MEMORANDUM

State of Alaska

DEPARTMENT OF FISH AND GAME

TO: Lowell Fair, Regional Supervisor
Region I – CF

DATE: August 27, 2018

FILE NO:

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FROM: Andrew Olson, Groundfish Project Leader
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SUBJECT: 2018 SSEI Hagfish

Overview

The purpose of this memo is to syntehsize historical hagfish harvest in Soutehast (SE) Alaska waters, describe research surveys and results, and designation of suitable habitat, and to set allowable harvest levels, management areas, and gear restirictions under the Commissioner's Permit system. Because hagfish harvests may continue to increase in SE the groundfish project is being proactive in setting acceptable harvest limits by area based on the best available information. Hagfish are harvested worldwide where they are prized for the skin to be used as leather, meat for human and animal consumption, and slime being used in medical research (Ellis et al. 2015). Hagfish are a prized delicacy in Korea and parts of Japan where the majority of the market occurs, however, hagfish biology is poorly understood and this lack of understanding has led to rapid fishery development and stock exploitation, resulting in serial depletions worldwide (Ellis et al. 2015; Martini and Beulig 2013). After the collapse of the Japanese-Korean hagfish fisheries in the 1980s and 1990s the hagfish fishery expanded in the eastern north Pacific in Washington, Oregon, and California with landings exceeding 1-million lbs (Figure 1).

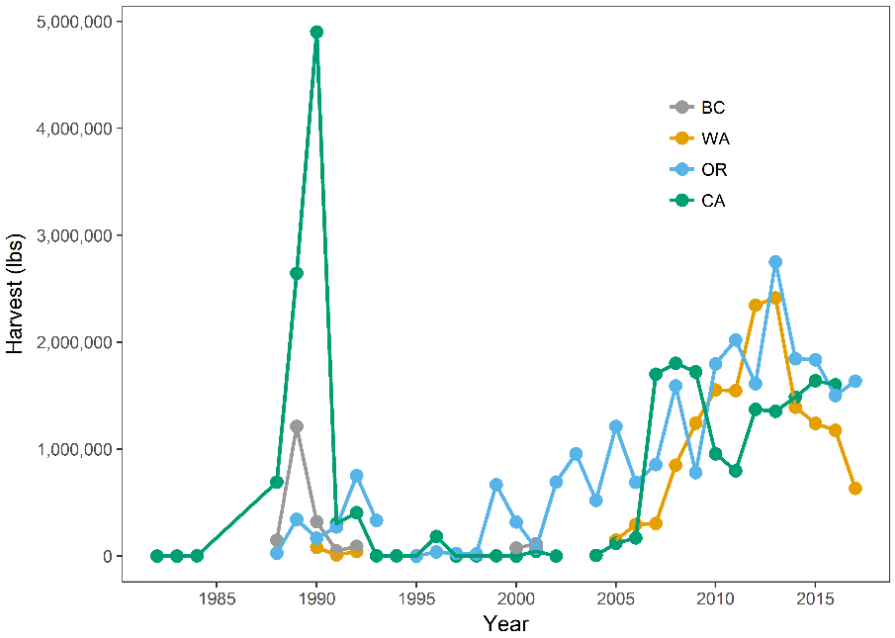

Figure 1.–Harvest of Pacific and black hagfish in the eastern north Pacific in B.C. Canada (BC) (Benson et al. 2001; Leask and Beamish 1999), Washington (WA), Oregon (OR), and California (CA).

The primary species harvested in the eastern north Pacific are *Eptatretus stoutii* (Pacific hagfish) and *E. deani* (black hagfish); in Southeast Alaska the primary species captured is *E. deani* at depths greater than 200 m. They often strip bait (as evidenced by slimed hooks) and are caught as bycatch in the Southern Southeast Inside (SSEI) subdistrict sablefish commercial longline fishery and are also captured in the commercial shrimp pot fishery. Exploratory fishing for hagfish occurred from 1989–1991 with a total of 15,148 lbs landed. By 1994 and 1995, interest from industry and processors had developed and an experimental hagfish fishery on a larger scale was prosecuted using a commissioner's permit; harvest was landed on a Commercial Fisheries Entry Commission (CFEC) miscellaneous finfish permit. However, there was difficulty in maintaining a quality skin product due to hagfish biting each other, therefore the fishery was unsuccessful and no further attempts were made to prosecute the fishery for over 15 years.

In the early 2010s renewed interest in prosecuting and marketing a hagfish fishery began to develop in Southeast Alaska. The first actual effort occured in 2016, when a commissioner's permit was issued for 60,000 lbs and gear was limited to 100 pots. As interest in the hagfish fishery continued to develop, the department researched hagfish life history, management strategies worldwide, and began exploratory surveys in order to provide opportunity while maintaining a conservative management approach. Based on this improved information, the commissioner's permit was modified in 2017 with the following restructions:

- gear is limited to Korean-style pots, 5-gal buckets, and plastic barrels in any combination not to exceed a 3,000-gal total pot gear volume;
- at least 20 escape holes of 0.625 in or greater dispersed on opposing sides of a pot to allow escapement of immature hagfish (Tanaka and Crane 2014);
- an entrance tunnel no larger than 4-in in diameter, and;

- a guideline harvest level of 60,000 lbs issued in 20,000 lb increments.

