Regional Operational Plan CF.1J.2018.02

Eptatretus spp. (Hagfish) Occurrence in Southern Southeast Alaska

by

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and

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June 2018

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN CF.1J.2018.02

EPTATRETUS SPP. (HAGFISH) OCCURRENCE IN SOUTHERN SOUTHEAST ALASKA

by
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Alaska Department of Fish and Game
Division of Commercial Fisheries

June 2018

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SIGNATURE PAGE

Project Title:	*Eptatretus* spp. (Hagfish) Occurrence in Southern Southeast Alaska
Project leader(s):	Andrew Olson
Division, Region and Area	Commercial Fisheries, Southeast Alaska
Period Covered	2016–2021
Field Dates:	August–September
Plan Type:	Category I
Project Title:	*Eptatretus* spp. (Hagfish) Occurrence in Southern Southeast Alaska

Approval

Title	Name	Signature	Date
Project leader	Andrew Olson		2/28/18
Biometrician	Ben Williams		2/28/18
Research Coordinator	Karla Bush		2/28/18

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PURPOSE

There is commercial interest to develop a fishery for Pacific hagfish (*Eptatretus stoutii*) and black hagfish (*E. deani*) in Southeast Alaska. However, information is lacking to properly develop and manage a sustainable fishery. Currently, the fishery is targeted using a Commissioner's permit with a maximum guideline harvest level (GHL) of 60,000 pounds. The primary market for hagfish occurs in Korea for human consumption and for their skin to be repurposed as leather. Little is known about the life history of either species within Southeast Alaska including: areas of occurrence, sizes at maturity, sex ratios, fecundity, and length or weight frequencies. Preliminary life history information will be collected using experimental longline traps fished opportunistically during the annual Southeast Alaska pre-season pot shrimp survey.

Keywords: Southeast Alaska, *Eptatretus stoutii*, *Eptatretus deani*, black hagfish, Pacific hagfish, bucket trap, maturity

OBJECTIVES

1. Determine areas of occurrence for Pacific and black hagfish in Southern Southeast Alaska;
2. Collect information on basic life history including: weight (g), length (cm), sex, fecundity, maturity stage and size at maturity to inform management on commercial fishery viability.

METHODS

SAMPLE DESIGN

Based on Tanaka and Crane (2014), twenty-five 5-gallon (20 L) buckets will be used as traps for each set to capture Pacific and black hagfish (Figures 1–2). A total of 50 escape holes at a size of 3/8 inches (9.5 mm), are drilled into each bucket dispersed in a similar pattern. Each trap will have one 4-inch (102 mm) entry funnel secured with zip-ties with a destruct device (1/4 inch mesh) four inches in diameter on the side of each trap secured with 30-count cotton twine, and a weight inside the trap (2 feet of ½ inch rebar ~2lb) to ensure correct orientation on the sea floor.

Each longline set will consist of 25 traps spaced 18 feet (5.5 m) apart and secured to a central ground line with snap on gear with a leash of four feet (1.2 m). A 20–40 pound ground weight will be secured at the beginning and end of each set. Each trap will be baited with approximately 1.5 pounds of herring in large chunks and soak time will range from 12 to 24 hours. Hourly temperature will be recorded at depth using a Tidbit® temperature logger attached to the first or last trap of each set. Temperature will be recorded to the nearest 0.2 °C. Hagfish station locations are based on historical harvest, incidental catch in surveys and commercial fisheries, depth, and mud bottom type from NOAA charts (Figure 3; Table 1). Stations may be adjusted at the discretion of the principle investigator in the field to ensure each hagfish set is placed on a mud-bottom and does not interfere nor compete with the pre-season shrimp stock assessment survey stations.

Hagfish sets will be placed in muddy/soft bottom substrate at depths (first trap and last trap) ranging from 10 to 100 fathoms for Pacific hagfish and 200–300 fathoms for black hagfish. Hagfish survey set forms (Figure 4) will be used to collect the set number, date, set time (beginning and end), haul time (beginning and end), set latitude and longitude (beginning and end), Tidbit number, and substrate.

