



Recommended Harvest Strategy for Southeast Alaska Golden King Crab (*Lithodes aequispinus*)

by

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BACKGROUND

The Alaska Department of Fish and Game (Department) golden king crab (GKC) fishery in Southeast Alaska is a data-limited fishery that is managed based on a 3-S management system (sex, size, and season). The management has been further developed by limiting the number of participants and gear, establishing guideline harvest levels (GHLs) that are set within guideline harvest ranges (GHRs) for each management area (Table 1), and allowing closure of management areas if there are stock health concerns. Most of the harvest occurs in the commercial sector where the fishery extends across seven management areas (Northern, Icy Strait, North Stephens Passage, East Central, Mid and Lower Chatham Strait, and Southern). The Department annually evaluates stock status and establishes GHLs for each management area using fishery dependent data (Stratman et al. 2017; Olson et al. 2018).

The commercial GKC fishery rapidly developed after the collapse of the red and blue king crab fisheries in the early 1980s. Harvest subsequently peaked in the late 1980s and early 2010s, experiencing a period of collapse in the 1990s. Harvest has been steadily declining since 2011 and many of the management areas are currently closed due to historically low fishery performance (Stratman et al. 2017; Olson et al. 2018; Stratman 2020).

Table 1.—Golden king crab guideline harvest ranges for Registration Area A [5 AAC 34.115].

Management Area	Guideline Harvest Range (lbs)
Northern	0–145,000
Icy Strait	0–55,000
North Stephens Passage	0–25,000
East Central	0–225,000
Mid-Chatham Strait	0–150,000
Lower Chatham Strait	0–50,000
Southern	0–25,000

BIOLOGY

Golden king crab are relatively long-lived slow growing species that have an asynchronous 20-month reproductive cycle (Somerton and Otto 1986; Long and Van Sant 2016), morphometric maturity at approximately 8 years of age (Koeneman and Buchanan 1985; Paul and Paul 2001; Hebert et al. 2008), lecithotrophic larvae that remain at depth (Sloan 1985; Shirley and Shijie 1997; Long and Van Sant 2016). Golden king crab exhibit spatial variability in size at maturity across the North Pacific and among the seven management areas within Southeast Alaska where size at maturity increases with increases in latitude (Jewett et al. 1985; Somerton and Otto 1986; Nizyaev 2005; Olson et al. 2018). Certain aspects of this species' life history are well documented whereas other critical components such as, growth rates, age at maturity, longevity, etc. are unknown.

PURPOSE

The purpose of this document is to lay the framework for a consistent and transparent inseason and postseason approach to determine GHs and close fisheries when warranted. The harvest strategy described herein remains consistent with the Board of Fisheries' Policy on King and Tanner Crab Resource Management (90-04-FB, March, 1990) [5 AAC 34.080], the Southeast Alaska Golden King Crab Management Plan [5 AAC 34.114], and will be treated as a guideline for managing GKC and not a prescriptive step by step approach. Many factors and sources of information can affect determining GHs or closing of fisheries that cannot be captured in a prescriptive framework.

MANAGEMENT GOALS AND OBJECTIVES

The primary goal and objective is to recommend a harvest strategy for Southeast Alaska GKC to improve and stabilize fishery performance using transparent and repeatable metrics (and their rationale) to evaluate stock health and measure performance for more consistent inseason and postseason management. Additional goals and objectives include minimizing and mitigating ecological risks from fishing related activities, maintaining various size and age compositions of stocks in order to maintain long-term reproductive viability; minimizing handling and unnecessary mortality of non-legal GKC and non-target species; and reducing dependency on annual recruitment.

Harvest strategies have been implemented for the GKC fisheries in the Aleutian Islands and Pribilof Islands to improve fisheries management and sustainability. These harvest strategies are comprised of biological, 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) or GH for a given management area and season (Daly et al. 2019; Daly and Jackson 2020; Siddeek et al. 2020).

PROPOSED PLAN

Here we propose a harvest strategy plan that informs inseason and postseason management using fishery dependent performance indicators and management decision rules.

Performance Indicators

The primary performance indicator used in this harvest strategy is commercial catch rate defined as logbook catch of GKC per unit of effort (CPUE):

$$CPUE_{le} = \frac{catch}{effort} \quad (1)$$

where $CPUE$ is the catch of legal size male GKC per unit of *effort* (*pot lifts*) for each logbook entry (le). Equation (1) is then applied to all logbook entries and averaged for a given management area and season where:

$$\overline{CPUE}_{a,s} = \frac{\sum CPUE_{le}}{n} \quad (2)$$

where a is a given management area, s is a given season, and n is the total number of logbook entries. Future iterations will incorporate soak time in order to standardize CPUE.

Due to the GKC and Tanner crab fishery occurring concurrently, it is difficult to differentiate between GKC that are harvested as bycatch or directly targeted. GKC that are harvested as bycatch can bias logbook CPUE and consequently trigger management actions during and after the season. To evaluate this concern a proportion of $\geq 60\%$ will be applied to GKC catch from commercial logbooks:

$$catch_{le}^{\geq 0.6} = \frac{crab_{gkc}}{(total\ crab_{gkc+tc})} \quad (3)$$

where $catch$ is for a given logbook entry (le), gkc is golden king crab and tc is Tanner crab. Then subsequently Equations (1) and (2) will be applied to calculate CPUE.

A secondary performance indicator that will be used in this harvest strategy is commercial catch rate obtained from fish ticket data. With fish ticket data, CPUE is calculated using each harvest landing for the entire season divided by the difference between the first and last catch date (which is defined as active fishing season). This secondary CPUE indicator is defined as "pounds per pot day" and will aid in understanding catch rates over time:

$$active\ fishing\ season(days) = (date_{first\ catch} - date_{last\ catch}) \quad (4)$$

$$CPUE_f = \frac{harvest(lbs)}{active\ fishing\ season(days)} \quad (5)$$

where $CPUE$ is the harvest (lbs) per day for each fish ticket landing (f). Equation (5) is then applied to all fish ticket landings and averaged for a given area and season where:

$$\overline{CPUE}_{a,s} = \frac{\sum CPUE_f}{n} \quad (6)$$

where a is a given management area, s is a given season, and n is the total number of fish ticket landings.

Supplementary information that may be evaluated in this harvest strategy includes biological, local ecological knowledge (LEK), and other anecdotal information that may not be captured quantitatively in this harvest strategy framework.

- Biological information will be evaluated by analyzing carapace length (CL) mm frequencies by area and season for recruit classes of GKC sampled during commercial landings. Size of GKC is defined as the CL measurement. Recruit class is used as an indicator of shell age and is defined as recruit (new shell and a CL of 151–166mm) and postrecruit (new or old shell and a CL ≥ 167 mm).

- LEK is experiential information from fishermen and the fishing industry about the natural environment as it pertains to GKC. LEK will be evaluated and reviewed through permit holder comments in logbooks, communication with permit holders and industry representatives, and discussion at annual industry meetings (Ainsworth 2011; Beaudreau and Levin 2014). Examples of LEK include lots of crab (recruits, females, and undersized), females with full clutches, softshell, sand fleas, bad weather, large tides, and parasitized crab.

Reference Points

The primary indicator Target Reference Point (RP_{targ}) for each management area and is set at the average logbook CPUE for the years 2000-2017 because these years capture logbook requirements for the fishery in 2000 and represents contrasting data (highs and lows) in fishery performance. The exception to this includes North Stephens Passage (excludes 2000) and Lower Chatham (excludes 2013) due to having substantial outliers in those given years that influenced the Target Reference Point. The Trigger Reference Point (RP_{trig}) is set between the Target and Limit Reference Point that prompts management actions and is set at 75% of the RP_{targ} . The Limit Reference Point (RP_{lim}) is set at the level at which stocks are considered in a danger zone and are no longer resilient to fishing pressure and is set at 50% of the RP_{targ} .

MONITORING STRATEGY

Herein lies a monitoring strategy with associated decision rules for inseason and post season management of GKC.

Decision Rules

As the primary performance indicator is the most readily available estimate of fishery performance the following decision rules will guide inseason and postseason management decisions.

Inseason

- Fishery performance will be assessed biweekly and/or with a minimum requirement of 500 pot lifts before taking management action whichever is the least restrictive under the following guidelines:
 - If logbook CPUE is $\geq RP_{\text{targ}}$ manage to GHL.
 - If logbook CPUE is $\geq RP_{\text{trig}}$ but $< RP_{\text{targ}}$ manage to GHL and monitor closely.
 - If logbook CPUE is $\geq RP_{\text{lim}}$ and $< RP_{\text{trig}}$ fishery close early.
 - If logbook CPUE is $< RP_{\text{lim}}$ close fishery early **and** subsequent closure of management area for a minimum of 1 year for commercial and personal use fisheries the following season, depending upon a postseason review.
- GHLs will not be changed inseason and are only subject to change per postseason decision rules.

Postseason

Increase in a GHL

- If the most recent logbook CPUE is $>$ than the most recent previous season and is $> RP_{\text{targ}}$ the GHL may increase up to a maximum of 20% the following season.
- If the most recent logbook CPUE is $>$ than the most recent previous season and $\leq RP_{\text{targ}}$ and $> RP_{\text{trig}}$ the GHL may increase up to a maximum of 10% the following season.
- If the most recent logbook CPUE is $>$ than the most recent previous season and is $\leq RP_{\text{trig}}$ and $> RP_{\text{limit}}$ the GHL may increase up to a maximum of 5% the following season.
 - New GHLs may not exceed respective management area GHRs.