Creating a volume limit for gear allowed permit holders the flexibility in prosecuting the fishery regardless of vessel size. Between October 2016 and April 2018 less than 3 permit holders participated in the directed fishery for hagfish in the SSEI management area in Southeast Alaska. Length frequency distributions of hagfish port sampled from the commercial fishery ranged from 26–66 cm with peaks in sizes ranging from 40–46 cm (Figure 2).

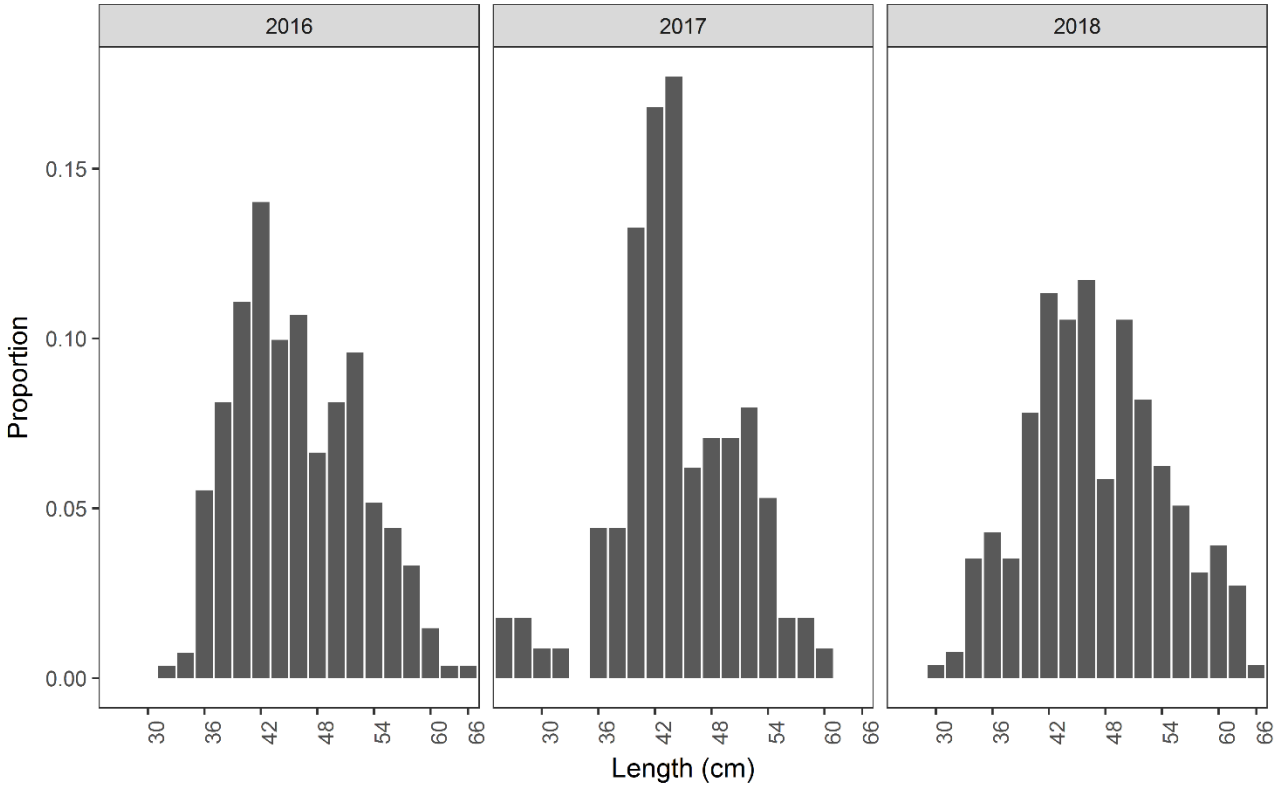

Figure 2.–2016–2018 black hagfish length frequencies (cm) from port sampling the commercial fishery in the Southern Southeast Inside (SSEI) management area.

Hagfish Research

Opportunistic surveys began for hagfish species in 2016 to determine their occurrence and distribution in Southeast Alaska and to collect biological information in order to provide information for managing the fishery. Surveys are conducted during the annual pre-season *Pandalus platyceros* (spot shrimp) stock assessment surveys that occurs in August and September. Hagfish survey stations were selected based on historical fishing effort, muddy habitat, and proximity to the spot shrimp stations. Gear utilized for the hagfish survey consists of longlined 5-gallon bucket traps with entrance tunnels of 4 in in diameter and escape holes of 0.375 in (9.5 mm) to order retain small immature individuals. Data collected includes a count by weight per trap and a sub-sample of captured hagfish are frozen and retained for biological analysis in the lab for species identification, length, weight, maturity, and fecundity (Olson and Baldwin 2018).

