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Final Spend Plan for funds appropriated to address the 2019/2020 Bering Sea Tanner crab fishery disaster determination. NOAA Fisheries allocated \$12,935,199 for the 2019/2020 Bering Sea Tanner crab fishery disaster. The spend plan informs the federal grant application submitted by Pacific States Marine Fisheries Commission (PSMFC) to NOAA Fisheries and is subject to change based on approval of the final grant.

Process to develop the spend plan: ADF&G posted an initial draft spend plan for public comment in December 2022 and received 5 written comments on the initial plan. ADF&G revised the plan based on public comments and posted a second draft plan for public comment on March 1, 2023. Nine additional comments were received (Appendix 1) and in response, ADF&G is recommending the following revisions:

Research: Projects were selected from the list provided in the second draft of the spend plan for direct funding. These research projects are responsive to the research themes developed by ADF&G, the Bering Sea Fisheries Research Foundation (BSFRF), and public comment.

Processors: Processing companies that recently processed Western Bering Sea Tanner crab (WBT), i.e., ‘active processors’ were included for direct payment distribution.

Guiding principles for disaster fund distribution: Disbursement of funds is intended to:

- 1) assist fishery participants harmed by the 2019/2020 Bering Sea Tanner crab fishery disaster, and
- 2) improve fishery information used to assess and forecast future fishery performance and to develop management approaches that avoid and/or mitigate the impacts of future fishery disasters that cannot be prevented.

Proposed allocations to project categories: The proposed categories and allocations reflect comments received from initial stakeholder input and comments on the first and second draft spend plans.

Proposed categories	Allocation	Estimated funds ^a
Research	10%	\$1,111,347
Communities	4.75%	\$614,000
Community Development Quota (CDQ) Program ^b	8.51%	\$1,101,000
Harvesters	57.72%	\$7,465,000
Processors	18.90%	\$2,444,000
ADF&G Program Support	0.12%	\$15,411
Total	100%	\$12,750,758

^a Additional funds will be allocated to Pacific States Marine Fisheries Commission (PSMFC) to administer the federal grant.

^b After allocations for research, communities, and administrative support are taken off the top, 10% of the remainder is allocated to CDQ groups; this represents approximately 8.51% of the total available funds.

- **Research:** The 2019/2020 Bering Sea Tanner crab fishery disaster resulted from undetermined and natural causes which led to low estimated mature male biomass in the eastern and western management areas. These estimates were below thresholds required for a fishery opening during the 2019/2020 season. The relationship between Tanner crab productivity, biomass, and the environment is not well understood but environmental changes and new extremes in sea temperature and ice extent likely play a role in the distribution, growth rate, and natural mortality of Tanner crab.
- **Communities:** Municipalities and boroughs rely on revenue generated from Bering Sea Tanner crab fishery landings and other economic activities related to the Bering Sea Tanner crab fishery. ADF&G is proposing direct payments to communities meeting all eligibility criteria. ADF&G notes that it is uncertain whether NOAA Fisheries will approve direct payments to communities where Bering Sea Tanner crab are landed. If direct payments are not approved, ADF&G proposes to make funds available to eligible communities for use in managing, repairing, or maintaining infrastructure, services, or habitat that support the Tanner crab fishery in the region using a project-based funding process similar to that used in recent Alaska fishery disasters.
- **Western Alaska Community Development Quota (CDQ) Program:** Direct payments to CDQ groups meeting all eligibility criteria. CDQ groups share an allocation of the Bering Sea Tanner crab Total Allowable Catch (TAC) and are mandated by statute to provide economic and social benefits to their respective communities from revenues generated by CDQ fishery allocations. ADF&G proposes to distribute funds to CDQ groups in proportion to each group’s Bering Sea Tanner crab fishery allocation specified in federal regulations¹.

The remaining funds are proposed to be shared between harvesters and processors based on the historical distribution of revenue from the Non-Binding Price Formula² for Tanner crab as reported in the 2018/19 Non-Binding Price Formula Report.

