Fisheries and Oceans Canada
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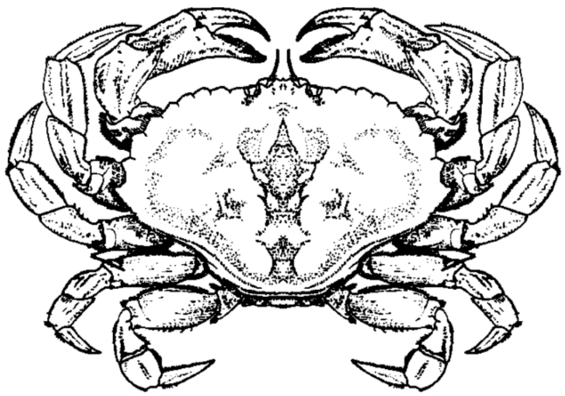
Canadian Science Advisory Secretariat
Gulf Region **Science Advisory Report 2025/018**

SOUTHERN GULF OF ST. LAWRENCE ROCK CRAB (*CANCER IRRORATUS*) STOCK REVIEW TO 2023 (LFAs 23, 24, 25, 26A, 26B)



*Atlantic rock crab (*Cancer irroratus*)*
Source: Fisheries and Oceans Canada

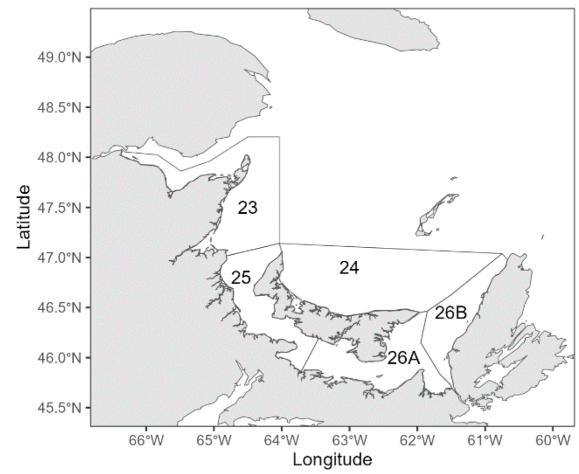


Figure 1. Map of the southern Gulf of St. Lawrence including the management areas for rock crab.

CONTEXT

The rock crab fishery in the southern Gulf of St. Lawrence (sGSL) originated in the 1960s as incidental bycatch in the lobster fishery. A small-scale directed exploratory fishery was initiated in 1974 and expanded in the 1980s as licences were issued in each of the five management areas: Lobster Fishing Areas (LFAs) 23, 24, 25, 26A, 26B. The most recent assessment, conducted in 2013, fell short of a formal stock assessment due to data limitations. Updates on fishery status indicators were conducted in 2017, 2019, and 2022, offering insight into key data sources for Fisheries Management.

This Science Advisory Report presents the results of the November 13-14, 2024, regional peer review on Southern Gulf of St. Lawrence Rock Crab (*Cancer irroratus*) Stock Review to 2023. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available. The objectives of this meeting were to update fisheries datasets, explore available data sources, and identify potential indices suitable for setting a Limit Reference Point (LRP) as required by the Fishery Decision-Making Framework outlined in Canada's Sustainable Fisheries Framework and the Fisheries Act s.6.2(1).

SUMMARY

- Rock crab landings in the southern Gulf of St. Lawrence (sGSL) from the directed fishery remained stable around 4,500 t from 2000 to 2011 but have decreased steadily, reaching approximately 1,500 t in 2023. Current levels are at time-series lows. Concurrently, the

annual number of fishing trips has been decreasing, from a maximum of 5,401 in 2001 to 1,660 in 2023.