SAMPLING METHODS

Each trap will be sampled for species (Pacific or black hagfish) (Figure 5), count-by-weight (number of hagfish and weight (g) per trap) (Figure 6), with a sub-sample of 5 hagfish per trap up to 125 per set to be frozen in gallon plastic bags to sampled for species identification from external anatomy (Figure 7), biological information including length (nearest 1 mm from head to tail, Figure 8), individual weight (g), and from internal anatomy (Figure 9) including: sex (male or female), fecundity, sexual maturity (yes or no), and maturity stage (Figures 10 and 11; Table 2) in the lab upon returning to port. Each frozen bag will be clearly labeled with the date, set number and pot number. Bycatch species and quantity will also be recorded. If sampling becomes overly burdensome samples should be separated by species (Pacific and black hagfish) and frozen in gallon plastic bags with the date, location, and set number clearly labeled on a label inside the bag, and on the outside of the bag.

DATA ANALYSIS

Catch per unit effort (CPUE)

Catch per unit effort will be modeled for catch in numbers or weight by soak time. If enough data are available the use of a Delta-lognormal GLM (Shelton et al. 2014) or nonlinear models (e.g., generalized additive models) will be explored for generating an index of abundance.

Maturity

Maturity will be estimated for each species separately by sex using a logistic mixed-effects generalized additive model that can account for spatial variability, of form:

$$M = f_1(length) + f_2(Longitude, Latitude) + f_3(Haul, bs = re) + Year, \quad (1)$$

where the f's are functions, the number of knots k are restricted to four to remain biologically reasonable, and $bs{=}re$ designates the variable as a random effect. Length, and location are continuous variables, and haul and year are categorical variables. Age can be substituted for length, if ages are known.

The median length where 50% of the sample population is mature (L_{50}) will be estimated from equation 1 with confidence limits calculated as two times the model-generated standard error (Williams et al. 2016).

Length-Weight Relationship

The length-weight relationship by sex and species for hagfish will be examined using either generalized linear or generalized additive models. The appropriateness of a Gamma family distribution using a log link and a GLM vs GAM will be examined using the Akaike Information Criteria (Burnham and Anderson 2002).

DATA MANAGEMENT

All set and biological data will be uploaded, managed, and housed in the ADF&G OceanAK regional database and will be available to researchers and managers statewide. Data fields to be collected are in Figures 5–7.

SCHEDULE AND DELIVERABLES

The 2016 biological data will be used to develop a standardized sampling protocol for hagfish species in Alaska.

Biological sampling and data analysis will commence immediately after each survey.

Data collected for this study will be used to inform management for development of a sustainable fisheries management plan and provide life history information for the hagfish species.

RESPONSIBILITIES

- Andrew Olson, Fishery Biologist III (Groundfish Project Leader)
- Aaron Baldwin, Fishery Biologist I (Biological and data support)
- Ben Williams, Biometrician (Biometric review)

REFERENCES CITED

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FIGURES

Figure 1.–Experimental longline set using 5-gallon bucket traps designed to capture Pacific and black hagfish during the Southeast Alaska pre-season shrimp survey.

Figure 2.–Black hagfish (*Eptatretus deani*, top) characterized by uniform black/dark brown colorization, 10–14 pairs of gill pores, and no white ring around their gill pores, and one dorsal finfold far back on its body. Pacific hagfish (*Eptatretus stoutii*, bottom) characterized by gray to light brown colorization, white ring around each gill pore, and white colorization along ventral finfold.