2018/19 Tanner crab - Harvester/Processor sharing based on the Non-Binding Price Formula	
Non-Binding Price Formula	Wholesale price x 0.49767 - 0.1043
Total Allowable Catch	2,439,000
First Wholesale Price (SAFE Report)	\$7.83
Expected Ex-vessel value from Formula	\$3.79
Recovery	64.3%
Fishery Gross Revenue	\$12,279,609
Ex-Vessel Gross Revenue	\$9,249,800
Harvester % of Gross	75.33%
Processor % of Gross	24.67%

- **Harvesters:** Direct payments are proposed to WBT crab quota share (QS) holders, vessel owners, captains and crew who meet all eligibility criteria. Quota share holders will be identified using the National Marine Fisheries Service (NMFS) Restricted Access Management (RAM) database for the 2019/20 WBT crab season. Vessel owners will be identified using the Commercial Fisheries Entry

¹ <https://www.federalregister.gov/documents/2006/08/31/06-7326/fisheries-of-the-exclusive-economic-zone-off-alaska-western-alaska-community-development-quota>

² § 680.20(g)(2)(ii) The Non-Binding Price Formula Report is prepared annually for the Bering Sea Arbitration Organization (harvesters) and the Alaska Crab Processors Arbitration Organization (processors).

Commission (CFEC) vessel license database for 2019. Captain and crew eligibility will be verified based on crew contract or settlement from the 2017/18 and/or 2018/19 season, or an affidavit from the vessel owner or CFEC permit holder. Captains may also be verified based on CFEC permit holder data from fish ticket landings during the 2017/18 and/or 2018/19 season.

- **Processors:** Direct payments to processor quota share (PQS) holders and active processing companies that meet all eligibility criteria. PQS holders are identified using the NMFS RAM database for the 2019/20 WBT season. Active processing companies are those companies that received landings of WBT during the 2017/18 and/or 2018/19 seasons.
- **Program Support:** The Alaska Department of Fish and Game proposes to designate funds for staff working on fishery disaster plan development and implementation in coordination with PSMFC.

Proposed allocations and eligibility for disaster relief funds:

Research – ~10% of available funds (\$1,111,347): Research funds are allocated to the Bering Sea Fisheries Research Foundation (BSFRF) to support projects that improve available fishery information and help prevent and/or mitigate future fishery disasters. The research projects and budgets are further described in Appendix 2 and are responsive to the research themes described below which were developed in the initial and second draft spend plans. Directing fishery disaster research funds to these projects in the spend plan expedites the administrative process and maximizes the amount of time for investigators to conduct research.

- Refined understanding of terminal molt and growth for Tanner crab stock components east and west of 166° W long., with an emphasis on growth increments at terminal molt.
- Further evaluation of mature male biomass (MMB), exploitation rates, and potential management strategy evaluation work to examine the relationships between MMB, legal size, and industry preferred size on stock dynamics.
- Further evaluation of spatial and temporal dynamics of the eastern/western stock components.
- Movement/distribution shifts as a function of environmental factors (e.g., temperature).
- Understanding the importance of groundfish (e.g., Pacific cod) predation and cannibalism as a function of crab abundance and environmental conditions.

Communities – 4.75% of total funds (~\$614,000): Municipalities and boroughs rely on revenue generated from Tanner crab landings and other economic activities related to the Tanner crab fisheries. Based on stakeholder input, ADF&G is proposing direct payments to affected communities that meet the eligibility criterion to mitigate the impacts of the disaster. ADF&G notes that it is uncertain whether NOAA Fisheries will approve direct payments to eligible communities. If direct payments are not approved, ADF&G proposes to make funds available to eligible communities for the purpose of managing, repairing, or maintaining approved infrastructure, services, or habitat that support Tanner crab fisheries in the Bering Sea using a project-based funding process similar to that used in recent Alaska fishery disasters. According to guidance from NOAA Fisheries, fishery disaster funds cannot be used as a match requirement for any other projects.