Decrease in a GHL

- **If the fishery closed short of a GHL inseason due to poor fishery performance and/or the most recent CPUE is $<$ than the previous season the GHL will be decreased based on the following conditions:**
 - If CPUE is $<$ than the most recent previous season and is $> RP_{\text{trig}}$ and $\leq RP_{\text{targ}}$ the GHL may be reduced up to a maximum of 40% the following season.
 - If the fishery closed short in-season due to poor fishery performance and CPUE is $<$ than the most recent season and $> RP_{\text{lim}}$ then the GHL decrease the following season may be within 20% of the total harvest at the time of closure during the most recent previous season, but not less than 7,500 lbs.

Closure and Re-opening

- If logbook CPUE is $<$ the RP_{lim} further management action may be required by implementing an area closure of a minimum of 1 year to reduce the risk of localized depletion.
- Upon re-opening an area after a closure, the GHL will be equal to the harvest at the time of closure rounded to the nearest 1,000 lbs and must not be less than 7,500 lbs whichever is greatest.

Review of GHGs or Decision Rules

If and when new information becomes available indicating that the harvest strategy framework and GHG setting decision rules are not consistent with the Board's policy of managing a sustainable GKC resource, the decision rules must be reviewed and the reference points must be adjusted accordingly.

Other Considerations for Management and Future Recommendations

Logbook CPUE currently lacks a soak time data field and cannot be standardized for comparison across years. Soak time was introduced as a reporting field in logbooks for the 2020 fishing season and will be used to inform this harvest strategy in future iterations. This harvest strategy may be amended in future iterations as more information and tools become available. This harvest strategy is a first step to increase transparency regarding management metrics utilized for inseason and postseason decisions. We recommend that this harvest strategy is further developed using a management strategy evaluation (MSE). A MSE is a tool that uses simulation to test how well a harvest strategy performs and if the objectives of the harvest strategy are being achieved (Punt et al. 2016; Goethel et al. 2019).

REFERENCES CITED

- Ainsworth, C. 2011. Quantifying species abundance trends in the northern Gulf of California using local ecological knowledge. *Marine and Coastal Fisheries* 3(1):190–218. Wiley Online Library.
- Beaudreau, A. H., and P. S. Levin. 2014. Advancing the use of local ecological knowledge for assessing data-poor species in coastal ecosystems. *Ecological Applications* 24(2):244–256. Wiley Online Library.
- Daly, B., and T. Jackson. 2020. Chapter 9: Pribilof Islands golden king crab. *In prep* 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.
- Goethel, D. R., S. M. Lucey, A. M. Berger, S. K. Gaichas, M. A. Karp, P. D. Lynch, J. F. Walter III, J. J. Deroba, S. Miller, and M. J. Wilberg. 2019. Closing the feedback loop: On stakeholder participation in management strategy evaluation. *Canadian Journal of Fisheries and Aquatic Sciences* 76(10):1895–1913. NRC Research Press.
- Hebert, K., W. Davidson, J. Stratman, K. Bush, G. Bishop, C. Siddon, J. Bednarski, A. Messmer, and K. Wood. 2008. 2009 report to the Alaska Board of Fisheries on Region 1 shrimp, crab, and scallop fisheries. Alaska Department of Fish and Game, Fishery Management Report (08-62). Anchorage.
- Jewett, S., N. Sloan, and D. Somerton. 1985. Size at sexual maturity and fecundity of the fjord-dwelling golden king crab *lithodes aequispina benedict* from northern British Columbia. *Journal of Crustacean Biology* 5(3):377–385. Oxford University Press.
- Koeneman, T., and D. Buchanan. 1985. Growth of the golden king crab, *lithodes aequispina*, in southeast Alaskan waters. Pages 281–297 *in* B. Melteff, editor. *Proceedings of the international king crab symposium*. University of Alaska, Alaska Sea Grant, Anchorage, Alaska.
- Long, C., and S. Van Sant. 2016. Embryo development in golden king crab (*lithodes aequispinus*). *Fishery Bulletin* 114(1).
- Nizyaev, S. 2005. Biology of golden king crab (*lithodes aequispinus benedict*) along the islands of Kuril Ridge. Sakhalin Institute of Fishery and Oceanography Publication, Yuzhno-Sakhalinsk (in Russian).
- Olson, A., C. Siddon, and G. Eckert. 2018. Spatial variability in size at maturity of golden king crab (*lithodes aequispinus*) and implications for fisheries management. *Royal Society Open Science* 5(3):171802. The Royal Society Publishing.
- Paul, A., and J. Paul. 2001. Growth of juvenile golden king crabs *lithodes aequispinus* in the laboratory. *Alaska Fishery Research Bulletin* 8(2):135–135.
- Punt, A. E., D. S. Butterworth, C. L. de Moor, J. A. De Oliveira, and M. Haddon. 2016. Management strategy evaluation: Best practices. *Fish and Fisheries* 17(2):303–334. Wiley Online Library.
- Shirley, T. C., and Z. Shijie. 1997. Lecithotrophic development of the golden king crab *lithodes aequispinus* (Anomura: Lithodidae). *Journal of Crustacean Biology* 17(2):207–216. Oxford University Press.
- Siddeek, M., J. Zheng, C. Siddon, B. Daly, M. Westphal, and L. Hulbert. 2020. Chapter 8: Aleutian Islands golden king crab stock assessment. *In prep* 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.
- Sloan, N. 1985. Life history characteristics of fjord-dwelling golden king crabs *lithodes aequispina*. *Marine ecology progress series*. *Oldendorf* 22(3):219–228.
- Somerton, D. A., and R. Otto. 1986. Distribution and reproductive biology of the golden king crab, *lithodes aequispina*, in the eastern Bering Sea. *Fishery Bulletin* 84(3):571–584. The Service.
- Stratman, J. 2020. 2019 golden king crab stock status and management plan for the 2019/2020 season. Alaska Department of Fish and Game, Regional Information Report (1J20-11). Anchorage.
- Stratman, J., T. Bergmann, K. Wood, and A. Messmer. 2017. Annual management report for the 2016/2017 Southeast Alaska/Yakutat golden king crab fisheries. Alaska Department of Fish and Game, Fishery Management Report (17-57). Anchorage.

MANAGEMENT AREA REPORTS

Each management area report will provide an overview of seasonal trends in fishery performance through the most recent season. This includes comparing harvest (lbs) to corresponding GHs, logbook CPUE compared to reference points (i.e. target, trigger, and limit), reviewing Tanner crab harvest influence, and spatial distribution of incidental catch during the annual Tanner crab stock assessment survey in Holkham Bay. Confidential harvest and effort data have been excluded from figures if less than 3 permit holders participated in a given management area for a given year.

NORTHERN

Season Overview

The Northern management area was closed for the 2019 and 2020 seasons.

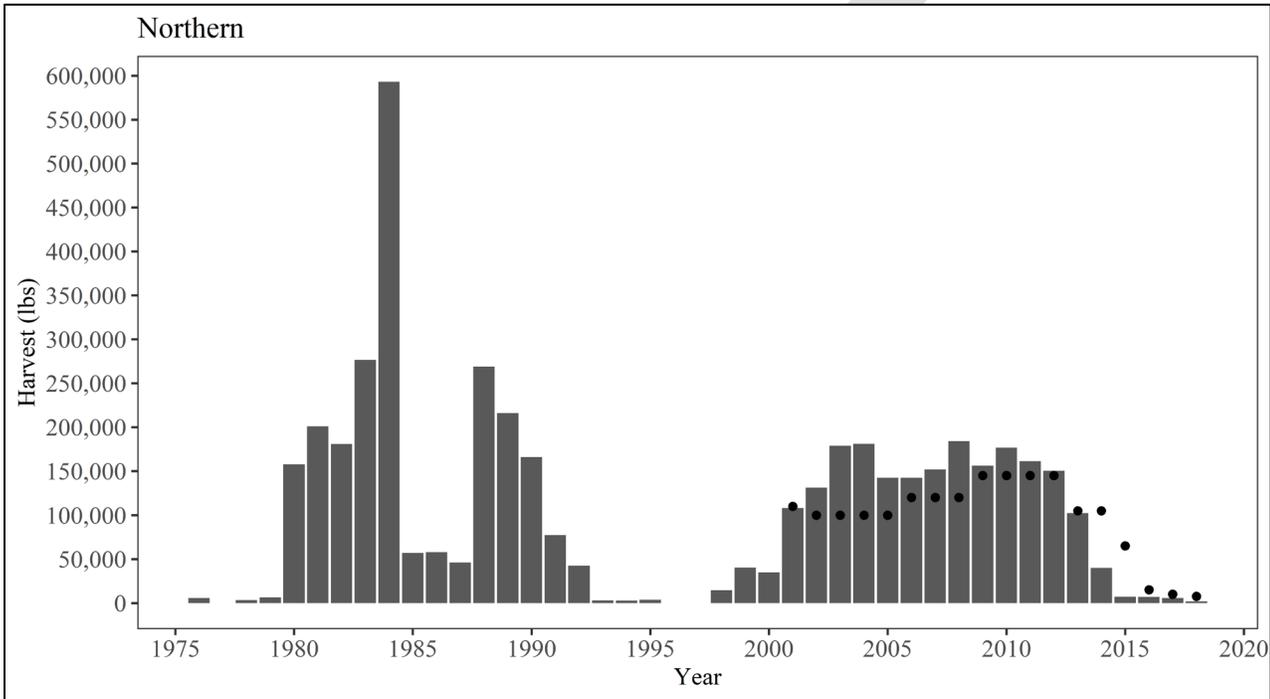


Figure 1.—Commercial GKC fishery harvest from the Northern management area. Dots represent the GH in a given year (2001–present).

