Age	Diet/Prey	Season/ Time	Location	Water Colum n	Bottom Type	Oceano-graphic Features	Other
Eggs	30–40 days	na	April–June	rivers, FW	D	S (CB?)		4 – 8°C for egg develop ment
Larvae	1–2 months?	copepods phytoplankto n mysids, larvae	summer/fall	ICS ?	P?	U, NA?	U	
Juveniles	2.5+ yrs up to age 3	copepods euphausiids	all year	MCS, OCS, USP	P	U, NA?	U F?	
Adults	3 yrs ages 3–5+		spawning (May–June)	rivers, FW	D	S (CB?)		
		copepods euphausiids	non-spawning (July–Apr)	MCS, OCS, USP	P	NA?	F?	

Literature

Allen, M.J. 1987. Demersal fish predators of pelagic forage fishes in the southeastern Bering Sea. Pp. 29-32 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Crawford, T.W. 1981. Vertebrate prey of *Phocoenoides dalli* (Dall's porpoise), associated with the Japanese hign seas salmon fishery in the North Pacific Ocean. M.S. Thesis, Univ. Washington, Seattle, 72 p.

Fritz, L.W., V.G. Wespestad, and J.S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. Pp. 30-44 In Is It Food: Addressing marine mammal and seabird declines. Workshop Summary. Alaska Sea Grant College Program Rept. No. AK-SG-93-01, Univ. Alaska, Fairbanks, AK 99775-5040.

Frost, K.J. and L. Lowry. 1987. Marine mammals and forage fishes in the southeastern Bering Sea. Pp. 11-18 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Res. Bd. Canada Bull. 180. Ottawa. 740 p.

Hunt, G.L., Jr., B. Burgeson, and G.A. Sanger. 1981a. Feeding ecology of seabirds of the eastern Bering Sea. Pp 629-647 In D.W. Hood and J.A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources, Vol. II. U.S. Dept. Commerce, NOAA, OCSEAP, Office of Marine Pollution Assessment, Univ. WA Press, Seattle, WA.

Hunt, G.L., Jr., Z. Eppley, B. Burgeson, and R. Squibb. 1981b. Reproductive ecology, foods and foraging areas of seabirds nesting on the Pribilof Islands, 1975-79. Environmental Assessment of the Alaskan Continental Shelf, Final Reports of Principal Investigators, RU-83, U.S. Dept. Commerce, NOAA, OCSEAP, Boulder, CO.

Kawakami, T. 1980. A review of sperm whale food. Sci. Rep. Whales Res. Inst. Tokyo 32: 199-218.

Morris, B.F., M.S. Alton, and H.W. Braham. 1983. Living marine resources of the Gulf of Alaska: a resource assessment for the Gulf of Alaska/Cook Inlet Proposed Oil and Gas Lease Sale 88. U.S. Dept. Commerce, NOAA, NMFS.

Ormseth, O.A., Conners, L., Guttormsen M., andVollenweider. 2008. Forage fishes in the Gulf of Alaska. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska Region

Ormseth, O.A. 2015. Status of forage species in the Bering Sea and Aleutian Islands region. In: Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea and Aleutians Islands. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Perez, M.A. and M.A. Bigg. 1986. Diet of northern fur seals, *Callorhinus ursinus*, off western North America. Fish. Bull., U.S. 84: 957-971.

Pitcher, K.W. 1980. Food of the harbor seal, *Phoca vitulina richardsi*, in the Gulf of Alaska. Fish. Bull., U.S. 78: 544-549.

Sanger, G.A. 1983. Diets and food web relationships of seabirds in the Gulf of Alaska and adjacent marine regions. Outer Continental Shelf Environmental Assessment Program, Final Reports of Principal Investigators 45: 631-771.

Wespestad, V.G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Yang, M.S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-AFSC-22. 150 pp.

Grenadiers (family Macrouridae)

Life History and General Distribution

At least seven species of grenadier are known to occur in Alaskan waters, but only three are commonly found at depths shallow enough to be encountered in commercial fishing operations or in fish surveys: giant grenadier (*Albatrossia pectoralis*), Pacific grenadier (*Coryphaenoides acrolepis*), and popeye grenadier (*Coryphaenoides cinereus*). Of these, giant grenadier has the shallowest depth distribution and the largest biomass, and hence is by far the most frequently caught grenadier in Alaska. On the slope (>400 meters) giant grenadier have by far the highest catch per unit effort and biomass in NMFS trawl surveys. Adults are caught in NMFS longline and trawl surveys but no other life stages are found in any NMFS surveys. The great majority of giant grenadier caught in surveys are female (96-99%). These results imply that much of the male population may reside in depths >1,000 that are not covered by the survey, at least during the summer period when the survey is occurring.