The following criterion must be met for a community to receive a distribution of funds:

- WBT crab must have been landed in the community during the 2018/19 season based on the port of landing from ADF&G Fish Ticket data.

Disaster funds are proposed to be distributed pro rata to eligible communities based on each community’s proportion of the total 2017/18 and 2018/19 pounds of WBT crab landed in all eligible communities. There are four communities where landings of WBT occurred during the 2017/18 and 2018/19 seasons: Dutch Harbor/Unalaska, Akutan, St. Paul, and King Cove.

CDQ Groups – 8.51% of total funds (~\$1.10 million): CDQ groups receive, in aggregate, a 10% allocation of the annual WBT crab harvest limit and depend on revenue generated from WBT crab landings to provide economic and social benefits in their respective communities consistent with statutory mandates. Based on initial stakeholder input, ADF&G is proposing direct payments to each CDQ group based on each group’s allocation of the WBT crab fishery CDQ allocation in federal regulation and shown in the table below.

CDQ group	Allocation	Estimated amount
Aleutian Pribilof Island Community Development Association	10%	\$110,000
Bristol Bay Economic Development Corporation	19%	\$209,000
Central Bering Sea Fisherman’s Association	19%	\$209,000
Coastal Villages Region Fund	17%	\$187,000
Norton Sound Economic Development Corporation	18%	\$198,000
Yukon Delta Fisheries Development Association	17%	\$187,000
Total	100%	\$1,100,000

Harvesters – 57.72% of total funds (\$7,465,000)

Based on public comments, ADF&G proposes to allocate harvester funds into three pools: QS holders, vessel owners, and a combined pool for captains and crew. The proposed allocation to QS holders is 31%, which is based on the 2018 median exvessel lease rate. The lease rate is the proportion of exvessel value paid by a harvester to a QS holder for use of individual fishing quota to harvest crab and is reported in Table 3 of the January 2022 economic status report³ for all Bering Sea Tanner crab quota types. The remaining 69% is proposed to be allocated to vessel owners and captain/crew. The 2017/18 and 2018/19 WBT seasons will be used as eligibility criteria for vessel owners and captains and crew because the WBT fishery was open in the two years immediately preceding the disaster and the 2016/17 season was closed.

- QS Holders – 31% of harvester funds (~\$2.3 million). The following criterion must be met for a QS holder to qualify for a direct payment:
 - Must be listed as a QS holder of Catcher Vessel Owner (CVO), Catcher/Processor Owner (CPO), Catcher Vessel Crew (CVC), and/or Catcher/Processor Crew (CPC) quota for WBT in 2019/20.

Direct payments to QS holders will be distributed pro rata based on each QS holder’s proportion of the total QS units of all QS holders who apply and are eligible for QS holder funds. There were 326 individual QS holders of WBT quota for the 2019/20 season.

- Vessel Owners, Captains and Crew – 69% of harvester funds (~\$5.1 million). The remaining 69% of funds allocated to harvesters are proposed to be shared between vessel owners and captains and crew

³ <https://meetings.npfmc.org/CommentReview/DownloadFile?p=9e166e8f-4e58-4522-973a-ca074306e42e.pdf&fileName=D7%20Crab%20Economic%20SAFE.pdf>

by calculating a vessel-based payment for each vessel meeting all criteria as described below. Vessel-based payments are proposed to be split 70/30 between vessel owners and captains/crew based on the proportion of fishery revenues paid to captains and crew, after deducting lease fees, for the 2018 Tanner crab fishery as reported in the January 2022 economic status report:

2018 Tanner crab Vessel owner and Captain/Crew split	\$Million	Revenue split
Bering Sea Tanner (BST) Gross Revenue (Table 1)	\$9.79	
BST All Quota Lease Fees (31%, Table 3)	\$3.03	
subtotal	\$6.76	
Payments to Captains and Crew (\$0.61 +\$1.44, Table 2)	\$2.05	30%
Net Revenue to Vessels	\$4.71	70%

The following criteria will be used to determine the vessel-based payments:

1. The vessel must have been used to harvest WBT in the Individual Fishing Quota (IFQ) fishery during either the 2017/18 or 2018/19 season.
2. Total vessel landings of WBT in the IFQ fishery for the 2017/18 and 2018/19 seasons must be greater than 100 pounds.