- The proportion of rock crab licenses that are active has also declined, now at about 50% across all LFAs, with only 10% of active license holders reaching their personal allotments – an all-time low.
- The rock crab fishing effort is concentrated within the Northumberland Strait, with LFAs 25 and 26A accounting for an average of 74.8% of total directed landings in 2023.
- While bycatch sales have dropped to negligible levels, the extent to which rock crabs are used as bait by the lobster fishery remains unknown. A recent bycatch study found that male rock crabs are the most common non-target species caught in the lobster fishery.
- Standardized catch per unit effort ($CPUE_{std}$) indices for the primary LFAs rose initially, before stabilizing for a period (2003 – 2020), followed by a decline. This decline began earlier in LFA 26A (2015).
- A reduction in the size distribution of landed crabs within the fishing season can be an indication of fishery induced depletion. Size frequency distributions show no consistent trend of size reductions during the fishing season, except for LFA 26A which saw a small but significant decrease in size (less than 1%) on average over the course of a season.
- In locations where bio-collectors consistently catch rock crab, juvenile density has decreased, in some cases by more than 50% relative to levels a decade earlier.
- $CPUE_{std}$ provides the most comprehensive index for setting an LRP. With relatively stable landings and $CPUE_{std}$ between 2004 and 2011, the mean $CPUE_{std}$ during this period (12.56 kg/trap) represents a proxy of CPUE at Maximum Sustainable Yield ($CPUE_{MSY}$).
- In keeping with the recommendations of the Precautionary Approach, setting the LRP at 40% of MSY, or a proxy thereof, results in an LRP at a $CPUE_{std}$ level of 5.02 (kg/trap). Current $CPUE_{std}$ levels (7.38 kg/trap) are above this proposed LRP. Following the recommendations of the PA, 80% MSY would yield an USR of 10.05 (kg/trap) which would place this stock in the Cautious zone.
- Caution is warranted when using CPUE to identify stock status and any indications of hyperstability in the future should be carefully reviewed. Recognizing this caveat, data gaps, and latent fishing effort, the management of this stock should err on the cautious side.

INTRODUCTION

The rock crab (*Cancer irroratus*) is a decapod crustacean found along the North American continental shelf and slope waters of the Atlantic coast, from South Carolina and Florida northward to Newfoundland and Labrador (Williams 1965). In the southern Gulf of St. Lawrence (sGSL), rock crabs are typically found at shallower depths ranging from 10 to 40 m. They are an important prey species for key benthic predators, including lobsters and large benthic fish such as Atlantic cod, rays, and skates (Hanson 2009; Hanson et al. 2014). Males mature at a larger size than females, with male crabs reaching maturity by 49 mm carapace width (CW) and almost all male crabs are mature by 73 mm CW (Rondeau et al. 2014), at an age of 3 – 4 years. Females mature with a smaller carapace width of 57 mm (DFO 2013a). Mature females can produce a large number of eggs (up to 330,000 at only 80 mm in size, Squires 1990) and all female rock crabs are protected from harvesting. Male rock crabs in the sGSL reach commercial size (102 – 108 mm) in about six years (DFO 2013a).

The rock crab fishery in the sGSL comprises two main components: a directed fishery conducted during the rock crab fishing season by rock crab licence holders, and incidental bycatch of rock crab during the lobster fishing season by lobster licence holders. The directed fishery operates during the summer and fall months throughout the sGSL, although the fishery has not operated in LFA 26B (Figure 1) since 2011 due to low catches.

The directed fishery is managed based on lobster fishing areas (LFAs; Figure 1), primarily using input controls including limits on the number of licences, individual trap allocations, gear restrictions, defined seasons, minimum legal sizes, and a prohibition on harvesting females. Output controls are also applied in the form of individual allocations. All landings from the directed fishery are subject to a dockside monitoring program and rock crab licence holders are required to complete logbooks.

There are fewer management measures on rock crab caught as bycatch by lobster harvesters. Rock crab bycatch is only permitted during the lobster fishing season and only males may be used as bait or landed. Since 2021, a condition of lobster licences in the sGSL has placed a size limit on rock crab used as bait (102 mm). There are currently no reporting requirements for the bycatch fishery but rock crab that is sold through licenced buyers is recorded in landing slips.