Preliminary analyses of hagfish specimens has revealed that black hagfish (n= 634) is the predominant species with very few Pacific hagfish (n= 3) captured in the SSEI management area and the ratio of captured black hagfish females to males is approximately 3:2. Black hagfish length distribution frequencies varied by sex with females ranging from 26–77 cm, males were slightly smaller ranging from 26–62 cm, and unknown sex ranging from 18–59 cm. Unknown sex specimens were expected to have a much smaller range since gonadal development was not easily identified in these immature individuals (Figure 3).

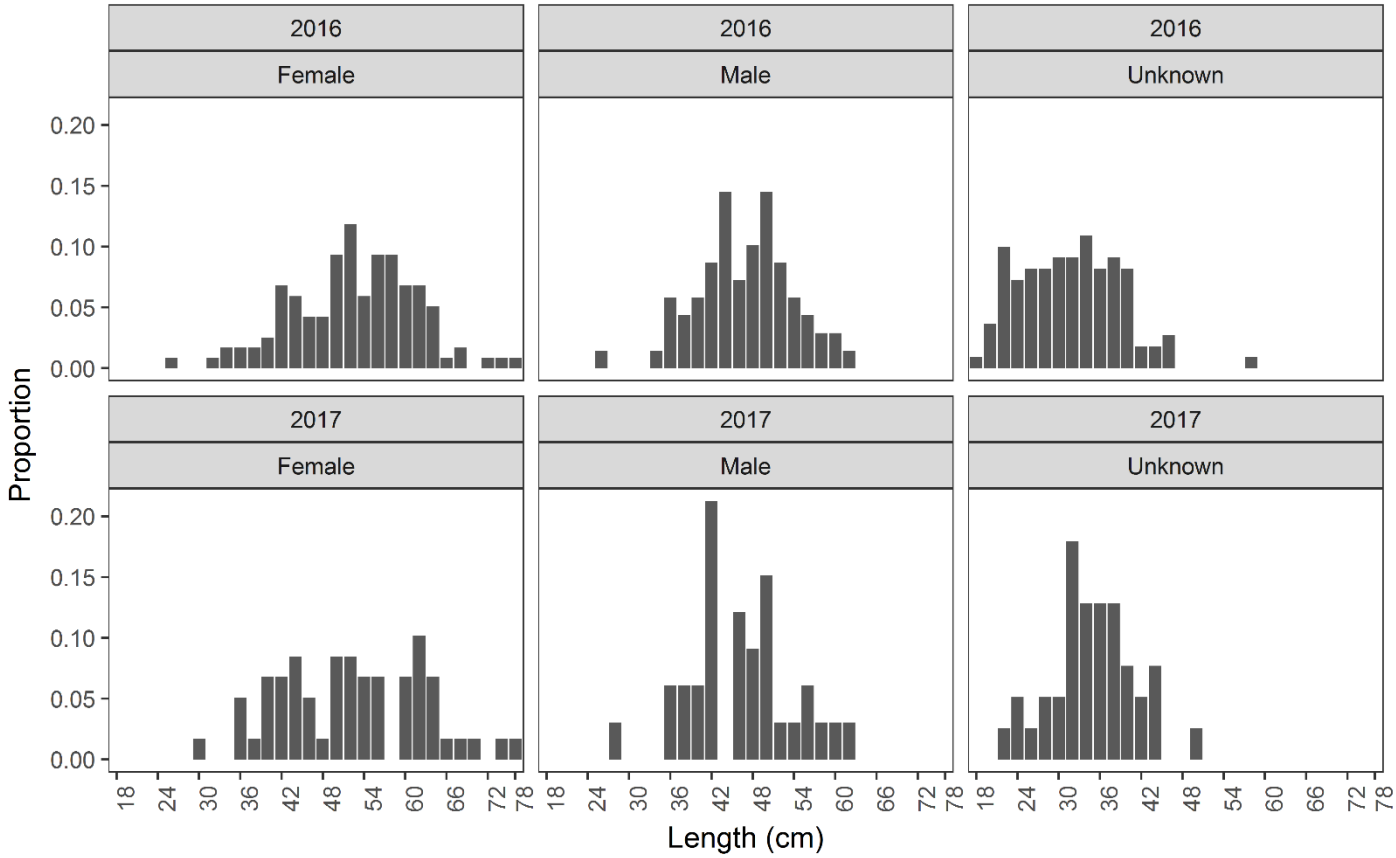

Figure 3.–2016–2017 black hagfish length frequencies (cm) for identified males, females, and unknown sex subsampled during surveys in the Southern Southeast Inside (SSEI) management area.