Reference Points

Table 2.—Golden king crab logbook catch per unit of effort (CPUE) reference points.

Indicators	Reference Point	Description
Target Reference Point	2.7 crab/pot	Average Commercial Logbook CPUE from 2000–2017
Trigger Reference Point	2.0 crab/pot	75% of the Target Reference Point
Limit Reference Point	1.3 crab/pot	50% of the Target Reference Point

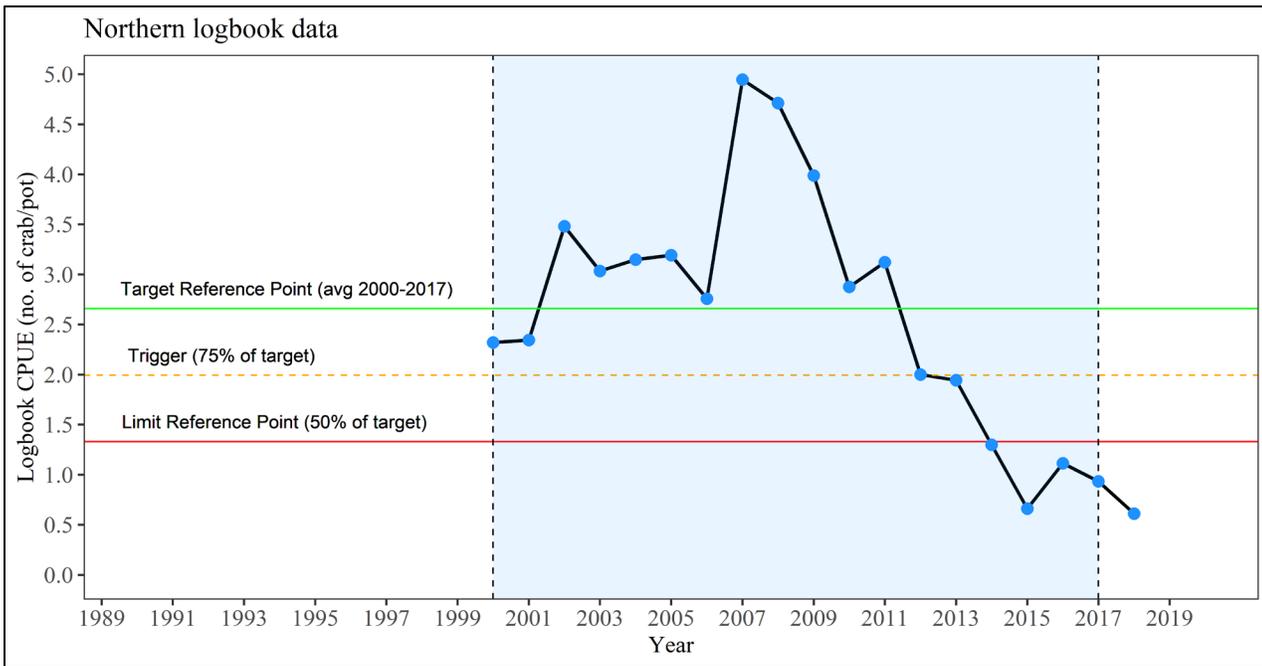


Figure 2.—Northern golden king crab reference points (Target, Trigger, and Limit) and fishery performance utilizing logbook CPUE.

ICY STRAIT

Season Overview

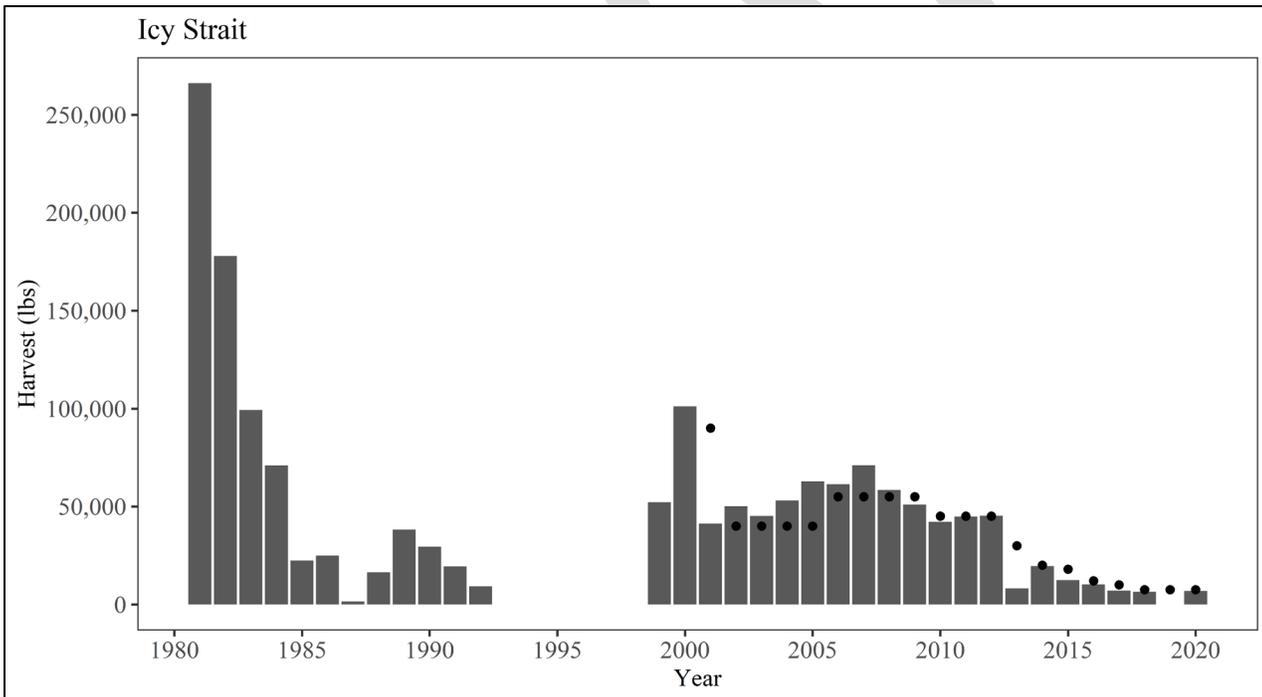


Figure 3.—Commercial GKC fishery harvest from the Icy Strait management area. Dots represent the GHL in a given year (2001–Present).

Reference Points

Table 3.– Golden king crab logbook catch per unit of effort (CPUE) reference points.

Indicators	Reference Point	Description
Target Reference Point	2.2 crab/pot	Average Commercial Logbook CPUE from 2000–2017
Trigger Reference Point	1.6 crab/pot	75% of the Target Reference Point
Limit Reference Point	1.1 crab/pot	50% of the Target Reference Point

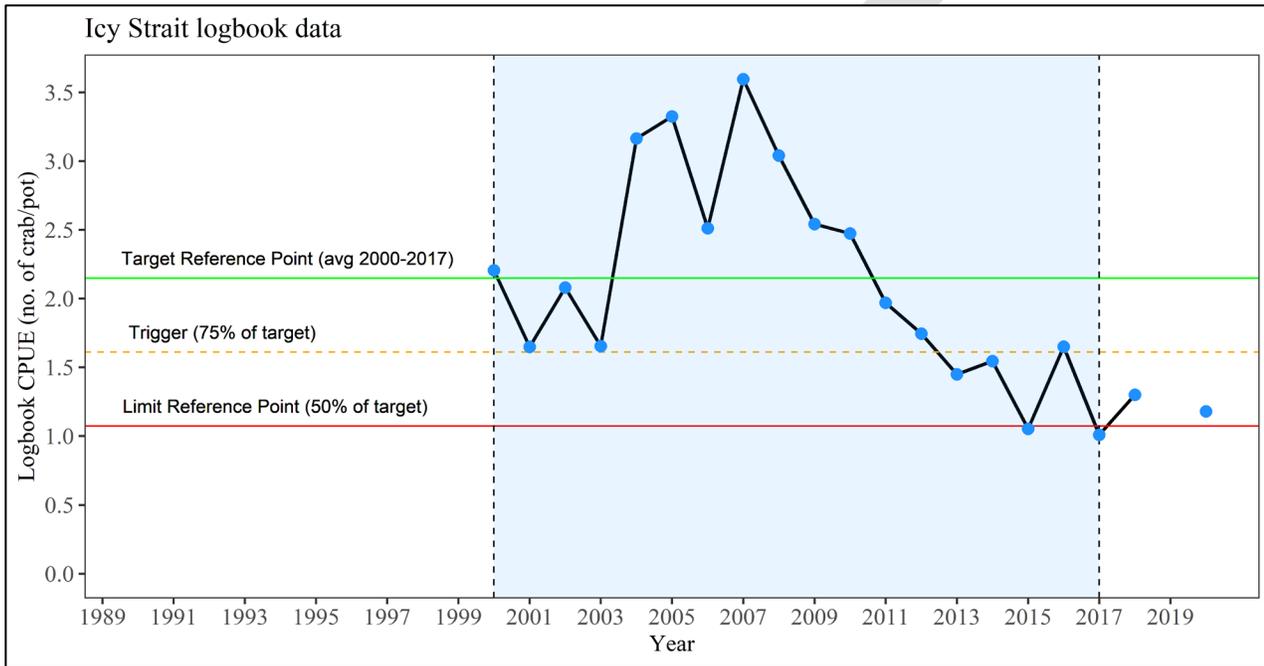


Figure 4.–Icy Strait golden king crab reference points (Target, Trigger, and Limit) and fishery performance utilizing logbook CPUE.