Giant grenadier range from Baja California, Mexico around the arc of the north Pacific Ocean to Japan, including the Bering Sea and the Sea of Okhotsk, and they are also found on seamounts in the Gulf of Alaska and on the Emperor Seamount chain in the North Pacific. In Alaska, they are especially abundant on the continental slope in waters >400 m depth. Giant grenadier are the largest in size of the world's grenadier species; maximum weight of one individual in a Bering Sea trawl survey was 41.8 kg. In a female maturity study, the maximum age was 58 years and the age at 50% maturity for females in the GOA was 23 years and the length at 50% maturity was 26 cm (pre-anal fin length).

Pacific grenadier have a geographic range nearly identical to that of giant grenadier, i.e., Baja California, Mexico to Japan. Popeye grenadier range from Oregon to Japan. Compared to giant grenadier, both species are much smaller and generally found in deeper water. Food studies off the U.S. West Coast indicate that Pacific grenadier are more benthic in their habitat than are giant grenadier, as the former species fed mostly on bottom organisms such as polychaetes, mysids, and crabs.

Relevant Trophic Information

The only food studies on grenadiers in the northeast Pacific have been on adults. One study of giant grenadier off the U.S. west coast concluded that the fish fed primarily off-bottom on bathy- and mesopelagic food items that included gonatid squids, viperfish, deep-sea smelts, and myctophids. Smaller studies of giant grenadier food habits in Alaska showed generally similar results. In the Aleutian Islands, the diet comprised mostly squid and myctophids (Yang 2003), whereas in the Gulf of Alaska, squid and pasiphaeid shrimp predominated as prey (Yang et al. 2006). Research on these deep-sea prey organisms in Alaska has been virtually non-existent, so information on prey availability or possible variations in abundance of prey are unknown.

In contrast to giant grenadier, a study of Pacific grenadier food habits off the U.S. west coast found a much higher consumption of benthic food items such as polychaetes, cumaceans, mysids, and juvenile Tanner crabs (*Chionoecetes* sp.), especially in smaller individuals. Carrion also contributed to its diet, and larger individuals consumed some pelagic prey including squids, fish, and bathypelagic mysids.

The only documented predators of giant grenadier are Pacific sleeper sharks and Baird's beaked whales. Sperm whales are another potential predator, as they are known to dive to depths inhabited by giant grenadier on the slope and have been observed depredating on longline catches of giant grenadier. Giant grenadier is a relatively large animal that is considered an apex predator in its environment on the deep slope, so it may have relatively few predators as an adult.

Habitat and Biological Associations

Little or no environmental information has been collected in Alaska for the deep slope habitat in which grenadiers live. The absence of larvae or post-larvae giant grenadier in larval surveys in Alaska, which have nearly all been conducted in upper parts of the water column, implies that larval giant grenadier may reside in deeper water.

Habitat and Biological Associations: Grenadiers

Stage - EFH Level	Duration or Age	Diet/Prey	Season / Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs	U	na	U	U	U	U	U	
Larvae	U	U	U	U	U	U	U	
Juveniles	U to 20 years	U	all year	continental slope, deep shelf gulleys and other habitats (few juveniles have been found)	Sometimes caught with bottom tending gear. presumably D	U	U	
Adults	20-58 years	opportunistic: gonatid squids, viperfish, deep-sea smelts, myctophids, pasiphaeid shrimp	Spawning may be year-round	continental slope, and deep shelf gulleys	Caught with bottom tending gear. presumably D	Likley in most bottom types	U	

Literature

Bakkala, R. G., W. A. Karp, G. F. Walters, T. Sasaki, M. T. Wilson, T. M. Sample, A. M. Shimada, D. Adams, and C. E. Armistead. 1992. Distribution, abundance, and biological characteristics of groundfish in the eastern Bering Sea based on results of U.S.-Japan bottom trawl and midwater surveys during June-September 1988. NOAA Tech. Memo. NMFS F/NWC-213, 362 p.

Britt, L. L., and M. H. Martin. 2001. Data report: 1999 Gulf of Alaska bottom trawl survey. Memo. NMFS-AFSC-121, 249 p.

Burton, E. J. 1999. Radiometric age determination of the giant grenadier (*Albatrossia pectoralis*) using ^{210}Pb:^{226}Ra disequilibria. Master's thesis, San Francisco State University, 91 p.