ADF&G estimates that 35 vessels may be eligible for vessel-based payments based on these criteria.

Vessel-based payments are proposed to be calculated pro rata to each eligible vessel’s proportion of the total 2017/18 and 2018/19 pounds of WBT crab, not including deadloss, landed by all eligible vessels.

70% of each eligible vessel’s payment is proposed to go to the individual listed as the 2019 vessel owner in the CFEC vessel database.

30% of each eligible vessel’s payment is proposed to be shared by the captains and crew who worked on the vessel during the 2017/18 and 2018/19 seasons and who meet all eligibility criteria.

Payments to captains are typically twice the amount of a crew member, so each eligible captain is proposed to receive two ‘shares’ and each eligible crew member is proposed to receive one ‘share’ for each season they are eligible for.

In the example below, the vessel met eligibility criteria for both seasons and operates with one captain and four crew members each season. A different captain worked each season and two crew members worked both seasons. The

maximum number of captain shares is four, two for each season, and the maximum number of crew shares is two. An individual may qualify on the same vessel for a captain share in one season and a crew share in the other season but may not qualify for both a captain and crew share on the same vessel for the same season.

	Season		Shares	Percent of total Captain/Crew funds
	2017/18	2018/19		
Captain A	X		2	16.7%
Captain B		X	2	16.7%
Crew 1	X		1	8.3%
Crew 2	X	X	2	16.7%
Crew 3	X	X	2	16.7%
Crew 4		X	1	8.3%
Crew 5		X	1	8.3%
Crew 6	X		1	8.3%
		Total	12	100%

The following criteria are proposed for captains and crew to qualify for a direct payment:

1. Captains and crew must have participated in the WBT IFQ fishery on an eligible vessel as defined above for vessel-based payments. Eligibility will be verified based on crew contract, crew settlement, or an affidavit from the vessel owner or CFEC permit holder. Eligibility for captains may also be verified from the CFEC permit information on Fish Tickets.
2. Captains must have held a CFEC T91Q permit for each season they are claiming eligibility and crew must have held a commercial crew license or a CFEC permit for any fishery for each season they are claiming eligibility. These requirements are met by holding a permit or license in 2017 or 2018 for the 2017/18 season and in 2018 or 2019 for the 2018/19 season.

Direct payments to minors are not authorized by the terms of the Federal grant but may be authorized to guardians in the same household on behalf of an eligible minor.

If no eligible captains or crew apply for the 30% portion of a vessel-based payment, the funds are proposed to be shared proportionally among all other eligible captains and crew. These unclaimed funds would be additive to the 30% portion of the vessel-based payment for other captains and crew.

Processors – 18.9% of total funds (\$2,444,000)

The processor allocation will be split 50/50 between the Processor Quota Share (PQS) holders and the active processing companies, i.e., those processing companies that process WBT.

The following criterion is proposed for PQS holders to qualify for a direct payment:

- Must be listed as a PQS holder for WBT in 2019/20. Payment distribution for PQS holders will be pro rata based on the total PQS units of all PQS holders who apply and are eligible for QS holder funds. There were 14 individual PQS holders during the 2019/20 WBT season.

The following criterion is proposed for active processors to qualify for a direct payment:

- Based on fish ticket records, WBT must have been delivered to a processing plant owned by the processing company during the 2017/18 and/or 2018/19 seasons. Payment distribution for active processing companies is pro rata based on each company's proportion of the total 2017/18 and 2018/19 pounds of WBT crab, not including deadloss, delivered to all processing companies. There were six active processing companies during the 2017/18 and 2018/19 seasons.

Program Support – 0.12% of total funds (\$15,411): ADF&G is proposing to allocate funds to partially cover salary and benefits for a Program Coordinator who helps manage the fishery disaster program on behalf of the State of Alaska.