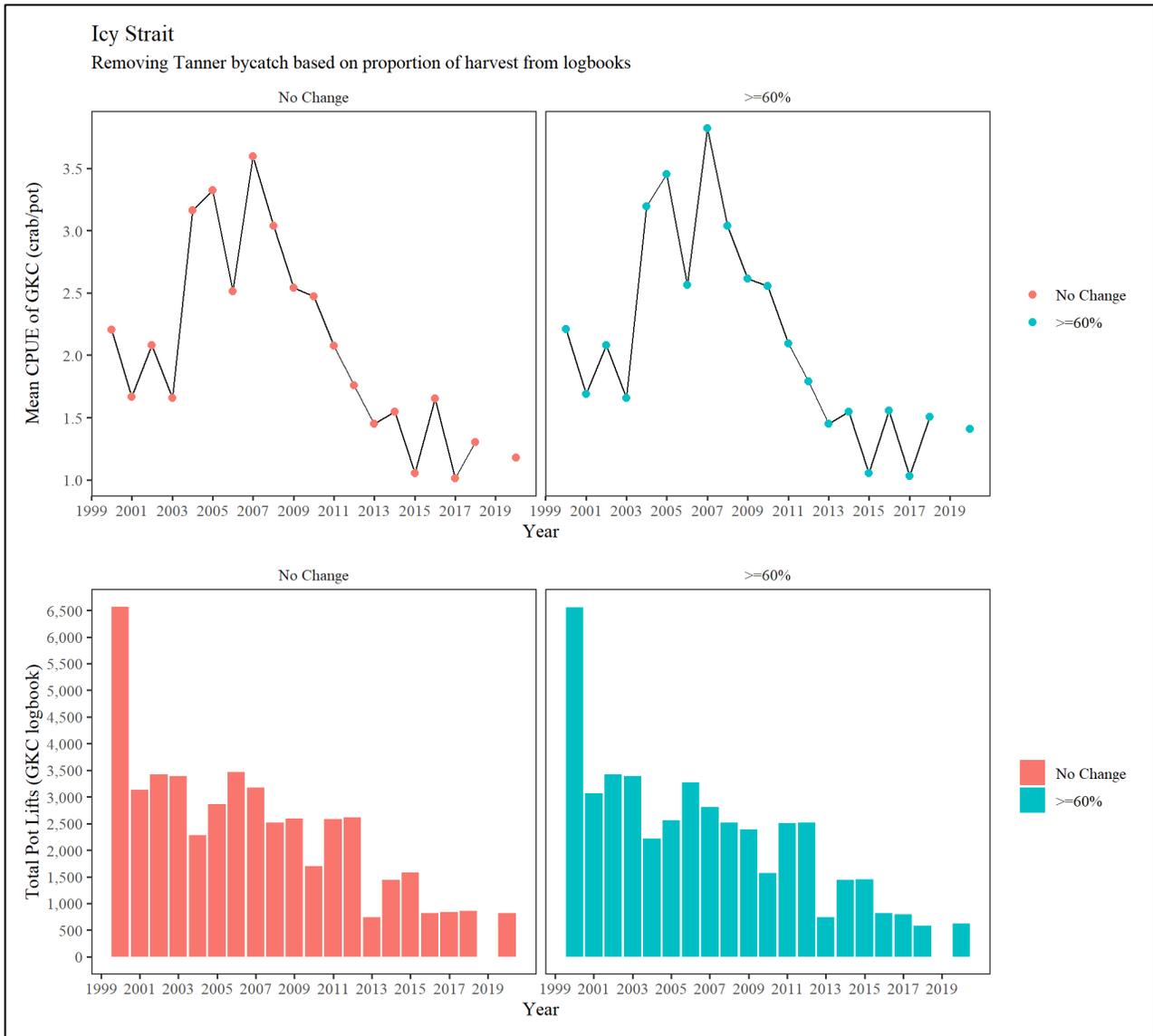


Figure 5.—Icy Strait golden king crab logbook CPUE and pot lift proportions based on reduction of Tanner crab harvest influence.

NORTH STEPHENS PASSAGE

Season Overview

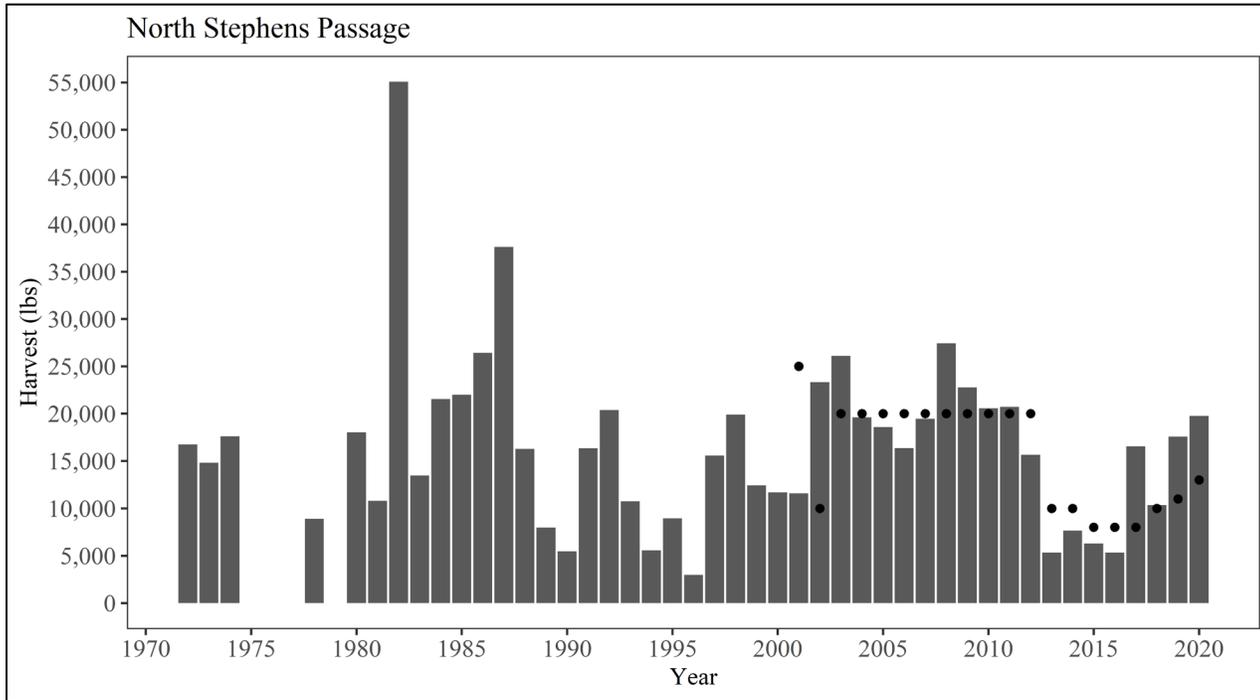


Figure 6.—Commercial GKC fishery harvest from the North Stephens Passage management area. Dots represent the GHL in a given year (2001–Present).

Reference Points

Table 4.—Golden king crab logbook catch per unit of effort (CPUE) reference points.

Indicators	Reference Point	Description
Target Reference Point	1.6 crab/pot	Average Commercial Logbook CPUE from 2001–2017 (excluding 2000)
Trigger Reference Point	1.2 crab/pot	75% of the Target Reference Point
Limit Reference Point	0.8 crab/pot	50% of the Target Reference Point