Black hagfish length at 50% maturity (L_{50}) was larger for females (51.6 cm, n = 263) than males (44.4 cm, n = 167) (Figure 4). A majority of the sampled female and male hagfish were either immature or mature: few samples were identified as transitional stages (immature to mature) and post-spawning (Figure 5). Reproductive stage 4 females are very rare to observe due to the eggs developing hooks as they are quickly released in a long chain and it is assumed the hooks help keep the eggs anchored at the place of extursion due to the limited data on hagfish reproduction and unsuccessful attempts with mating experiments in the wild and captivity (Powell et al. 2005). Additionally, through observration of captured hagfish during the sablefish longline survey in SSEI, mature female hagfish have been noted to release eggs upon capture most likely as a reproductive strategy which can result in limited data on reproductive stage 4 females. It appears that black hagfish have an asynchronous

reproductive cycle due to the number of varying reproductive stages that have been observed over the survey and fishery time periods. Female hagfish were found to be highly fecund in their immature stages (1-2) and as they matured (stage 3) eggs became larger and less abundant. Female mature fecundity (stage 3) ranged from 13–56 eggs with an average fecundity of 26.8 eggs.

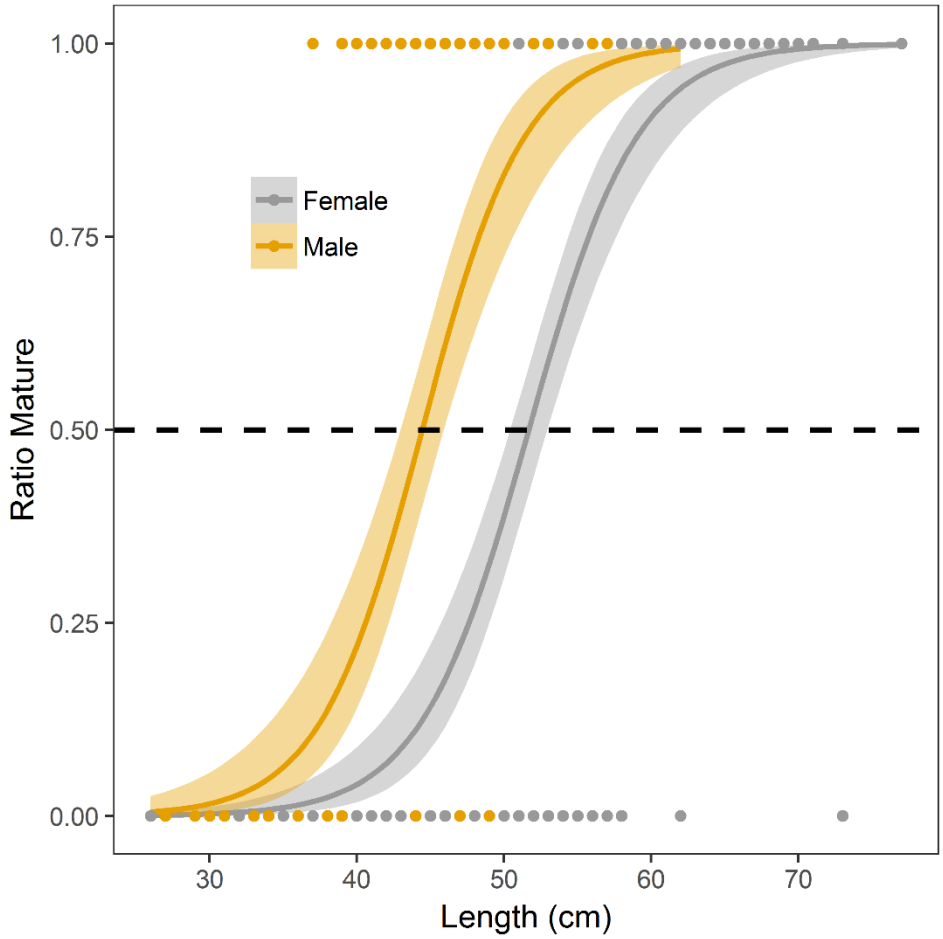

Figure 4.– Estimated length at 50% maturity (L_{50}) with 95% confidence intervals for male (44.4 cm) and female (51.6 cm) black hagfish in Southern Southeast Inside (SSEI) management area in Southeast Alaska.