ANALYSIS

Fishery Landings

Prior to 2000, rock crab landings were not categorised by type of fishery. Since then, landings have been attributed to either the directed fishery, conducted by rock crab licence holders during the rock crab fishing season or as bycatch, landed by lobster licence holders during the lobster fishing season.

Total annual landings were initially stable at around 500 tonnes (t) between 1966 and 1982 (Figure 2), increasing to around 1,000 t between 1983 and 1992. Landings then increased steadily to around 4,200 t between 2000 and 2011. Since then, total landings have steadily declined and are currently around 1,500 t. Landings from the bycatch fishery peaked in the early 2000s, shortly after landings began being classified by fishery, and have since declined annually to their current level of <0.01 t per year.

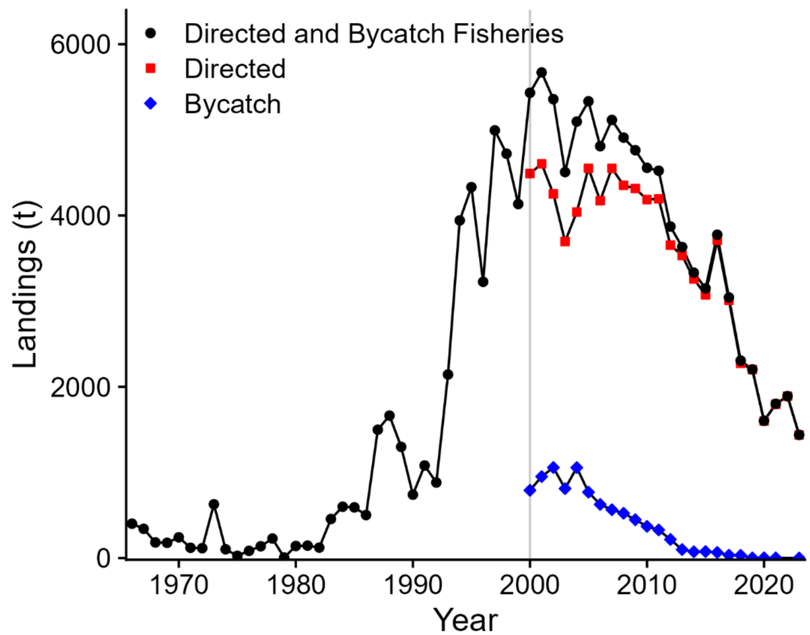


Figure 2. Landings of rock crab in the southern Gulf of St. Lawrence from 1966 - 2023. The vertical grey line marks the point from which the landings began to be classified into the directed or bycatch fisheries.

Within the directed fishery, most landings come from the two Northumberland Strait LFAs: 25 and 26A (Figure 3). Landings in LFA 26B have been minimal throughout the history of the fishery and fishing in this LFA ceased completely in 2014. Landings in the four main LFAs have declined by an average of 3-5% per year since ~2010.