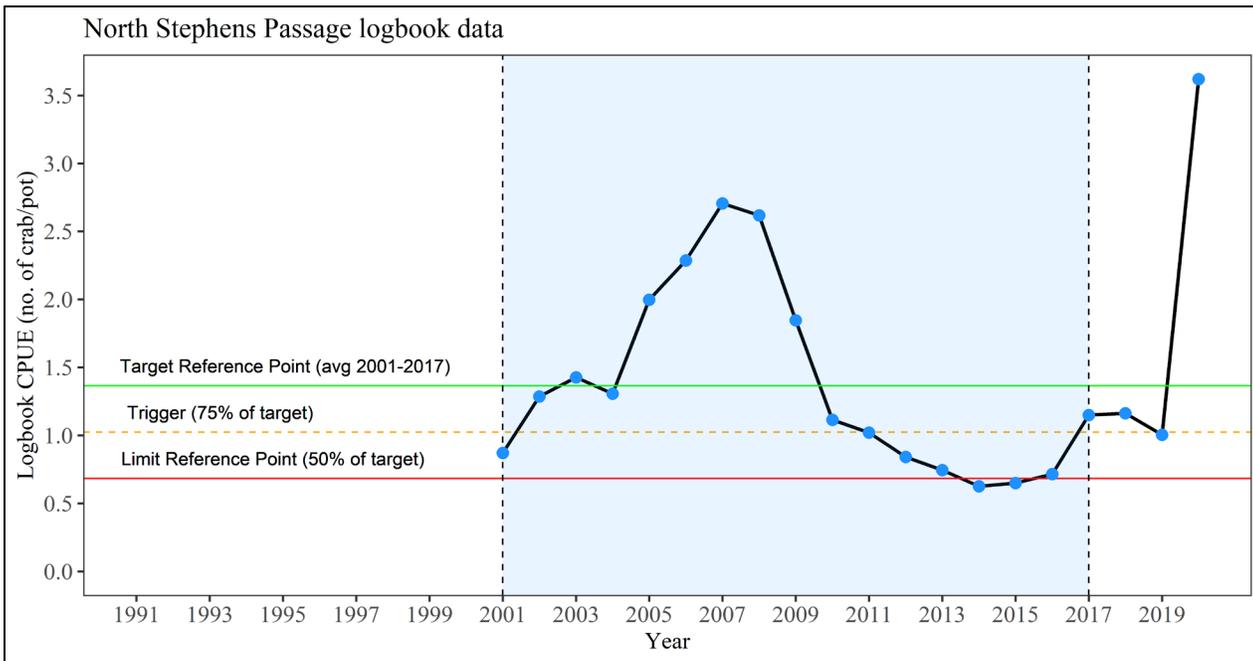


Figure 7.—North Stephens Passage golden king crab reference points (Target, Trigger, and Limit) and fishery performance utilizing logbook CPUE.

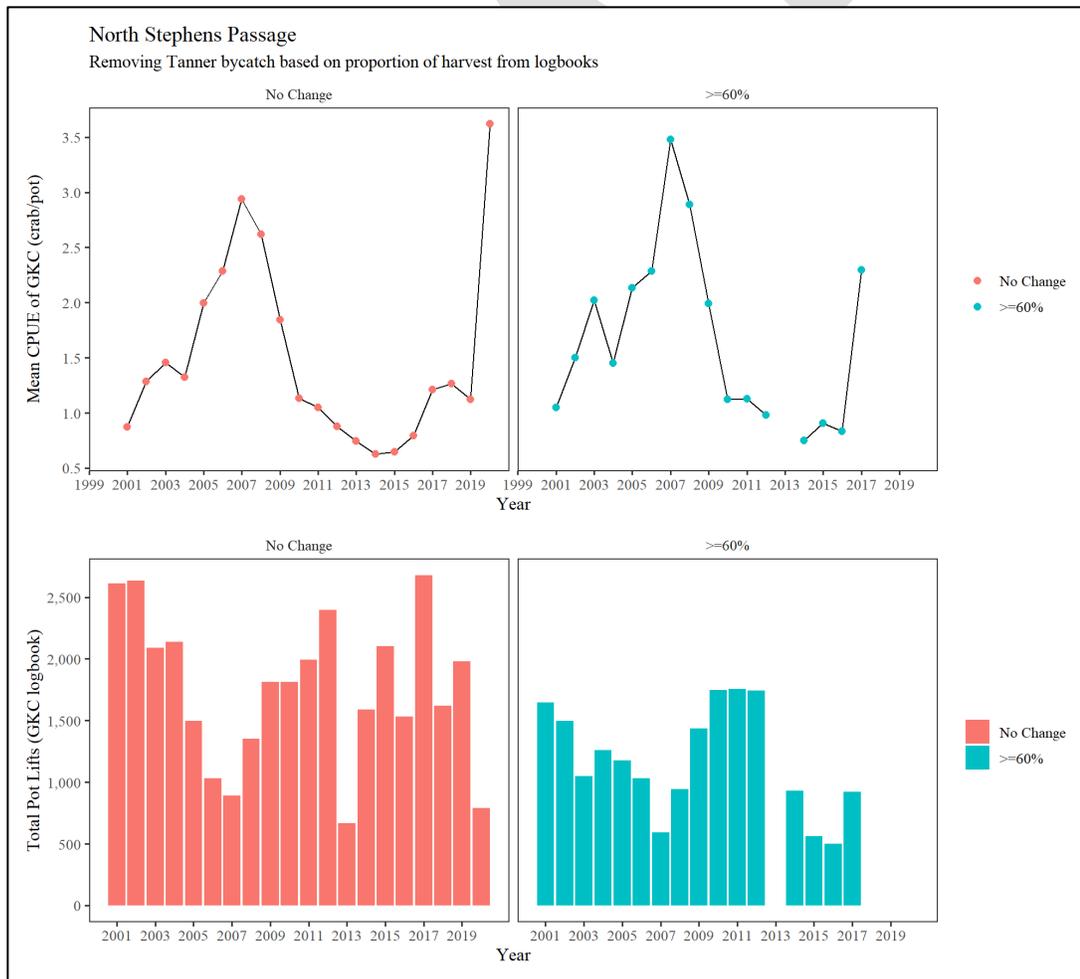


Figure 8.—North Stephens Passage golden king crab logbook CPUE and pot lift proportions based on reduction of Tanner crab harvest influence.

Information from Annual Tanner Crab Stock Assessment Survey

The Department conducts an annual stock assessment survey in Holkham Bay where GKC have been caught incidentally. Data presented here includes spatial distribution and quantity of catch and by sex and recruit status.

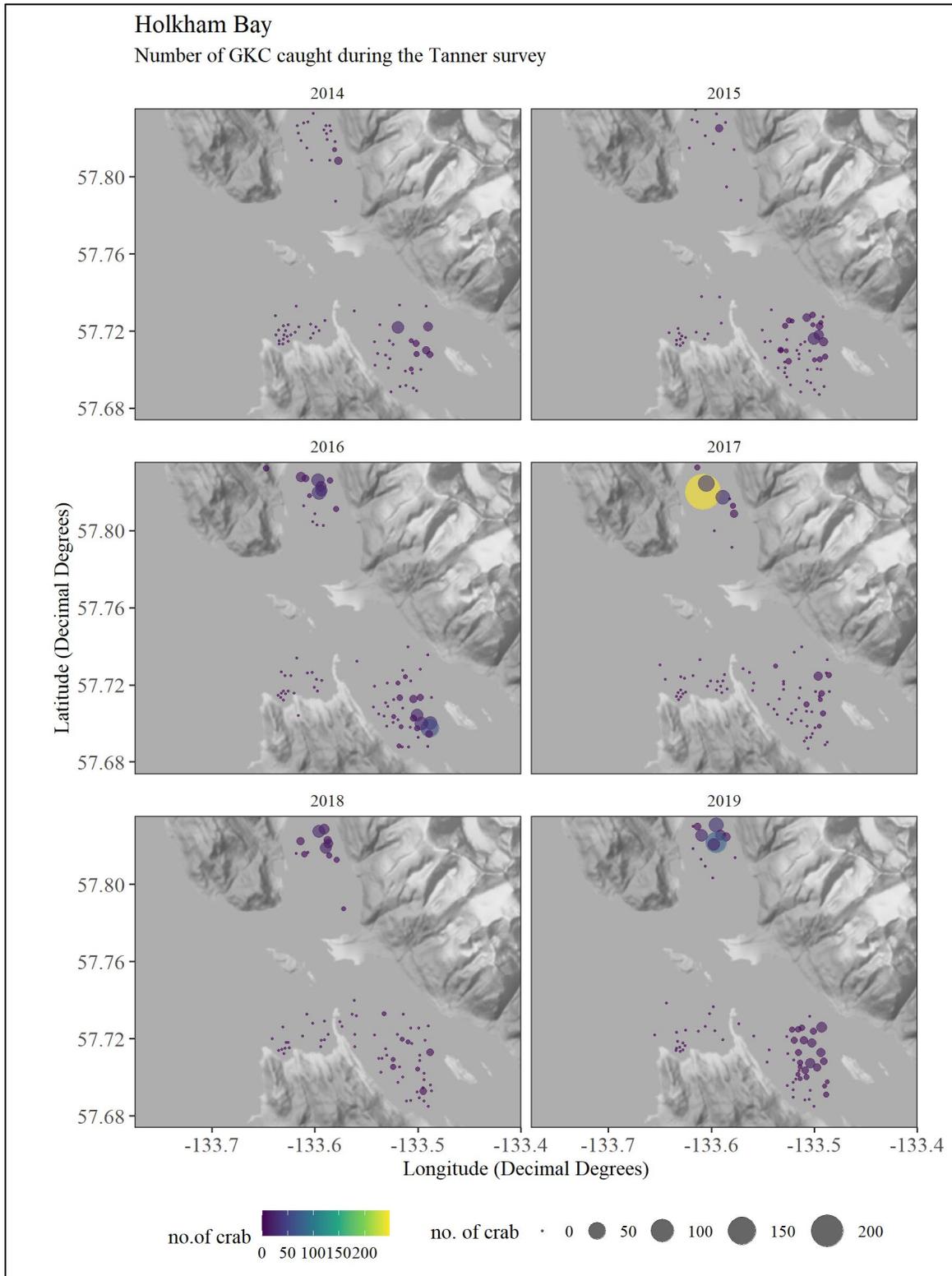


Figure 9.—Number of golden king crab caught during the annual Tanner crab stock assessment survey in Holkham Bay (2014–2019).

