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Recommended Harvest Strategy for Southeast Alaska Red (*Paralithodes camtschaticus*) and Blue King Crab (*P. platypus*) Commercial and Personal Use Fisheries

by

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PURPOSE

The purpose of this document is to recommend an update to the Southeast red and blue king crab harvest strategy [5 ACC 34.113 and 5 ACC 77.664] for consideration, and to lay the framework for a consistent and transparent approach for management decisions. We provide a brief history of the biology and stock assessment, fishery management goals, and a recommended harvest strategy.

BACKGROUND

Red king crab (*Paralithodes camtschaticus*) are taken primarily in the protected bays, inlets, and adjacent shorelines in Southeast Alaska north of Petersburg; few red king crab are caught from the southern portion of Southeast. Red king crab generally inhabit depths less than 200 fathoms. Historically, important red king crab fishing grounds have included Gambier Bay, Pybus Bay, Seymour Canal, the Juneau area, Lynn Canal, Holkham Bay, Excursion Inlet, and Peril Strait. Blue king crab (*P. platypus*) may be taken only during the open fisheries for red and golden king crab (*Lithodes aequispinus*) and Tanner crab (*Chionoecetes bairdi*). Small quantities of blue king crab are harvested only incidentally during the golden king crab and Tanner crab fisheries (Messmer et al. 2021).

Management of the commercial red king crab fishery is based on the *Southeast Alaska Red King Crab Management Plan* (5 AAC 34.113). This management plan was designed to be consistent with the Board of Fisheries' Policy on King and Tanner crab Resource Management (90-04-FB, March, 1990) [5 AAC 34.080], which establishes a November– January season that avoids sensitive life history stages of reproduction including mating and molting, restricts harvest to males only with a minimum legal-size limit of seven inches carapace width, and establishes gear restrictions and annual guideline harvest levels (GHLs) based on appropriate harvest rates and annual stock assessment surveys. Harvest of red and blue king crab, regardless of their sex or size, infected with parasitic barnacle species *Briarosaccus regalis* is allowed because these parasites hinder reproduction and suppress growth of king crab (Noever et al. 2016).

Within Section 11-A, management of the red and blue king crab personal use fishery is based on the *Section 11-A Red and Blue King Crab Management and Allocation Plan* (5 AAC 34.111), which allocates harvest between the commercial and personal use fishery at 40% and 60% respectively. The plan also allocates the personal use GHL between winter and summer seasons at 10% and 50% respectively to provide greater opportunity for the public. The personal use fishery requires harvest permits for Section 11-A and for the remainder of the region to document harvest, to account for all sources of known mortality, and to aid in managing the fishery. The regionwide permit began in 2018 and is required for all king crab species (red, blue, and golden), whereas the Section 11-A permit is required only for red and blue king crab (Messmer et al. 2021).

BIOLOGY AND STOCK ASSESSMENT

Life history of red king crab is better understood than other Lithodid species but remains incomplete (Donaldson 2005). Adult females brood tens of thousands of embryos, with fecundity increasing with carapace length (Otto et al. 1990). When the embryos are fully developed, they hatch as zoea (swimming larvae), but are susceptible to the movements of tides and currents (Stevens 2014a). After feeding on plant and animal plankton for several months and undergoing several body changes with each molt (Stevens 2014a), the larvae settle to the ocean bottom and molt into glaucothoe (nonswimming larvae) (Stevens 2014b). Juveniles pass through three phases (cryptic, exploratory, and gregarious) based on their current needs. In the third (gregarious) phase they form mixed-sex pods of similar aged crab (Stevens 2014b). Adult and older juveniles occur on a variety of substrates including rock and gravel, mud, sand, shell hash, and mixtures of these types. Red king crab are sexually mature at five to six years of age (O'Clair and O'Clair 1998). Males are polygynous and prior to mating grasp the female for days until the female molts, then mating occurs. Adult red king crab exhibit near shore to offshore (or shallow to deep) and back, annual migrations. They come to shallow water in late winter and by spring the female's embryos hatch (O'Clair and O'Clair 1998). Adult crabs tend to aggregate by sex, and by shell condition, on the mating-molting grounds (Webb 2014). Red king crab of both sexes have been known to migrate long distances, in one study averaging over 50 km per month (Bell et al. 2016)