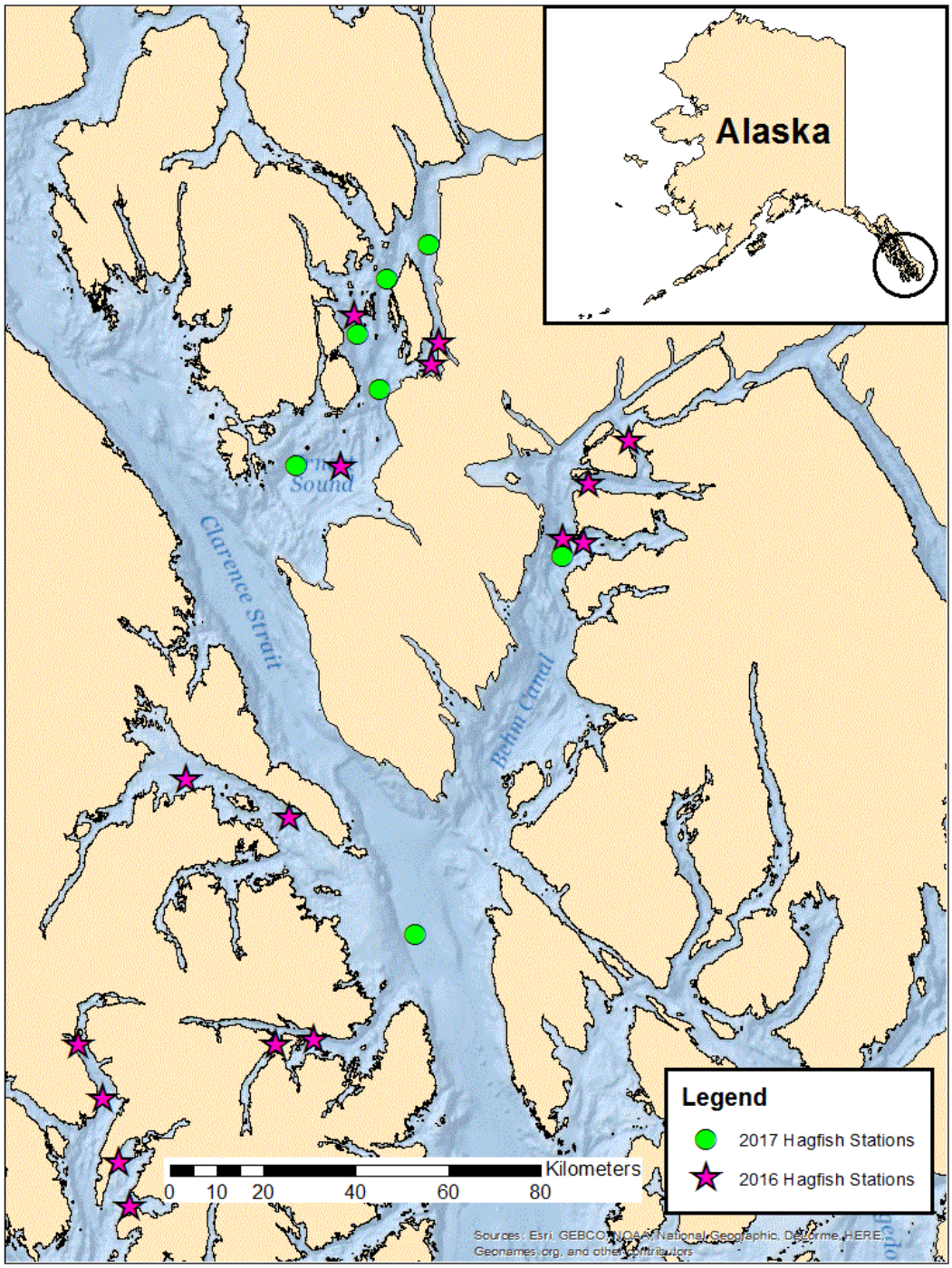

Figure 3.–Experimental set locations for hagfish in 2016 and 2017.

HAGFISH SET FORM

Year:________ Project:_______________ Trip #:____________ Dist/Subdistrict:_______________ Location:______________________ Recorder:____________________

STATION NO.	SET TYPE	BEGIN / END	SET		LIFT		BUOY NO.	SOAK PERIOD	HAULBACK ORDER	NUMBER OF POTS	LENGTH OF SET	POT DISTANCE	DEPTH			LATITUDE / LONGITUDE				TIDBIT NUMBER	COMMENTS
			MONTH/ DAY	TIME	MONTH/ DAY	TIME							BEGIN	MID	END	DEG. N	MINUTES TO 1,000ths	DEG. W	MINUTES TO 1,000ths		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		
	S/E	Begin	/		/												.		.		
		End	/		/			12/24 36/48	S/O								.		.		

Figure 4.–Hagfish set form.