Appendix 2. Bering Sea Tanner Crab (*bairdi*) Fishery Disaster Research Projects.

This appendix provides a summary of two proposed project components; one for *bairdi* research priorities to be included in PhD chapters by a graduate student in coordination with BSFRF, and the second as other direct BSFRF projects that address different priorities separately. The first section below covers the proposed projects (PhD chapters) which cover 3 of 9 priorities, and the second direct BSFRF proposed projects cover 2 additional of the 9 priorities. The research priorities identified in the second draft of the spend plan were as follows:

1. Refined understanding of terminal molt and growth for Tanner crab stock components east and west of 166° W long., with an emphasis on growth increments at terminal molt.
2. Further evaluation of mature male biomass (MMB), exploitation rates, and potential management strategy evaluation work to examine the relationships between MMB, legal size, and industry preferred size on stock dynamics.
3. Evaluation of juvenile bottlenecks related to the recent apparent lack of recruitment to the legal-size class.
4. Examine the relationship between spatiotemporal changes in fishing-induced habitat disturbance and Tanner crab abundance and spatial distribution.
5. Further evaluation of spatial and temporal dynamics of the eastern/western stock components.
6. Movement/distribution shifts as a function of environmental factors (e.g., temperature).
7. Understanding the importance of groundfish (e.g., Pacific cod) predation and cannibalism as a function of crab abundance and environmental conditions.
8. The relationship between snow and Tanner crab stock status, including the dynamic of hybridization, with emphasis on Tanner crab status in response to the snow crab collapse.
9. Gear modifications to reduce incidental catch of female/small male crab.

PhD Related Projects

Potential Title: Eat or be eaten: an exploration of *Chionoecetes bairdi* fishing mortality, natural mortality, and spatial management considerations.

Executive Summary

Population dynamics of Tanner crabs (*Chionoecetes* spp.) are difficult to understand, and uncertainties around life history and ecosystem-level interactions, including predation, cannibalism, and spatial variability in biology and fishing effort, pose substantial challenges to direct exploitation and conservation management. The pronounced cyclic nature of the Eastern and Western Tanner crab (*Chionoecetes bairdi*) stock status has led to frequently closed seasons posing significant economic challenges for the crab industry. The 2015/16 fishery marked a two-decade peak in catches of approximately 20 million pounds and was immediately followed by a season closure in 2016/17. Following the 2016/17 season closure there were limited harvesting opportunities in the west area in 2017/18 and 2018/19. The 2019/20 season was closed in both areas, prompting a fishery disaster determination. This substantial decline in total allowable catch (TAC) initiated a management strategy evaluation exploring harvest control rule options for Tanner crab that resulted in an update to the *bairdi* harvest strategy for the State of Alaska in March 2020 ([Heller-Shiple et al., 2021](#)). The update has allowed for seasons to be open but at relatively low levels. While the declines and variability in open seasons and catch have led to some positive steps for managers, the economic impacts to Tanner crab stakeholders have also qualified them for fishery disaster funds, which includes funds designated for research specific to Tanner crab.

This research will be conducted through the BSFRF and support capacity building for a graduate student seeking to specialize in size-structured population dynamics pertaining to the assessment of commercial crab in Alaska. The following dissertation chapters seek to connect Spending Plan research priorities to projects that could inform management actions for *C. bairdi* and other Alaskan crab fisheries in a rapidly changing climate.

In general, chapters are broken down into two categories, 1) related to or informing management decisions, and 2) informing parameters that could be broadly used by assessment authors and fishery managers. Chapters 1, 2, and 3 have direct management utility, while 4 and 5, explore life history uncertainties that could play a role in mature male biomass through recruitment controls, natural mortality assumptions, and expectations for *Chionoecetes* fisheries as the climate continues to warm.