Management of red king crab fisheries in Southeast Alaska is abundance-based and requires annual surveys to assess stock size (Stratman et al. 2019). Stock assessment utilizes several types of data: commercial and personal use harvest and catch per unit effort (CPUE) and length/weight relationships from surveys. These data, along with estimates of growth and natural mortality, are used as input into a 3-stage catch-survey analysis model (CSA model) to determine regional biomass estimates of mature and legal red king crab, that along with harvest rates, are used to determine harvestable surplus levels for the commercial and personal use fisheries (Palof and Stratman 2021).

Outside Section 11-A, red and blue king crab personal use fisheries are managed by size, sex, season, and a bag and possession limit; there are no allocations specified in regulation and no GHLs are established. However, stock assessment information is used to guide decisions on closing areas to personal use fishing and to establish personal use bag and possession limits.

The department has conducted surveys of red king crab abundance in Southeast Alaska since 1979. The surveys provide indices of crab abundance by sex and recruit class in terms of crab per pot. The surveys occur in areas of historically high red king crab harvest. Significant improvements, resulting in successive decreases in the coefficient of variation (CV; a measure of variability) of CPUE data, have been achieved over the 30-year survey time series. These include a change from fixed to random pot locations and stratification of survey areas in 1986; a gradual shift from square to cone pots over the period 1995–1999 (Zhou and Shirley 1997); re-stratification of the survey to redefine strata boundaries based upon the CPUE of legal, sublegal, and female red king crab in 2005 (Clark 2008); and most recently, an increase in the number of pots set in each surveyed area to improve the precision of survey area estimates. A detailed timeline and methods of survey development is outlined in Clark (2008) and Clark et al. (2003).

Due to industry concerns about the red king crab stock assessment program many improvements have been made to the survey methodologies and general biological knowledge of the stock in the last 15 years. In 2005 the department initiated an external review (Quinn et al. 2006) and several suggestions for improvements were made, including delaying the start date of the survey to avoid non-feeding molting crab, re-stratifying the survey design to improve precision in determining a relative index of abundance (Clark 2008; Quinn et al. 2006), implementing a tagging study to help

determine molt increments and movements, deploying temperature loggers on each pot, and assessing clutch fullness each year in each bay (Stratman et al. 2019). Even with these improvements, because of continued industry concerns, the department and industry cooperatively operated a project from 2010–2018 to independently estimate red king crab abundances using mark–recapture methods (Palof and Stratman 2021).

HARVEST STRATEGY AND MANAGEMENT CONSIDERATIONS

The primary goal of the recommended Southeast red and blue king crab harvest strategy is to transition from a fishery opening decision based on an economic threshold [5 AAC 34.113 (c)] to a biological threshold using historical legal male biomass estimates from survey data (Palof and Stratman 2021) and improve harvest control rules (HCRs) that aid management of the fishery. Secondary goals are to recommend a regionwide harvest strategy that improves and stabilizes fishery performance using transparent and repeatable metrics from long-term baseline survey data; maintain historical size and age compositions to maintain long-term reproductive viability; and minimize handling and unnecessary mortality of non-legal red king crab and non-target species.

Harvest strategies have been implemented for king crab fisheries in other areas of Alaska to improve fisheries management and sustainability. These harvest strategies are comprised of biological and fishery dependent and independent reference points (i.e., mature male biomass, CPUE, annual recruitment, etc.) that are used in recommending the total allowable catch (TAC) for a given management area and season (Daly et al. 2019; Daly and Jackson 2020; Siddeek et al. 2020).