HAGFISH SPECIMEN FORM **Date**__________ **Page**______ **of** _______

Year _____ **Project** _________________________ **Recorder** ____________

Location___________________ **Trip #**_______ **Set#**__________ **Trap#**______________

Specimen #	202 Black 212 Pacific Species Code	Length (mm)	Weight (g)	1=Male 2=Female 3=Hermp. 0=Unknown Sex	1=Yes 0=No Mature	Maturity Stage Condition Code	# of Eggs per Female	G=Genetic H=Histological J=Jaw Extra Samples	Comments
1			.						
2			.						
3			.						
4			.						
5			.						
6			.						
7			.						
8			.						
9			.						
10			.						

Location___________________ **Trip #**_______ **Set#**__________ **Trap#**______________

1			.						
2			.						
3			.						
4			.						
5			.						
6			.						
7			.						
8			.						
9			.						
10			.						

Location___________________ **Trip #**_______ **Set#**__________ **Trap#**______________

1			.						
2			.						
3			.						
4			.						
5			.						
6			.						
7			.						
8			.						
9			.						
10			.						

Location___________________ **Trip #**_______ **Set#**__________ **Trap#**______________

1			.						
2			.						
3			.						
4			.						
5			.						
6			.						
7			.						
8			.						
9			.						
10			.						

Figure 5.–Hagfish specimen form for biological sampling.