Proposed chapters/projects for *C. bairdi*:

1) Tanner crab MSE Lite

Category: Informing Management

This chapter would fulfil research priority #2, which focuses on using an MSE for MMB, exploitation, and male *bairdi* size issues. This work will be built off of the Tanner crab management strategy evaluation (MSE) conducted in 2020 for a master's thesis ([Heller-Shipley et al., 2021](#)), where a suite of harvest control rules was simulated using the federally approved Tanner crab assessment model and results were used to update the State of Alaska Tanner's crab harvest strategy. This chapter would constitute taking the results of the full MSE, which uses a complex estimation model, and compare harvest control rule scenario outputs to a "lite" version using a simplified estimation model, generating male and female biomasses from auto-correlated log-normal distributions. The estimation model comparisons will focus on the magnitude of difference in performance metrics for each approach, informing MSE methodologies. When using a complex estimation model, model runs are time consuming and computing intensive, which can lead to budgetary and schedule difficulties for time sensitive projects. Simple estimations models can be run efficiently with limited computing power, but ideally should produce outputs that reflect complex estimation methods. Discerning the appropriateness of estimation model methods will help define best practices for future model-based investigations of Alaskan crab stocks.

2) Considerations for *Chionoecetes* Reference Point: F_{OFL}

Category: Informing Management

This chapter will also fulfill research priority #2, with a specific focus on reference points and the dynamics of exploitation. In May 2022, at the North Pacific Fishery Management Council's (NPFMC) Crab Plan Team (CPT) meeting, a presentation (lead by Dr. M. Dorn) focused on the reference points and associated assumptions used in crab management, and possible reconsiderations for the metric F_{OFL} , the instantaneous fishing mortality used in the calculation of the overfishing limit. F_{OFL} seeks to inform F_{MSY} , the instantaneous fishing mortality producing maximum sustainable yield, and the chosen proxy is to be 35% of spawning biomass. This proxy was based on groundfish life history and management (Clark 1991) that was then applied to crab stocks. Crab have substantially different life history strategies, and fishing targets large males only, and there are questions to the appropriateness of the proxy $F_{35\%}$, particularly for *Chionoecetes* spp. Some of the suggested alternatives include:

- evaluating ranges of F_{OFL} proxies,

- switching crab from a tier 3 to tier 4 designation where $F_{OFL}=M$, and B_{MSY} is the mean biomass over a specified period,
- using functional maturity instead of morphometric maturity or a stepped maturity approach when determining spawning biomass when defining F_{MSY} ,
- or partitioning unfished biomass into categories (small, medium, large) to spread fishing pressure over more size classes.

This project would conduct a yield-per-recruit style analysis exploring these, and other potential F_{OFL} designations and how different proxies may retroactively impact how the fisheries are prosecuted, and what fisheries could look like under projected scenarios. The focus of this chapter would be Tanner crab, and this work would be presented to managers to demonstrate how changing the F_{OFL} proxy could impact the stock and management.

3) Eastern and Western *bairdi* District Split

Category: Informing Management

This chapter will fulfil research priority #5: “Further evaluation of spatial and temporal dynamics of the eastern/western stock components.” The federal assessment model defines Eastern Bering Sea Tanner crab as a single stock; however, the state of Alaska defines two directed fisheries, designated as the eastern and western districts, one on either side of 166°W. This split is based on apparent eastern and western growth rates reflected in average sizes of mature male and female crab, likely explained by environmental influences (Somerton 1981). Two state districts result in two TAC calculations, the combined total not to exceed the federal ABC. These TACs are computed in the fishery harvest control rule, outlined in the ADFG harvest strategy. In 2011 an update to the Tanner crab harvest strategy was implemented which considered district level splits in assumptions of maturity (Zheng and Pengilly 2011), but notably “No evidence supports partitioning the unit stock into discrete, non-interbreeding, non-mixing sub-populations which can be assessed and managed separately” (Rugelo and Turnock 2010). Questions on the validity of environmental influences on maturity designation necessitating a district split remain, especially as species distributions continue to change with higher prevalence of marine heatwaves and warmer conditions. This chapter would use time series analysis methods for the two areas, using summer survey data from the annual Eastern Bering Sea Bottom Trawl Survey conducted by the National Marine Fisheries Service and BSFRF to 1) review the considerations for the district separation for *bairdi*, 2) explore methods of area management in other parts of the world and 3) re-assess the eastern Bering Sea Tanner crab district split approach and it’s appropriateness in a changing climate.