RECOMMENDED HARVEST STRATEGY

We recommend a harvest strategy derived from the *Saint Matthew Island Section blue king crab* [5 AAC 34.917] and the *Aleutian Islands golden king crab* [5AAC 34.612] harvest strategies (Daly et al. 2019) and adapted to reflect the spatial stock structure of red and blue king crab in Southeast Alaska. The harvest strategy is comprised of 1) legal male biomass (LMB) biological reference points for opening and closing the directed fishery and establishing bag and possession limits for the regionwide personal use fishery (outside 11-A) and 2) maximum harvest rates on LMB relative to established reference points. When LMB/LMB_{AVG} <50% the directed fishery will be prohibited, and bag and possession limits reduced in the regionwide personal use fishery (Figure 1). The harvest rates applied to LMB increase linearly based on the ratio of the current year LMB relative to the long-term average of LMB and subsequently capped when $LMB/LMB_{AVG} \geq 1$ (Figure 2). The 1979–2020 period for LMB_{AVG} was chosen because it uses all the survey data to date which incorporates more contrasting high and low years of biomass estimates than the current long-term baseline used in the stock assessment (1993–2007) and will be updated triennially to reduce annual data biases.

The commercial fishery may open under the following conditions 1) or 2):

1) when LMB is greater than 50% but less than 100% of LMB_{AVG}, the maximum TAC, TAC_{max}, will be no more than:

$$TAC_{max} = 0.1 \times (\frac{LMB}{LMB_{AVG}}) \times LMB_{regionwide}$$

where LMB = the current year preseason surveyed biomass estimate of legal males, LMB_{AVG} = the averaged surveyed biomass estimate of legal males, and $LMB_{regionwide}$ = the current year sum of surveyed and non-surveyed biomass estimates of legal males.

2) when LMB is equal to or greater than LMB_{AVG} the maximum harvest rate applied to $LMB_{regionwide}$ will be no more than 10 percent.

For the purposes of this section, the preseason surveyed estimate means the biomass estimate of legal male red king crab present at the time of the preseason surveys as estimated directly by the CSA method from annual pot survey data. Legal males are defined as all male red king crab at least seven inches or greater in carapace width. In recommending this harvest strategy the department will use the best scientific information available to consider the reliability of estimates of red king crab, the manageability of the fishery, and any other factors it determines necessary to be consistent with sustained yield principles.

MANAGEMENT CONSIDERATIONS AND FUTURE RECOMMENDATIONS

The recommended Southeast red and blue king crab harvest strategy provides an option to further the discussion with industry to update the current harvest strategy from an economic to a biologically based threshold and establishes maximum harvest rates relative to the level of LMB. The current and historical management process and fishery threshold has resulted in inconsistent application of harvest rates used to calculate a TAC and trigger a fishery opening and has reduced fishing opportunity in the commercial and personal use fisheries.

The recommended harvest strategy provides a transparent framework in setting a maximum harvest rate and TAC at the regionwide level relative to LMB while maintaining management flexibility in setting area specific TACs. The overall health of each survey area from survey data will be used to aid in setting area specific TACs and determining management feasibility and sustainability. Management of the commercial fishery in recent years (2011 and 2017) has resulted in specific areas open approximately 24 hours which increases difficulty for managing to a respective TAC using area and time restriction HCRs. The recommended harvest strategy would allow a commercial fishery at a much lower maximum TAC than the current 200,000 pound LMB threshold. Implementing new HCRs to make this achievable will be considered. Industry has requested and proposed increasing fishing opportunity at lower TACs, utilizing HCRs that include one or a combination of equal quota share (EQS) and trip-limits. An EQS approach has been proposed by industry at the triennial Southeast board meeting since 2012 and may be the most practical for inseason management due to the potential of decreasing the pace of the fishery and allowing permit holders flexibility when to harvest their allotted quota under an EQS management regime.