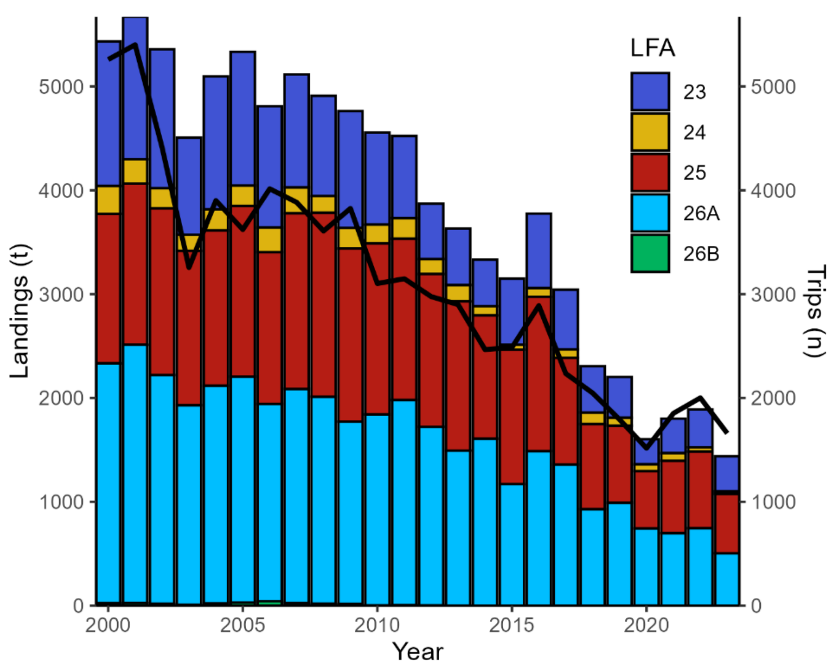


Figure 3. Annual landings (tonnes) from the directed fishery partitioned by LFA. The line represents the total number of trips each year by licenced rock crab harvesters.

Participation in the Fishery

Along with the decline in landings, the rock crab fishery in the sGSL has also seen a decline in the proportion of licence holders actively fishing and the number of harvesters achieving their individual allocation (Figure 4). Currently, only about half of the licences issued each year for a given LFA are active, while the proportion of those active harvesters achieving their allocations (landing ≥90% of their individual allocation) averages at about 10% overall, an all-time low for this fishery.

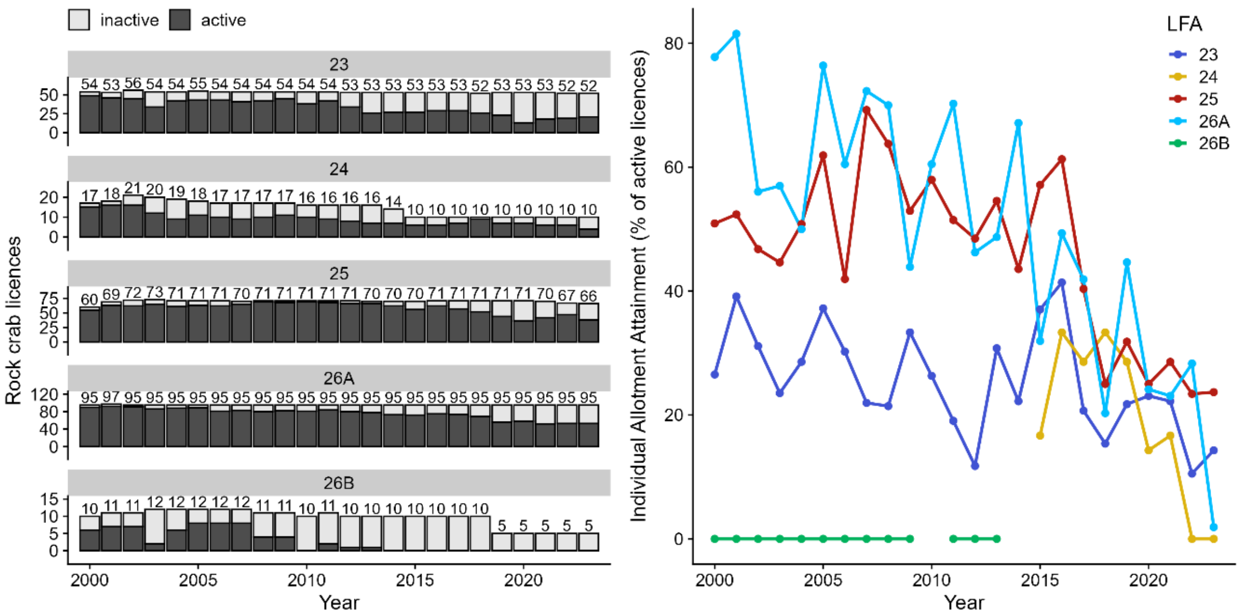


Figure 4. The number of rock crab licence holders per LFA (left), with dark bars indicating active licences, and the percentage of active licence holders achieving their individual allocation per year and LFA (right).