4) Add size-structure population models to CEATTLE for exploration of temperature-based cod predation rates on *Chionoecetes*

Category: Informing Parameters (M)

This chapter would fulfil research priority #7, “Understanding the importance of groundfish (e.g., Pacific cod) predation and cannibalism as a function of crab abundance and environmental conditions.” It is established that groundfish, particularly Pacific cod (*Gadus macrocephalus*) predate on *Chionoecetes* species, but there is much uncertainty surrounding the rates of predation and the impact on *Chionoecetes* populations as the climate warms and metabolic demands of groundfish change. CEATTLE, is a multi-species age-structured assessment model used for groundfish in the Bering Sea and Gulf of Alaska (Holsman *et al.*, 2015; Adams *et al.*, 2022) and

stands for Climate-Enhanced, Age-based model with Temperature-specific Trophic Linkages and Energetics. While there are multiple groundfish stocks parameterized in the model, with methods for exploring predation, there is not yet a way to include stocks assessed using size-structure. The first part of this chapter would be to add a size-structure utility into CEATTLE for the Bering Sea to incorporate a generalized *Chionoecetes* model, whereas the second part would consider temperature-based mortality estimates for *Chionoecetes* by groundfish predators (cod) in an MSE-style exercise, as some evidence suggests that cod could be consuming more crab as the climate warms and species distributions change with increased crab and cod spatial overlap (Holt *et al.*, 2021).

5) *Chionoecetes* Cannibalism

Category: Informing Parameters (M)

This chapter would also fulfil research priority #7, “Understanding the importance of groundfish (e.g., Pacific cod) predation and cannibalism as a function of crab abundance and environmental conditions.” It is established that many crustaceans are cannibalistic, but the specific mechanism and rates of cannibalism are not well understood, especially in a changing climate. Laboratory studies suggest that intercohort predation is a more significant source of mortality compared to intracohort predation (Sainte-Marie and Lafrance 2002), and anecdotal accounts of collection efforts for juvenile *Chionoecetes* spp. support the notion that cannibalism occurs between different cohorts when molting. As the Bering Sea warms, there are uncertainties on possible changes in bioenergetics and spatial distribution of juvenile crab and whether this could impact rates of cannibalism contributing to recruitment bottlenecks. This two-part study would have a laboratory component, considering cannibalism rates between different size classes of mature and juvenile crab with temperature and density controls. These data, along with available bioenergetic based mortality and standard assessment data would then be used in a modeling exercise using the new size-structured functionality of CEATTLE in an MSE-style exploration of cannibalism assumptions. This could give insight to assumptions about natural mortality and how it may change with warming waters.

Budget Summary

These projects are expected to take an estimated three to four years for completion, with each project accounting for a portion of support from *bairdi* disaster relief research funds. Some project details are likely to change, but the general scope is expected to be similar to those outlined. It is estimated that the total scope of the budget will cover three years of PhD level work, with expenses estimated to be approximately \$480,000 in total. The graduate student, Madison Heller-Shipley, is in the final quarter of her first year at the University of Washington in Dr. André Punt’s lab. Ms. Heller-Shipley has been working with the BSFRF for nine years, conducted the MSE for the *bairdi* harvest strategy exploration, which updated the harvest strategy in 2020, and has the necessary expertise to pursue meaningful work supporting *bairdi* research priorities. She will coordinate with university, federal, state, and industry members for guidance and support, and pursue work that is of direct utility for the betterment of crab management in Alaska.

Table 1: Breakdown of total expense amounts. Further details of labor and cost structure will be provided separately.