EQS has been employed in the Northern Southeast Inside (NSEI/Chatham Strait) and Southern Southeast Inside (SSEI/Clarence Strait) sablefish fisheries since 1994 and 1997 respectively, due to increasingly shorter seasons, difficulty in targeting management area TACs, and increased operating efficiency of industry (Ehresmann et al. 2021). The transition to EQS in the sablefish fisheries has increased industry efficiency by allowing permit holders to fish multiple permits on a single vessel (permit stacking), conduct emergency quota transfers through the Commercial Fisheries Entry Commission (CFEC), and grant permit holder flexibility of when to harvest their quota within a season. Similarly, management of the fishery has become more efficient by removing inseason management actions that target a quota and having regulatory measures that reduces a permit holder's EQS the following season if they exceed their EQS during the current season. For the NSEI sablefish fishery, the process leading to the determination of an EQS includes compiling fishery and survey data, conducting the stock assessment to determine sablefish biomass, and accounting for additional sources of morality through decrements (e.g., bycatch mortality, sport fishery harvest, personal use and subsistence harvest, etc.) (Ehresmann and Olson 2021).

The red and blue king crab stock assessment and management plan relies on estimating legal and mature male biomass and collecting biological information (carapace length, chela height, sex, maturity, and female clutch fullness) to determine stock health and an appropriate harvest rate for the legal portion of the population in each area (surveyed and non-surveyed), which helps set commercial and personal use fishery openings, closures, and bag and possession limits (personal use fishery only). If the EQS management framework of the NSEI and SSEI sablefish fishery were applied to the red and blue king crab fishery in Southeast, the department would need to determine how best to adapt an EQS to a fishery that has multiple fishery areas, while tracking EQS overages and underages for subsequent seasons, decrementing other sources of known mortality (e.g., 11-A and regionwide personal use fishery and blue king crab harvest), updating the registration process, and reviewing additional regulations affected by this management framework. Overall, this recommended harvest strategy is an important step to increase transparency regarding management metrics utilized in a biologically-based management plan and review industry input with regards to new HCRs that may increase opportunity, sustainability, and manageability of the fishery.

REFERENCES

Bell, J., J. M. Leon, T. Hamazaki, S. Kent, and W. W. Jones. 2016. Red king crab movement, growth, and size composition within eastern Norton Sound, Alaska, 2012-2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-37, Anchorage.

Clark, J. E. 2008. Restratification of the red king crab stock assessment survey in Southeast Alaska. Alaska Department of Fish and Game, Fisheries Data Series 08-54, Douglas.

Clark, J. E., T. Koeneman, C. A. Botelho, S. Merkouris, and D. Woodby. 2003. Estimation of red king crab (Paralithodes camtschaticus) abundance and available harvest in Southeast Alaska for the 2001/2002 season using a pot survey. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 1J03-25, Douglas.

Daly, B., and T. Jackson. 2020. Chapter 9: Pribilof Islands golden king crab. *in* Stock assessment and fishery evaluation report for the king and Tanner crab resources of the Bering Sea and Aleutian Islands Regions, North Pacific Fishery Management Council, Anchorage.

Daly, B., M. A. Stichert, M. Siddeek, J. Zheng, and S. J. Martell. 2019. Recommended harvest strategy for Aleutian Islands golden king crab. Alaska Department of Fish and Game, Fishery Manuscript Series (No. 19-03), Anchorage.

Donaldson, W., and S. Byersdorfer. 2005. Biological Field Techniques for Lithodid Crabs. Alaska Sea Grant College Program, University of Alaska, Fairbanks.

Ehresmann, R., A. Baldwin, M. Bargas, E. Ebert, M. Leeseberg, E. Teodori, and K. Wood. 2021. Management report for the Southeast Alaska and Yakutat groundfish fisheries, 2017–2020. Alaska Department of Fish and Game, Fishery Management Report No. 21-02, Anchorage.

Ehresmann, R., and A. Olson. 2021. Northern Southeast Inside Subdistrict sablefish management plan and stock assessment for 2021. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 1J21-13, Douglas.

Messmer, A., J. Stratman, K. Palof, and A. Olson. 2021. Management report for the Southeast Alaska and Yakutat red and blue king crab fisheries, 2017/18–2019/20. Alaska Department of Fish and Game, Fishery Management Report No. 21-08, Anchorage.

Noever, C., A. Olson, and H. Glenner. 2016. Two new cryptic and sympatric species of the king crab parasite Briarosaccus (Cirripedia: Rhizocephala) in the North Pacific. Zoological Journal of the Linnean Society 176.1 (2016): 3-14.