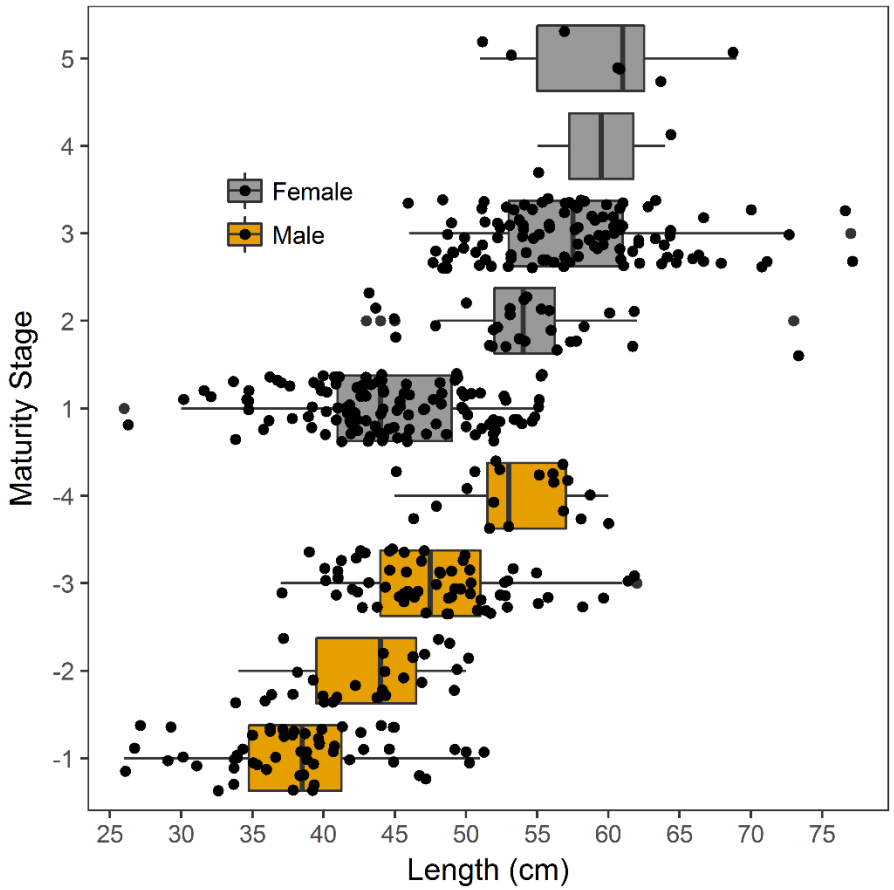

Figure 5.– Length distribution (cm) of black hagfish maturity stages for females and males. Female stages 1–2 are immature and stages 3–5 are mature and for males stages -1–-2 are immature and stages -3–-4 are mature.

Distribution and Habitat

Hagfish survey stations thus far have revealed hagfish occur in Ernest Sound, Behm Canal, and Clarence Strait and survey catch rates increased in 2017 due to refining station locations based on data collected in 2016 (Figure 6 and Table 1). Black hagfish appear to be fairly well distributed across Clarence Strait based on hagfish bycatch, evidence of slime in the annual sablefish longline survey, and logbook information from the commercial fishery. Commercial fishery location information was removed due to less than 3 permit holders participating in the fishery so that information is confidential (Figure 7). Data collected from the hagfish surveys, hagfish bycatch and evidence of slime during the sablefish longline survey, and the directed hagfish fishery from 2016–2018 were utilized to develop a hagfish habitat suitability model utilizing available substrate and bathymetry data for the SSEI management area (Figure 8). Data was limited for the Dixon Entrance area so it was excluded from the analysis. Hagfish have a habitat preference of soft substrate that includes mud and sand, most likely due to their burrowing behavior, and habitat suitability was found to be high in Clarence Strait and at the entrance of Behm Canal, moderate in areas of Sumner Strait, Ernest Sound, Behmn Canal, and Cordova Bay with the remaining areas having low to high suitability (Figure 8).

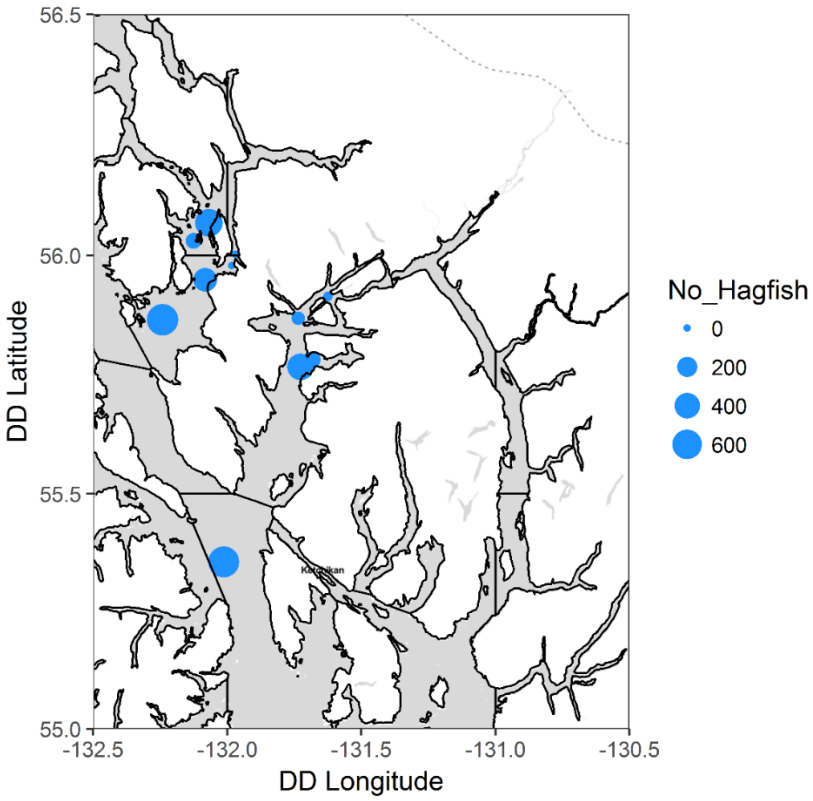

Figure 6.–2016–2018 hagfish survey station catch by number of individuals per set.