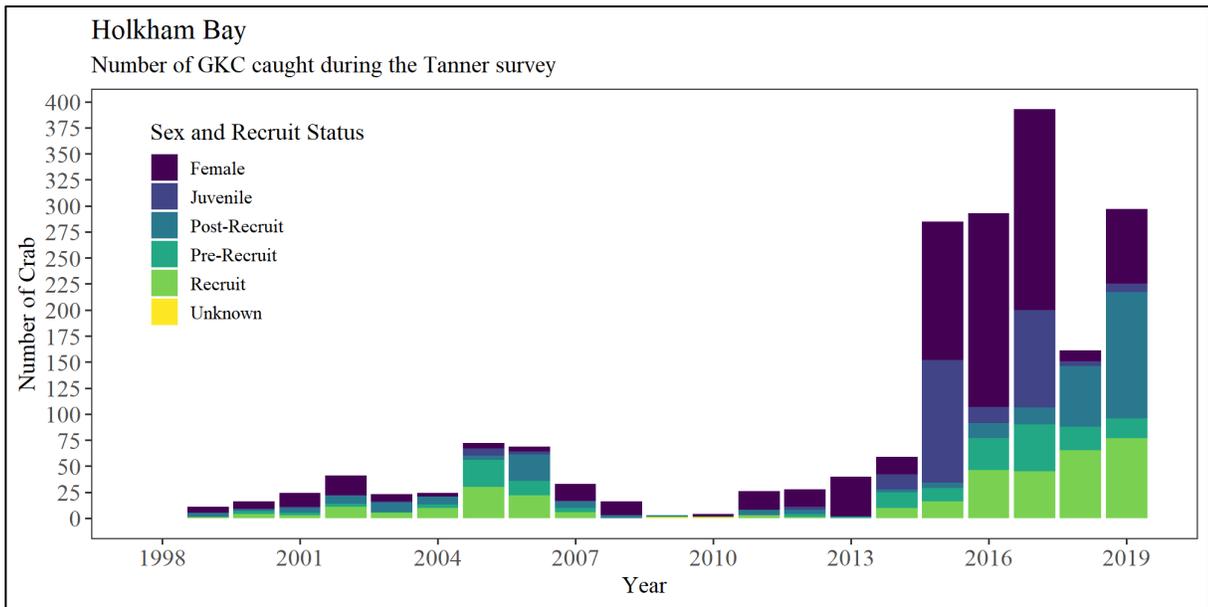


Figure 10.—Number of golden king crab caught during the annual Tanner crab stock assessment survey in Holkham Bay by sex and recruit status (1999-2019).

EAST CENTRAL

Season Overview

The East Central management area was closed for the 2018 and 2020 seasons.

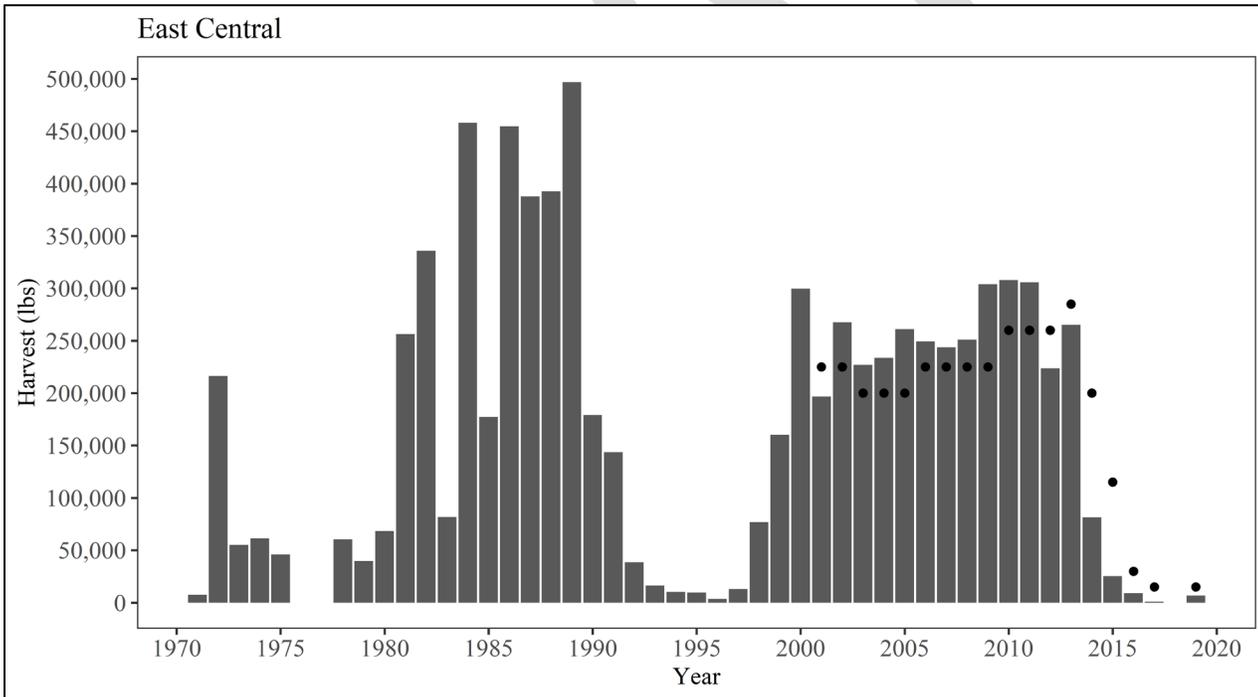


Figure 11.—Commercial GKC fishery harvest from the East Central management area. Dots represent the GHL in a given year (2001–Present).

Reference Points

Table 5.—Golden king crab logbook catch per unit of effort (CPUE) reference points.

Indicators	Reference Point	Description
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Target Reference Point	3.4 crab/pot	Average Commercial Logbook CPUE from 2000–2017
Trigger Reference Point	2.5 crab/pot	75% of the Target Reference Point
Limit Reference Point	1.7 crab/pot	50% of the Target Reference Point

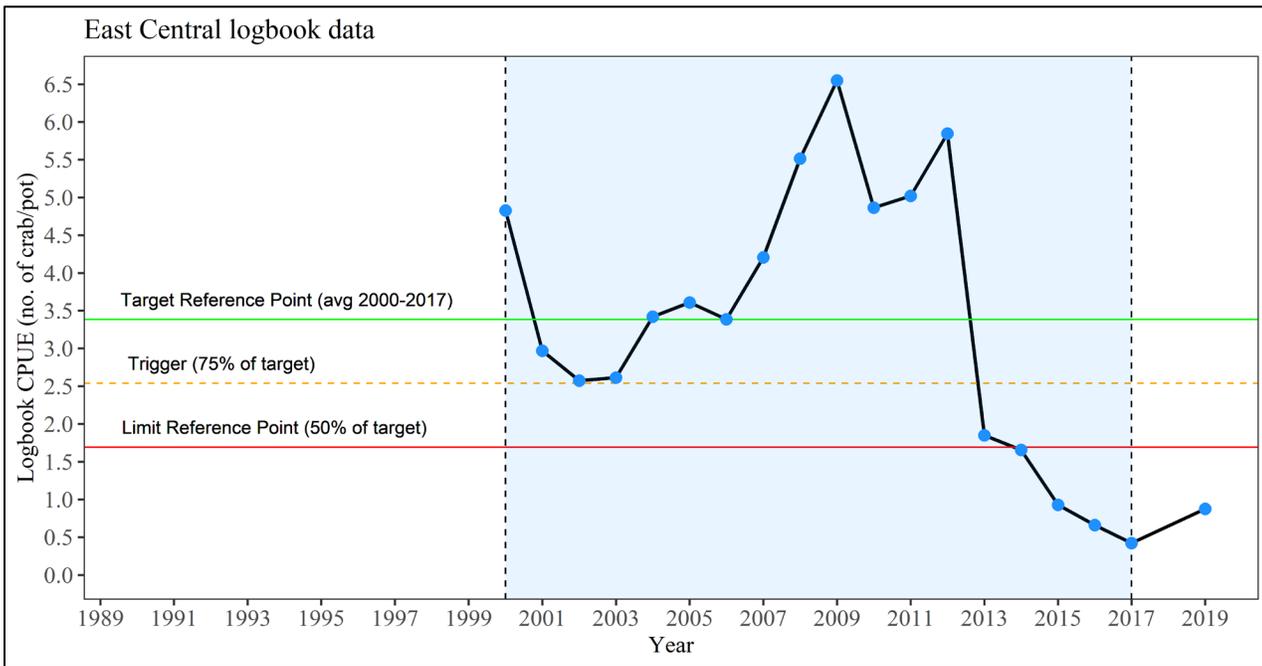


Figure 12.—East Central golden king crab reference points (Target, Trigger, and Limit) and fishery performance utilizing logbook CPUE.

MID-CHATHAM STRAIT

Season Overview

The Mid-Chatham Strait management area was closed for the 2020 season.