O'Clair, R., and C. O'Clair. 1998. Southeast Alaska's Rocky Shores. Plant Press. Auke Bay, Alaska.

Otto, R. S., R. A. MacIntosh, and P. A. Cummiskey. 1990. Fecundity and Other Reproductive Parameters of Female Red King Crab (*Paralithodes camtschatica)* in Bristol Bay and Norton Sound, Alaska. Proceedings of the International Symposium on King & Tanner Crabs: 65-90.

Palof, K., and J. Stratman. 2021. 2020 Southeast Alaska Red King Crab Stock Assessment and Management Plan for the 2020/2021 Season. Alaska Department of Fish and Game, Regional Information Report No. 1J21-01, Douglas.

Quinn, T. J., II, D. T. C. Shirley, and T. M. Koeneman. 2006. Southeast Alaska red king crab stock assessment review. Alaska Department of Fish and Game, Special Publication 06-12, Juneau.

Siddeek, M., J. Zheng, C. Siddon, B. Daly, M. Westphal, and L. Hulbert. 2020. Chapter 8: Aleutian Islands golden king crab stock assessment. *in* Stock assessment and fishery evaluation report for the king and Tanner crab resources of the Bering Sea and Aleutian Islands Regions, North Pacific Fishery Management Council, Anchorage.

Stevens, B. G. 2014a. Development and biology of king crab larvae. Pages 234–255 [*In*] B.G. Stevens, editor. King crabs of the world biology and fisheries management. CRC Press, Boca Raton.

Stevens, B.G. 2014b. Biology and ecology of juvenile king crabs. Pages 262–280 [*In*] B.G. Stevens, editor. King crabs of the world biology and fisheries management. CRC Press, Boca Raton.

Stratman, J., A. Messmer, K. Wood, T. Bergmann, and K. Palof. 2019. Operational plan: Southeast Alaska red king crab pot survey, 2018–2022. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF.1J.2019.02, Douglas.

Webb, J. 2014. Reproductive ecology of commercially important lithodid crabs. Pages 296–298 [*In*] B.G. Stevens, editor. King crabs of the world biology and fisheries management. CRC Press, Boca Raton.

Zhou, S and T.C. Shirley. 1997. Performance of two red king crab pot designs. Canadian Journal of Fisheries and Aquatic Sciences 54(8):1858-1864.