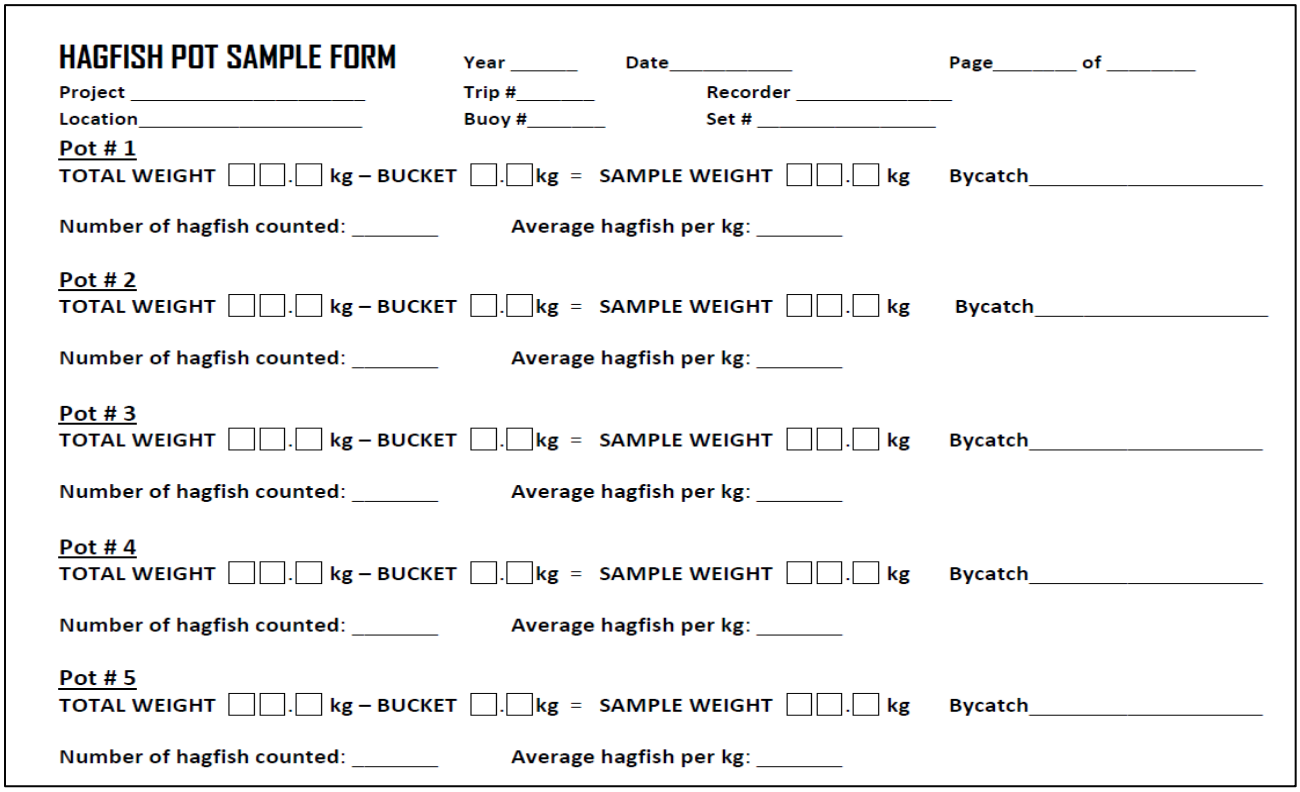

Figure 6.–Hagfish pot sample form.

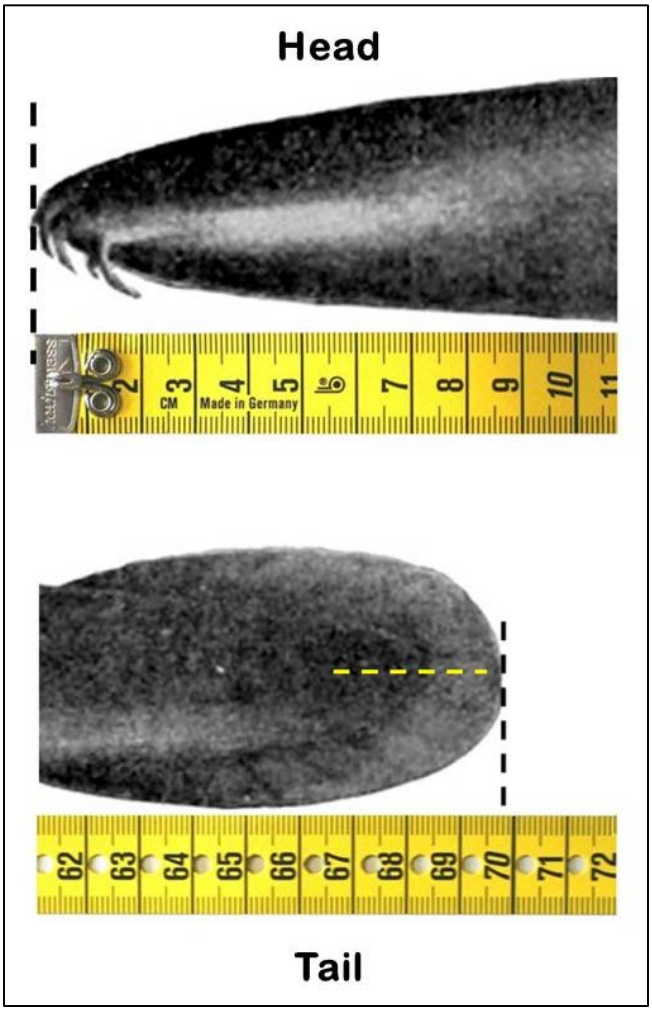

Figure 7.–Standardized length measurements for hagfishes to the nearest 1 mm.