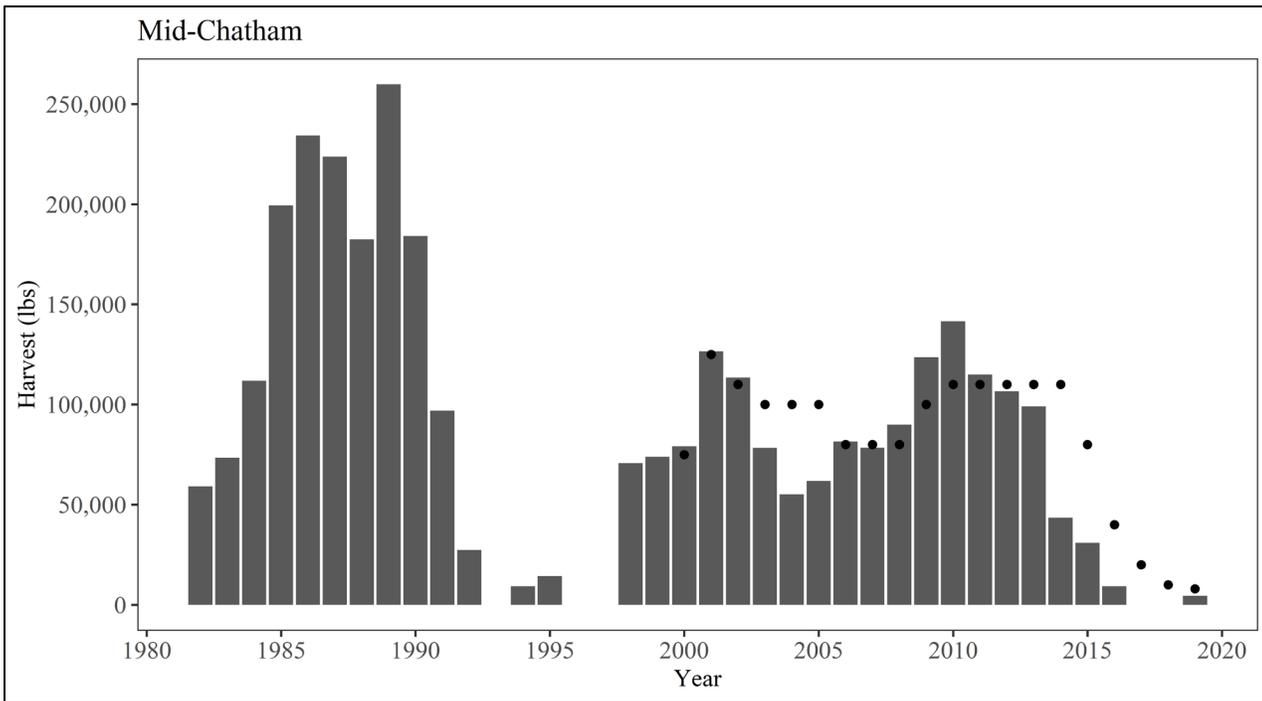


Figure 13.—Commercial GKC fishery harvest from the Mid-Chatham Strait management area. Dots represent the GKL in a given year (2001–Present).

Reference Points

Table 6.—Golden king crab logbook catch per unit of effort (CPUE) reference points.

Indicators	Reference Point	Description
Target Reference Point	3.4 crab/pot	Average Commercial Logbook CPUE from 2000–2017
Trigger Reference Point	2.5 crab/pot	75% of the Target Reference Point
Limit Reference Point	1.7 crab/pot	50% of the Target Reference Point

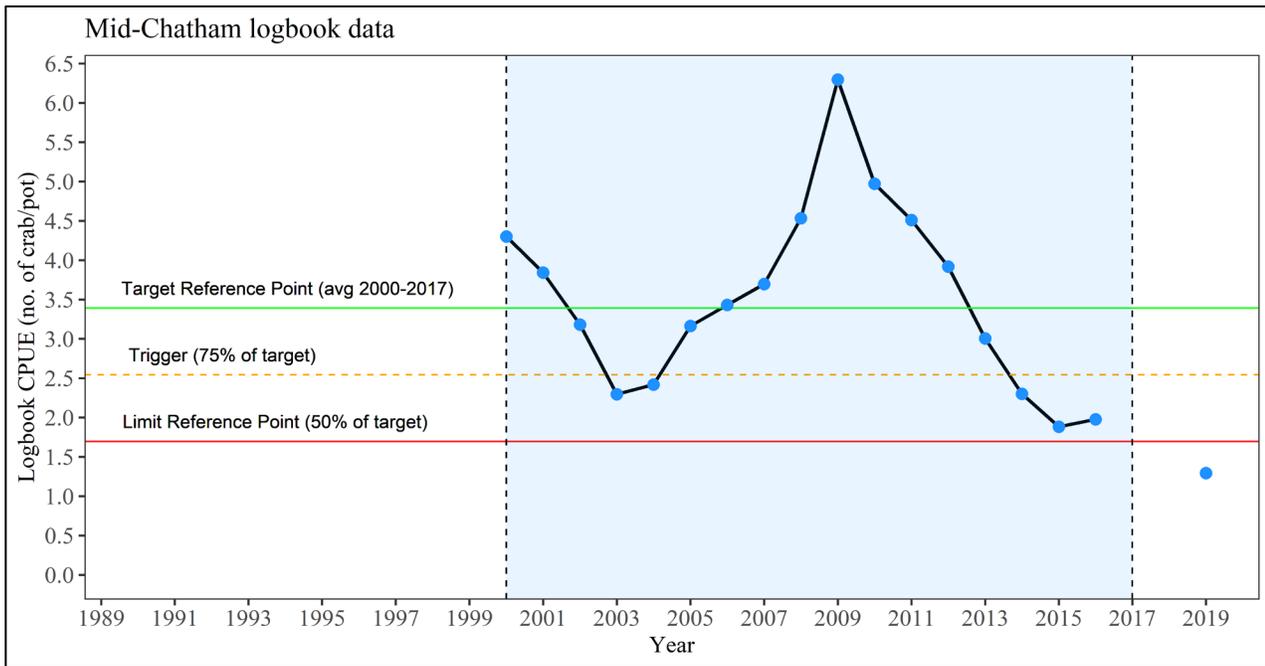


Figure 14.—Mid-Chatham Strait golden king crab reference points (Target, Trigger, and Limit) and fishery performance utilizing logbook CPUE.

LOWER CHATHAM STRAIT

Season Overview

The Lower Chatham Strait management area was closed for the 2020 season.

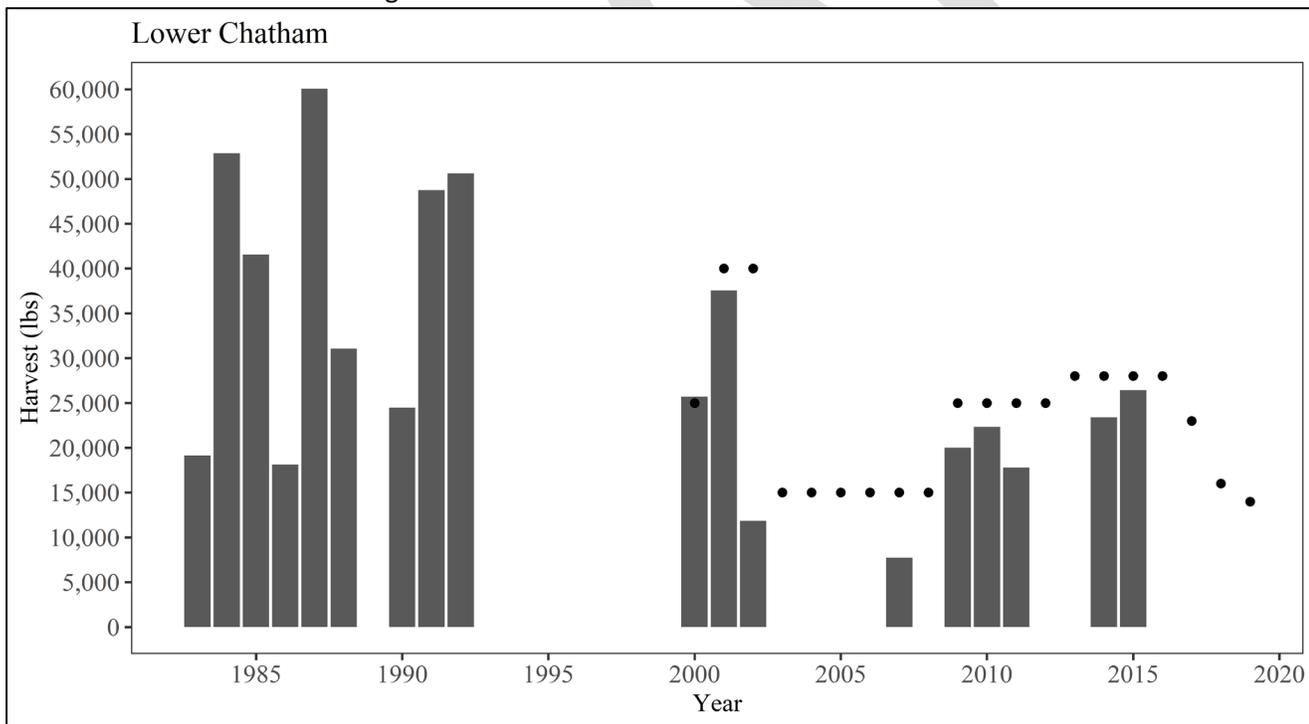


Figure 15.—Commercial GKC fishery harvest from the Lower Chatham Strait management area. Dots represent the GHL in a given year (2001–Present).

Reference Points

Table 7.—Golden King Crab logbook catch per unit of effort (CPUE) reference points.