Year	Chapter Priorities	Estimated Costs
2023	Chapter 1, Chapter 3	\$20,000
2024	Chapter 1, Chapter 2, Chapter 3	\$140,000
2025	Chapter 2, Chapter 4	\$140,000
2026	Chapter 4 and Chapter 5	\$140,000
2027	Wrapping up, defending	\$40,000
TOTAL		\$480,000

Direct BSFRF Proposed Projects

BSFRF Growth Charters – Collection of Pre-molt Tanner Crab Nearing Terminal Molt

Category: Improving parameters (growth), and informing management

This project would address research priority #1 to improve the understanding of adult *bairdi* growth. The understanding of growth in Bering Sea *bairdi* and snow crabs is informed by a mix of information from the Bering Sea and Gulf of Alaska (Kodiak). Generally, Bering Sea measurements of growth per molt for *bairdi* are lacking across a broad range of sizes for both male and female *bairdi*. More specifically, samples are absent or low for growth increments that inform sizes for male and female *bairdi* through terminal molt sizes. The Bering Sea *bairdi* stock is managed as a single stock spanning two districts (East and West of 166 degrees W longitude). Body size (carapace width) of mature males is smaller in the west compared to the east, the two districts are managed for different sizes of mature male biomass but a uniform retention size. In recent seasons, fishing efforts have occurred near the East/West district boundary. Overall understanding of stock structure would improve with better data available for differential growth near terminal molt sizes especially across district boundaries. BSFRF has collaborated with NOAA and ADF&G to complete a number of Chionoecetes spp. growth collection charters (2012, 2015, 2016, 2017, and 2019). For this proposed work, two spring (early April) charters are planned which would be similar in scope and scale to prior *bairdi* growth charters. Fishing vessels (catcher trawlers) would be chartered to transit to *bairdi* grounds for sampling (Nephrops trawl) for retaining live pre-molt crab to monitor growth. Estimated project costs are \$150,000 annually for a total of this proposed project of \$300,000. These costs include daily charter rate, fuel, gear, vessel provisioning, and scientific party labor.

BSFRF Collaborative Movement and Tagging for East and West *Bairdi*

Category: Informing management

This project would address research priority #6 to improve the understanding of adult *bairdi* movement and overall stock structure. Successful tagging research for Bering Sea *bairdi* has been limited but some recent tagging near areas closed to fishing (Pribilof Islands “home plate”) has shown that *bairdi* movement and its timing is important for stock management. Seasonal movement of Tanner crab in and across both districts would be improved through specific and opportunistic tagging projects. Further, the overall understanding of movement near boundaries and closure areas needs further research as a function of temperature and related changes in the ecosystem. The proposed work would procure 150

satellite tags (Wildlife Computers, ~ \$250,000) to be available for tagging mature *bairdi* crab. Initial tagging would likely begin during existing or currently planned research (NMFS summer surveys, growth charters, cost recovery, or other fishing). A second component of the *bairdi* movement and tagging work would be a specific charter(s) of vessels to sample specified grounds for tagging of mature male and female *bairdi*, likely near the East/West district boundary. This sampling would likely occur in coordination of other activities to connect, if possible, the current season understanding of distribution (summer survey and directed fishing distribution patterns) to better inform the general understanding of movement.

Total Proposed Project Budget

Year	PhD Chapter Priorities	Estimated Costs
2023	Chapter 1, Chapter 3	\$20,000
2024	Chapter 1, Chapter 2, Chapter 3	\$140,000
2025	Chapter 2, Chapter 4	\$140,000
2026	Chapter 4 and Chapter 5	\$140,000
2027	Wrapping up, defending	\$40,000
SUBTOTAL		\$480,000
Year	Direct BSFRF Growth Project	Estimated Costs
2024	Growth Charter Yr-1	\$150,000
2025	Growth Charter Yr2	\$150,000
SUBTOTAL		\$300,000
Year	BSFRF <i>Bairdi</i> Tagging Projects	Estimated Costs
2023	Tag Purchase (WC, Inc. 150 tags)	\$250,000
2024-2025	Tagging Charter (~22 total days)	\$260,000
SUBTOTAL		\$510,000
GRAND TOTAL	Proposed Project Total	\$1,290,000

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