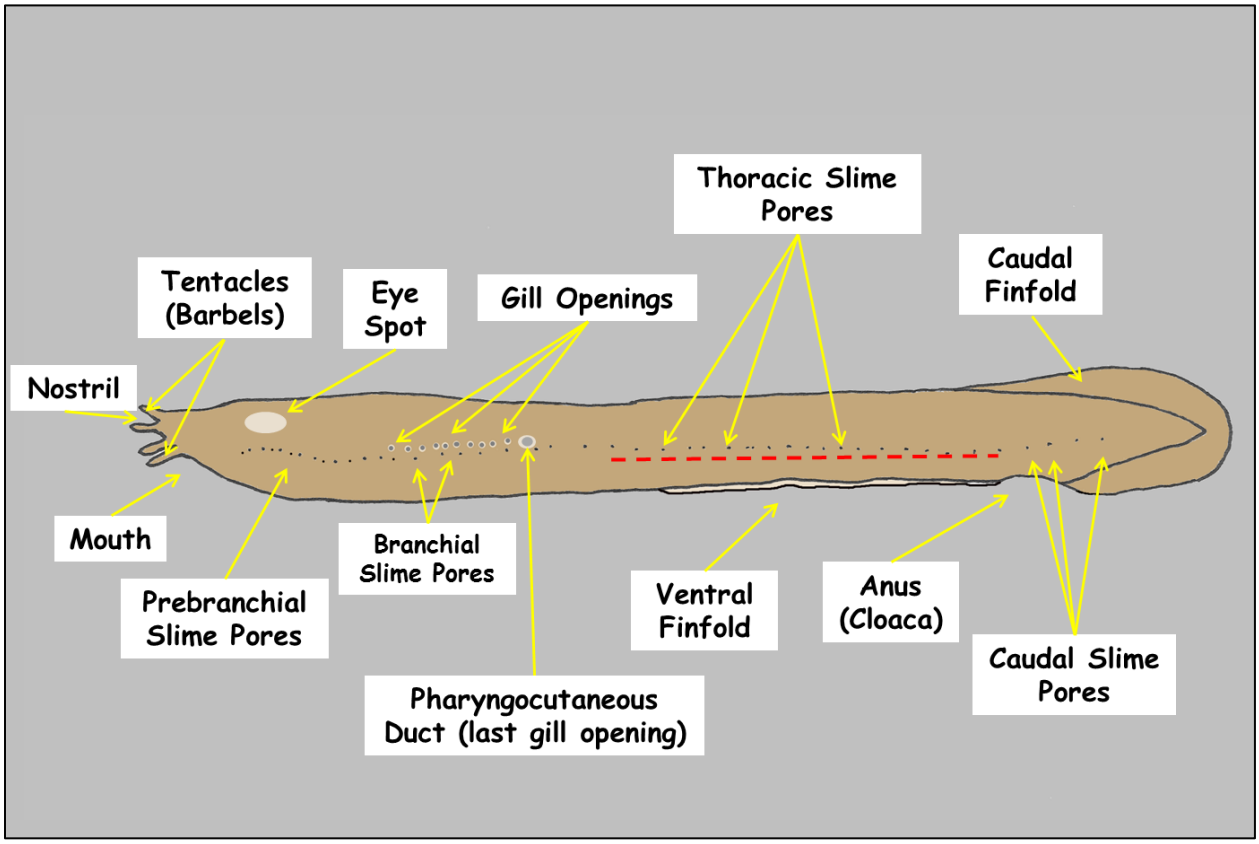

Figure 8.–External anatomy of a Pacific hagfish. The red dashed line indicates the optimal location for beginning dissection.