Indicators	Reference Point	Description
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Target Reference Point	3.1 crab/pot	Average Commercial Logbook CPUE from 2000–2017 (excluding 2013)
Trigger Reference Point	2.3 crab/pot	75% of the Target Reference Point
Limit Reference Point	1.6 crab/pot	50% of the Target Reference Point

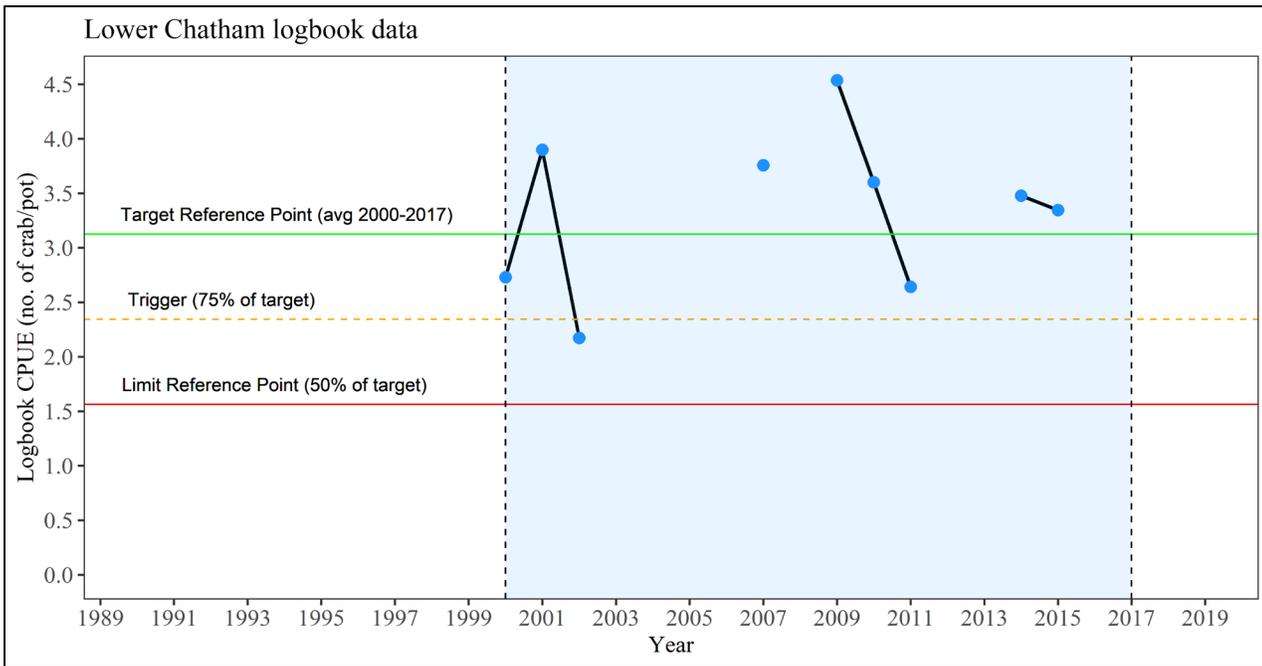


Figure 16.—Lower Chatham Strait golden king crab reference points (Target, Trigger, and Limit) and fishery performance utilizing logbook CPUE.

SOUTHERN

Season Overview

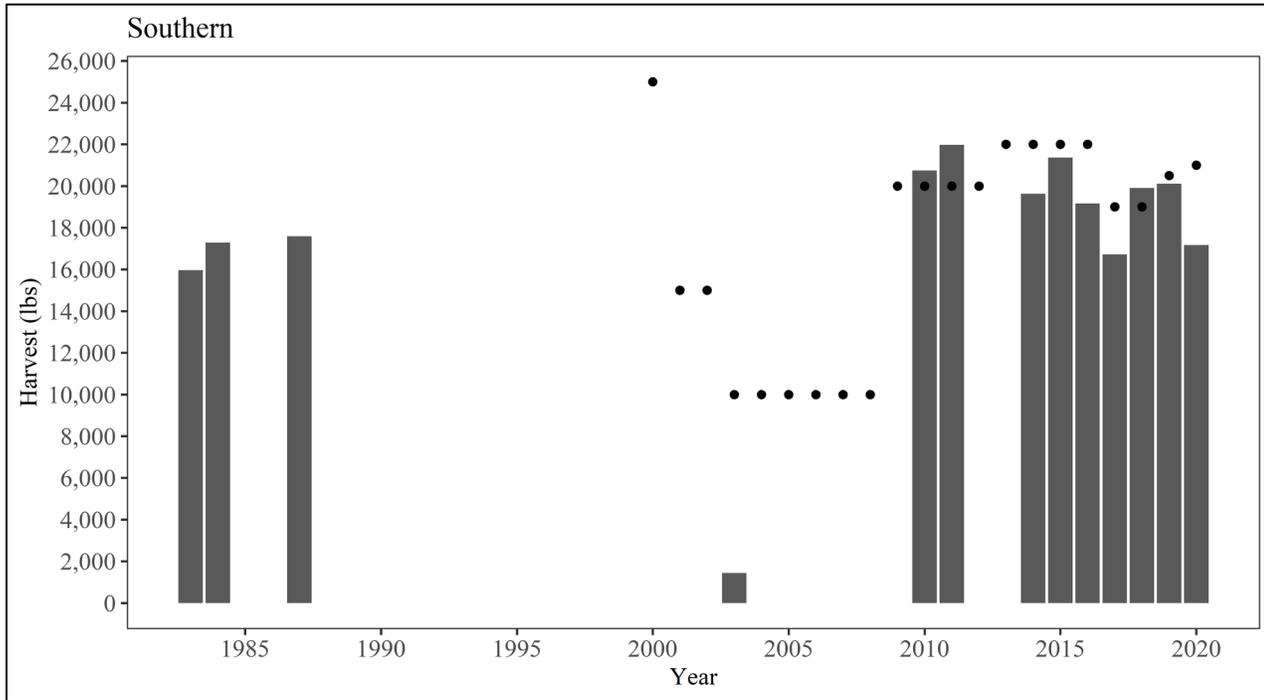


Figure 17.—Commercial GKC fishery harvest from the Southern management area. Dots represent the GKL in a given year (2001–Present).

Reference Points

Table 8.—Golden king crab logbook catch per unit of effort (CPUE) reference points.

Indicators	Reference Point	Description
Target Reference Point	4.1 crab/pot	Average Commercial Logbook CPUE from 2000-2017
Trigger Reference Point	3.1 crab/pot	75% of the Target Reference Point
Limit Reference Point	2.0 crab/pot	50% of the Target Reference Point

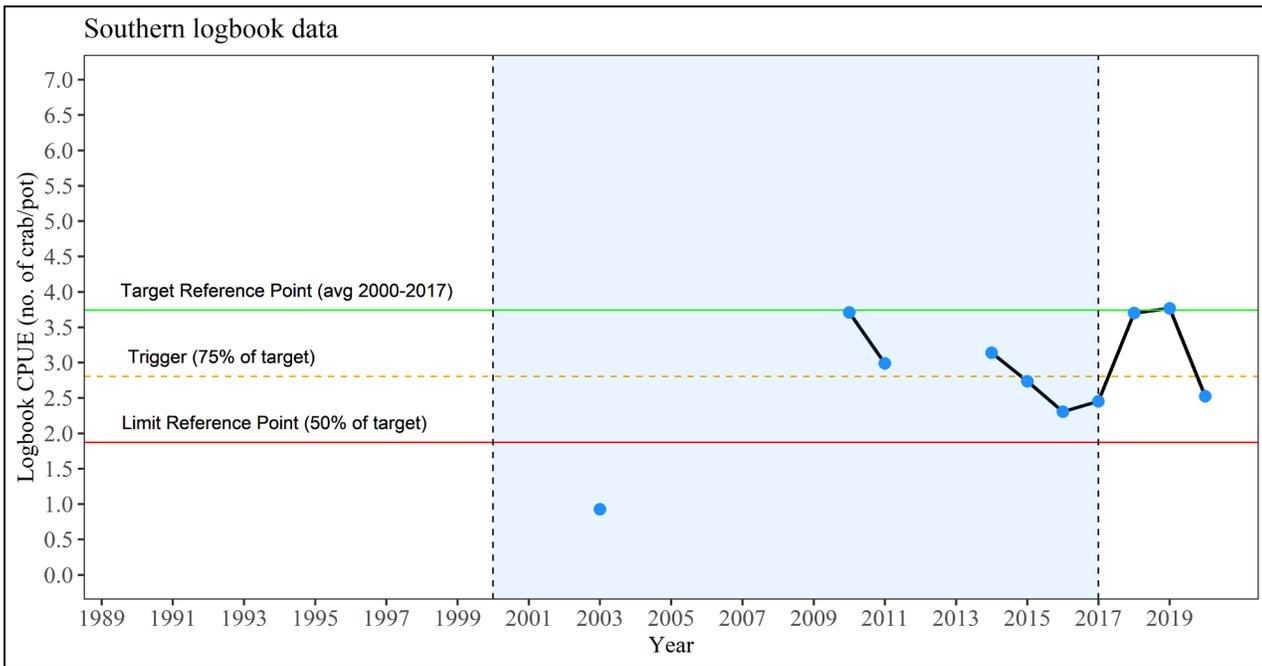


Figure 18.—Southern golden king crab reference points (Target, Trigger, and Limit) and fishery performance utilizing logbook CPUE.

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