Table 1.–2016–2017 hagfish survey station average set soak time and CPUE by number of fish and weight per pot.

Year	Location	Total pots	Avg. Soak Time		Avg. CPUE		Avg. CPUE	
			Hours	Std. Dev	Fish per pot	Std. Dev	kg/pot	Std. Dev
2016	Behm Canal	98	18.8	1.06	6.1	10.3	1	1.3
2016	Ernest Sound	98	18.1	1.3	4.2	6.4	0.7	1.1
2017	Behm Canal	25	23.3	*	12	11.4	1.8	1.7
2017	Clarence Strait	24	46.6	*	27.8	19.9	3.2	2.2
2017	Ernest Sound	74	18.8	1.68	20.5	18.1	2.9	2

*****Only 1 station was set in Behm Canal and Clarence Strait in 2017.

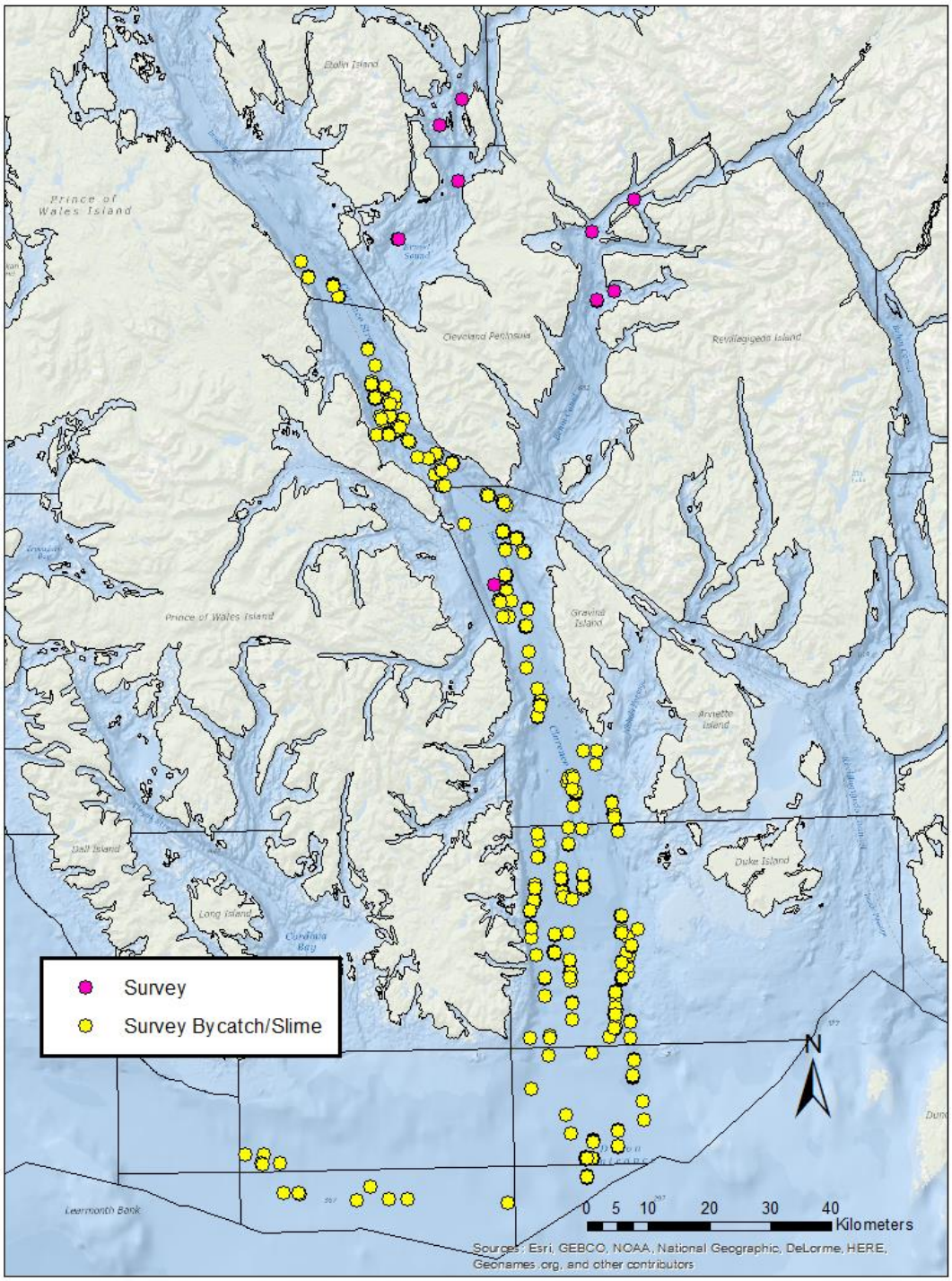

Figure 7.–Evidence of hagfish presence in Southern Southeast Alaska from catch during the hagfish survey from 2016–2017 (pink), and from bycatch of hagfish and slime on longline hooks during the sablefish longline survey from 1997–2018 (yellow). Commercial fishery information was removed from this map due to less than 3 permits holders participating in the fishery therefore the information is confidential.