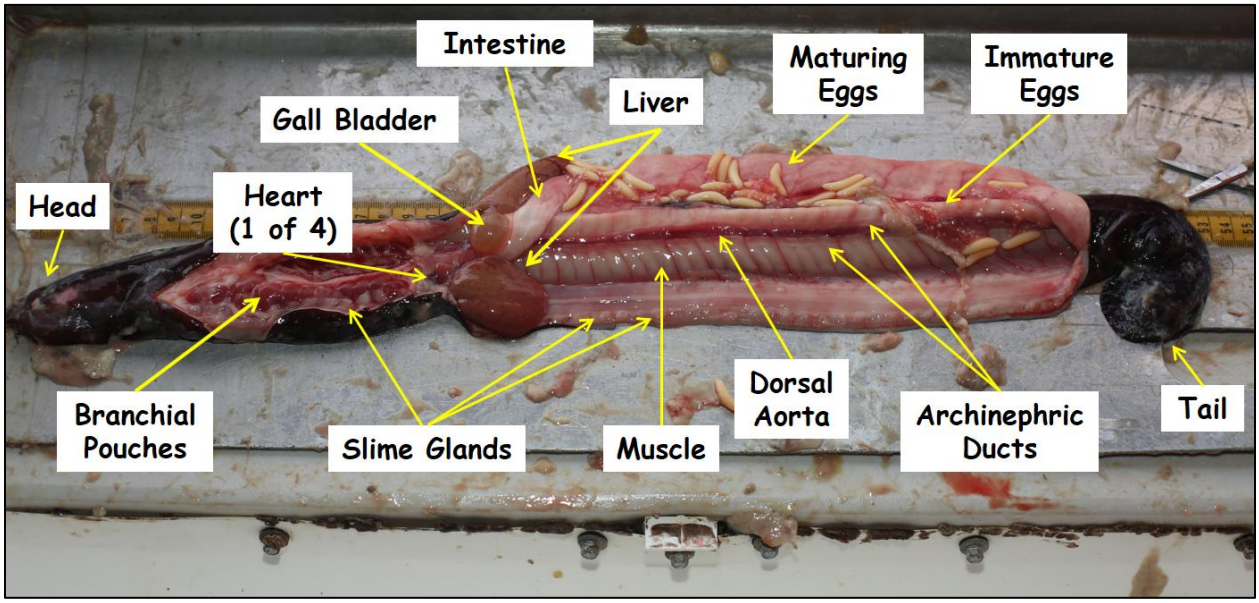

Figure 9.–Internal anatomy of a mature female black hagfish.

Figure 10.–Female hagfish maturity condition stages as based on Barss 1993.