FIGURES

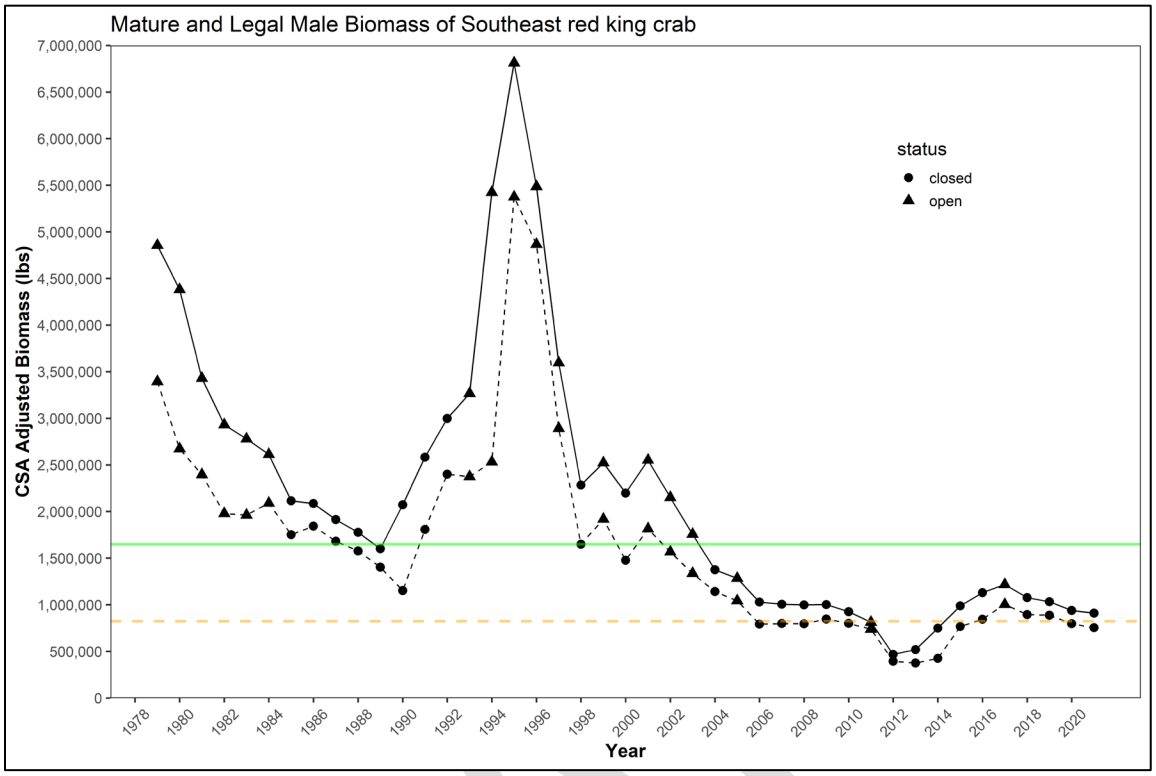

Figure 1: Mature (solid black) and legal male (dashed black) biomass estimates with legal biomass reference points from the Southeast Alaska red king crab stock assessment survey CSA model, adjusted by the mark-recapture experiments in all survey areas except Juneau, and historical fishery openings (triangle) and closures (circle) (Palof and Stratman 2021). Reference points include Target ($LMB_{1979–2020}$, solid green line) and Trigger (50% of $LMB_{1979–2020}$, dashed orange line).

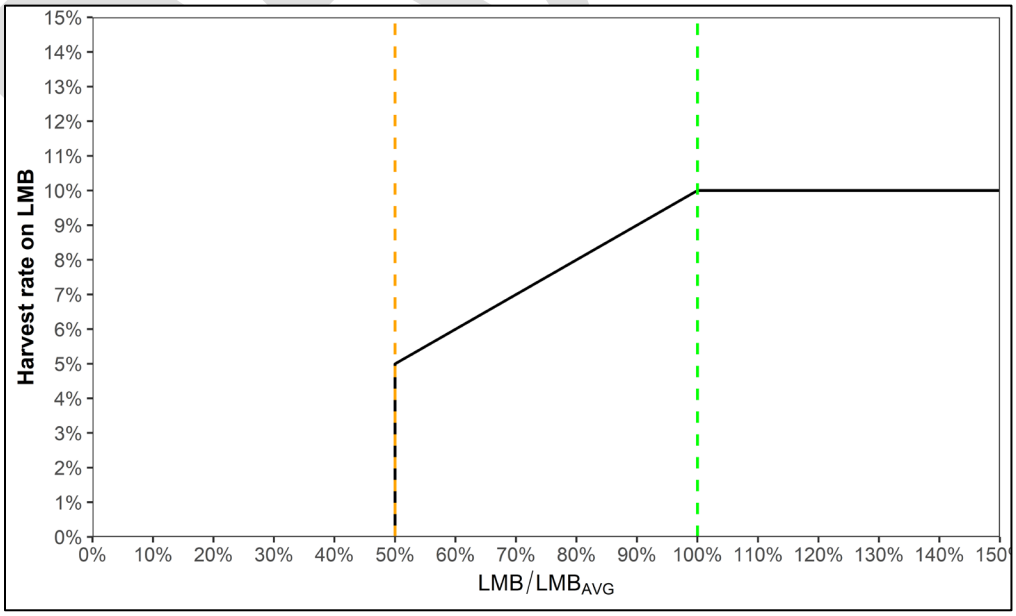

Figure 2: Harvest rate scenario on legal male biomass (LMB) based on the current year relative to LMB_{AVG}, the mean value of LMB for the period of 1979–2020. Orange and green lines are indicative of the target and trigger refence points in Figure 1.