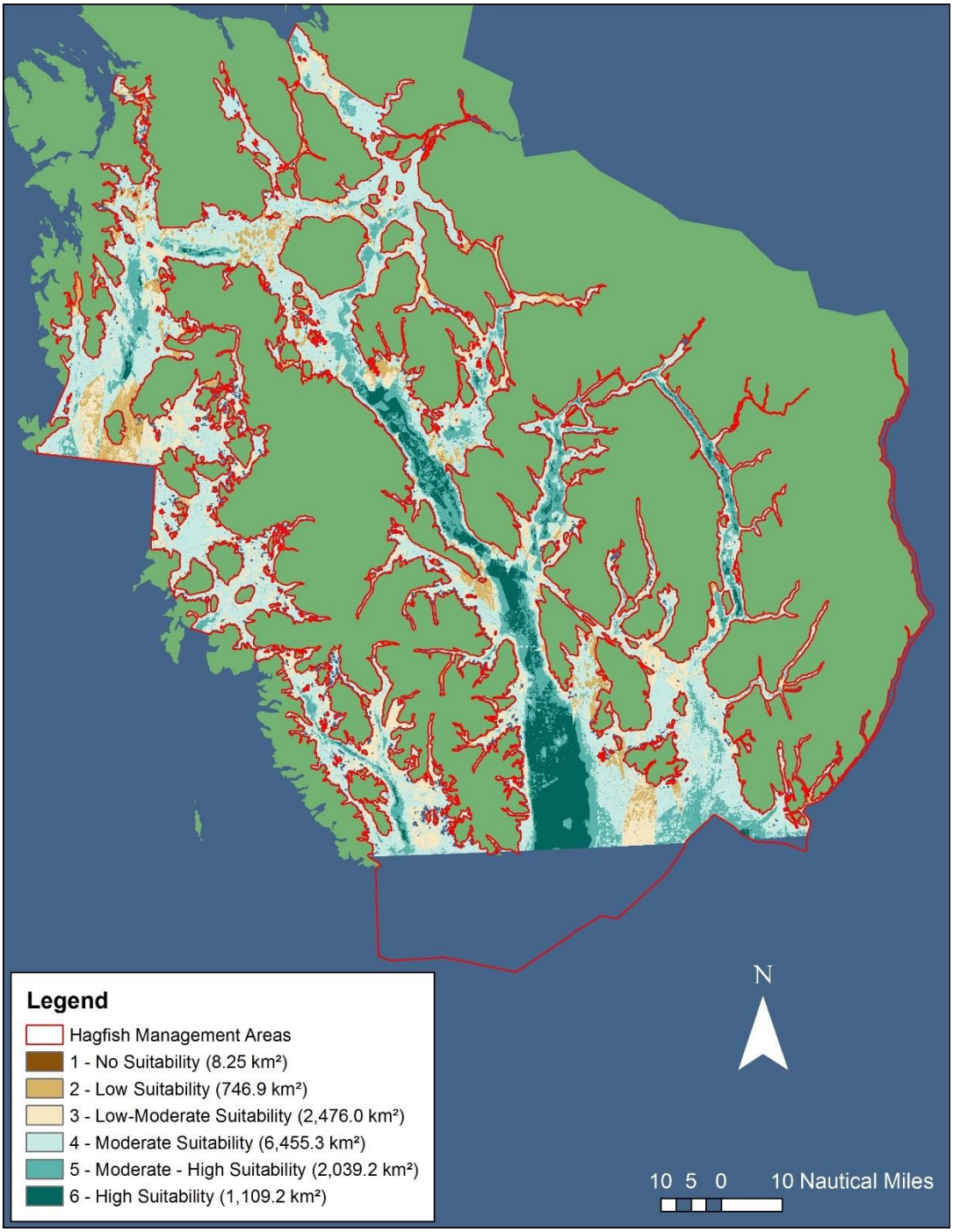

Figure 8.– Habitat suitability model for hagfish in Southern Southeast Alaska ranked from no suitability (1) to high suitability (6). Limited data was available for Dixon Entrance and habitat suitability could not be modeled.