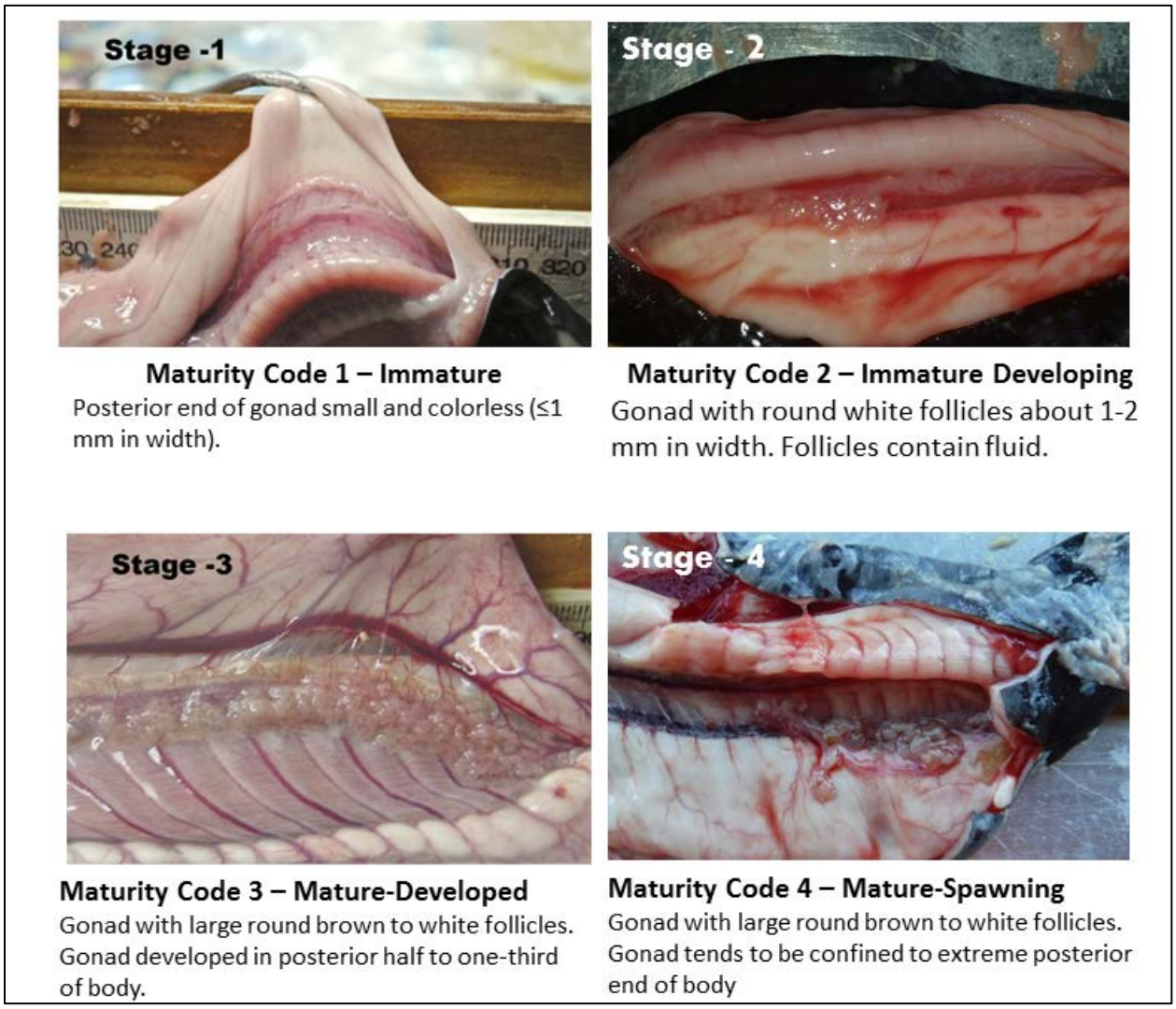

Figure 11.–Male hagfish maturity condition stages as based on Barss 1993. Stages 1 and 3 photos from Martini and Beulig, 2013.

TABLES

Table 1.–Experimental set locations for hagfish in 2016 and 2017.

Year	Set Number	Location	Latitude	Longitude
2016	1	Hetta Inlet	55.23281153580	-132.66730483900
2016	2	Hetta Inlet	55.17257455430	-132.62023322500
2016	1	Nutkwa Inlet	55.10195607570	-132.58949900400
2016	2	Nutkwa Inlet	55.05330038910	-132.56880969700
2016	1	Kasaan Bay	55.52458493010	-132.45865940400
2016	2	Kasaan Bay	55.48259976460	-132.25957886400
2016	1	Cholmondeley Sound	55.23278180900	-132.28422625200
2016	2	Cholmondeley Sound	55.23843323180	-132.21163886300
2016	1	Ernest Sound	56.00015851400	-131.96858163200
2016	2	Ernest Sound	56.03038331900	-132.13376904200
2016	3	Ernest Sound	55.97656009440	-131.98343661500
2016	4	Ernest Sound	55.86546781490	-132.16013960800
2016	1	Behm Canal	55.78364529310	-131.68883259200
2016	2	Behm Canal	55.78665234550	-131.72804974700
2016	3	Behm Canal	55.89408537700	-131.59940559500
2016	4	Behm Canal	55.84691146150	-131.67813700500
2017	1	Ernest Sound	55.865967	-132.24475
2017	2	Ernest Sound	56.008178	-132.127
2017	3	Ernest Sound	55.948708	-132.082142
2017	4	Ernest Sound	56.067715	-132.070016
2017	extra	Ernest Sound	56.10527	-131.987494
2017	1	Behm Canal	55.767483	-131.7279
2017	1	Clarence Strait	55.353558	-132.014835

Table 2.–Specimen reference table for biological data collection. Maturity criteria is based on Barss 1993 and Tanaka's (personal communication, 2016) descriptions.

Species Code	Species
202	Black Hagfish
212	Pacific Hagfish

Sex Code	Sex
1	Male
2	Female
3	Hermaphrodite
0	Unknown

Sex	Maturity Stage Code	Maturity Stage Description	Maturity Stage Criteria
Female	1	Immature	All round eggs ≤ 3 mm, eggs may appear as round or oval bubbles in anterior half of narrow gonad.
	2	Immature developing	Oblong eggs between 5–10 mm (rice)
	3	Mature developing	Oblong eggs between 10–40 mm (beans). Egg fattest in middle.
	4	Mature developed	Large eggs, > 20 mm (Cheetos) with hooks in gelatinous capsule. Egg evenly as wide throughout.
	5	Mature spent	Empty ovarian capsules and small eggs (spent).
Male	1	Immature	Posterior end of gonad small and colorless (≤1mm in width).
	2	Immature developing	Gonad with round white follicles about 1–2 mm in width. Follicles contain fluid.
	3	Mature developed	Gonad with large round brown to white follicles. Gonad developed in posterior half to one-third of body.
	4	Mature spawning	Gonad with large round brown to white follicles. Gonad tends to be confined to extreme posterior end of body.
Unknown	1	Immature	Empty gonad, no testis or eggs observed.
Hermaphrodite	1	Hermaphrodite	Both eggs and follicles of testis present.