Busby, M. S. 2005. An unusual macrourid larva (Gadiformes) from San Juan Island, Washington, USA. 52: 86-89.

Clausen, D. M., andJ 2012. Assessment of grenadiers in the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska and Bering Sea/Aleutian Islands regions, Appendix 1. North Pacific Fishery Management Council, 605 W 4th Ave., Suite 306, Anchorage AK 99501.

Drazen, J. C., T. W. Buckley, and G. R. Hoff. 2001. The feeding habits of slope dwelling macrourid fishes in the eastern North Pacific. I 48:909-935.

Drazen, J. C. 2008. Energetics of grenadier fishes. *In* A. M. Orlov and T. Iwamoto (Editors), Grenadiers of the world oceans: biology, stock assessment, and fisheries, p. 203-223. Amer. Fish. Soc Sympos. 63. (Published by Amer. Fish. Soc., Bethesda, MD).

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

Goddard, P., andZimmermann. 1993. Distribution, abundance, and biological characteristics of groundfish in the eastern Bering Sea based on results of U.S. bottom trawl surveys during June-September 1991. AFSC Processed 93-15, 338 p. (Available from National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115).

Hoff, G. R., and LBritt. 2011. Results of the 2010 eastern Bering Sea upper continental slope survey of groundfish and invertebrate resources, 300 p.

Iwamoto, T., and D. L. Stein. 1974. A systematic review of the rattail fishes (Macrouridae: Gadiformes) from Oregon and adjacent waters. Occasional Papers of the California Academy of Sciences No. 111, 79 p.

Lunsford, C. and C. J. Rodgveller. 2014. F/V *Ocean Prowler* cruise report OP-13-01, longline survey of the Gulf of Alaska and eastern Bering Sea, May 26-August 28, 2013. Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801.

Lunsford, C., C. J. Rodgveller, and P. Malecha. 2014. F/V *Alaskan Leader* cruise report AL-14-01, longline survey of the Gulf of Alaska and eastern Aleutain Islands, May 25-August 28, 2014. Alaska Fisheries Science Center, Auke Bay Laboratories, 17109 Point Lena Loop Rd., Juneau, AK 99801.

Mecklenburg,T. A. Mecklenburg, and L. K. Thorsteinson. 2002. Fishes of Alaska. Amer. Fish. Soc., Bethesda, Maryland, 1,037 p.

Orlov, A. M., and S. 1999. Some biological features of Pacific sleeper shark, *Somniosus pacificus* (Bigelow *et* Schroeder 1944) (Squalidae), in the northwestern Pacific Ocean. Polish Academy of Sciences, National Scientific Committee on Oceanic Research, Institute of Oceanography, University of Gdansk. Oceanological Studies FVIII No. 1-2: 3-16.

Rodgveller, C. J., D. M. Clausen, J. J. Nagler, and C. Hutchinson. Reproductive characteristics and mortality of female giant grenadiers in the northern Pacific Ocean.Coast. Fish.: Dynamics, Management, and Ecosystem Sci. 2:73-82.

Ronholt, L. L., K. Teshima, and D. W. Kessler. The groundfish resources of the Aleutian Islands region and southern Bering Sea 1980, 1983, and 1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-31, 351 p.

Sasaki, T., and K. Teshima. 1988. Data report on abundance indices of flatfishes, rockfishes, shortspine thornyhead, and grenadiers based on the results from Japan-U.S. joint longline surveys, 1979-87. (Document submitted to the Annual Meeting of the International North Pacific Fisheries Commission, Tokyo, Japan, 1988 October.) 31 p. Fisheries Agency of Japan, Far Seas Fisheries Research Laboratory, 5-7-1 Orido, Shimizu, Japan 424.

Tuponogov, V. N. 1997. Seasonal migrations of the grenadier *Coryphaenoides pectoralis* in the Sea of Okhotsk and contiguous waters. J. Mar. Bio. 23(6):314-321.

Walker, W. A., J. G. Mead, andL. Brownell, Jr. 2002. Diets of Baird's beaked whales, *Berardius bairdii*, in the southern Sea of Okhotsk and off the Pacific coast of Honshu, Japan. Marine Mammal Science 18(4): 902-919.

Yang, M-S. 2003. Food habits of the important groundfishes in the Aleutian Islands in 1994 and 1997. AFSC Processed Rep. 2003-07, 233 p. (Available from National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle WA 98115).

Yang, M-S., K. Dodd, R. Hibpshman, and A. Whitehouse. 2006. Food habits of groundfishes in the Gulf of Alaska in 1999 and 2001. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-164.