Management Recommendations

The groundfish project recommends establishing a hagfish fishery season from July 1–June 30 and deliniating smaller management areas within SSEI to prevent serial stock depletion. Black hagfish

in Southeast Alaska are asynchronous reproducers, have low fecundity (13–56 eggs), and an estimated L_{50} of 51.6 cm for females and 44.4 cm for males. Basic life history such as reproductive strategy, growth rates, movement, etc. remain unknown for the majority of hagfish species worldwide and have resulted in rapid fishery development and resultant crashes due to this basic lack of knowledge. The 0.625 in (15.9 mm) pot escapement hole size that is utilized for this fishery is based on an escapement hole study for hagfish pots in California to reduce the harvest removal of immature hagfish (Tanaka and Crane 2014). Pacific hagfish off the coast of California (Nakamura 1994) and Oregon (Barss 1993) were estimated to reach an L_{50} of 32.5 cm and 34.0 cm which is much smaller than L_{50} estimates from Southeast Alaska. Additionally, comparing estimates of L_{50} for black hagfish in SSEI to the commercial fishery indicates that a large portion of the harvest is immature; therefore, the groundfish project recommends increasing the escape hole size that allows the escapement of immature hagfish from 0.625 in (15.9 mm) to 0.75 in (19.05 mm) to shift the distribution of harvest towards mature individuals and reduce potential for recruitment overfishing.

The groundfish project also recommends establishing smaller hagfish management areas within the SSEI subdistrict, each with their own GHL, based on the evidence of widespread hagfish presence from survey and commercial fishery catch and habitat suitablity to distribute harvest and prevent serial stock depeltion in a localized area. Management areas will include: Sumner Strait, Ernest Sound, Behm Canal, Back Behm Canal, and Exploratory (Figure 9). Due to limited harvest history and hagfish survey information, management areas areas that have relatively low habitat suitability and no survey or harvest information will have a GHL of 10,000 lbs each (Sumner Strait and Exploratory), areas with moderate habitat suitability and a history of survey and harvest information will each have a GHL of 20,000 lbs (Ernest Sound, Behm Canal, and Back Behm Canal, and Clarence Strait), which is the largest management area with the highest habitat suitability and most evidence of hagfish distribution will have a GHL of 40,000 lbs (Table 2). These changes result in an increase to the total GHL for hagfish in SSEI from 60,000 lbs to 120,000 lbs.

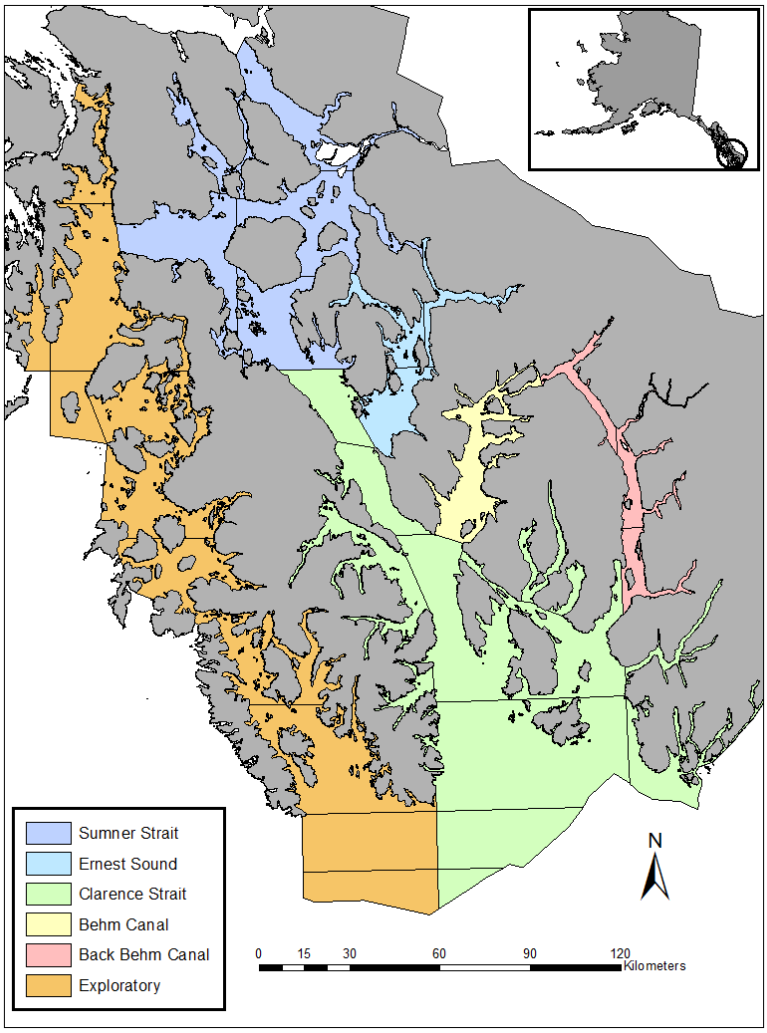

Figure 9.–Management areas for the hagfish commercial fishery in Southeast Alaska.

Table 2.–Hagfish management areas and guideline harvest levels (GHLs).

Management Area	GHL (lbs)
Sumner Strait	10,000
Ernest Sound	20,000
Clarence Strait	40,000
Behm Canal	20,000
Back Behm Canal	20,000
Exploratory	10,000
Total	120,000

Future Research

The deparment is exploring methods to tag hagfish using a variety of disc and dart tags in an attempt to collect hagfish movement and growth information and is working with the University of Alaska to obtain grant funding for investigating the genetic stock structure of black hagfish across the northeast Pacific.

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