Index of Abundance: Catch Limit Rate

Despite the consistent long-term decline in landings, a time-to-event analysis of the number of fishing days required to land an arbitrary total catch limit of 9,000 kg, the catch time rate, showed varying trends across the main LFAs. In LFA 23, the mean number of days required to land the catch limit initially decreased by ~30%, from 12 days in 2000 to ~8 days in 2003 where it remained stable until its lowest value of 6 days in 2020 (Figure 5). Since then, there has been a steady increase, with harvesters requiring 10 days in 2023. LFA 24 exhibits the slowest times, with 16 days required in 2000. This catch limit rate decreased to a stable level of ~7 days between 2004 and 2011 but has since increasing by over 200%, reaching its peak of 37 days in 2023. It is worth noting that estimates for LFA 24 it was not possible to produce an estimate for each year due to the low number of events (harvesters landing the catch limit of 9,000 kg). In LFA 25, the number of days required was ~8 in 2000, followed by a gradual decrease to a time series low of ~6 days in 2012. Since then, times have steadily risen back to ~8 days, matching the levels observed at the start of the time series. Finally, in LFA 26A, the time required to land the catch limit remained stable at ~7 days between 2000 and 2015. Afterward, the time began to increase steadily, reaching 13 days in 2023 - nearly double the initial times observed in this LFA.

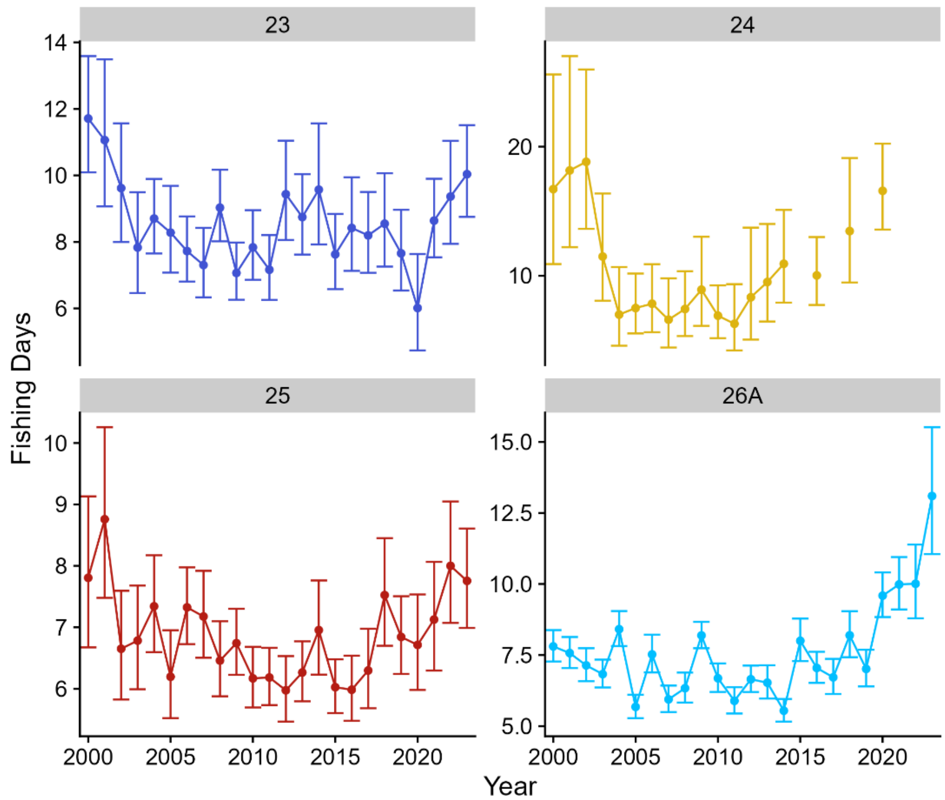


Figure 5. Estimated mean number of fishing days required per season for harvesters to cumulatively land 9,000 kg of rock crab.

Index of Abundance: Standardised CPUE

Standardised CPUE values ($CPUE_{std}$) from the four main fishing areas were calculated using landings and effort values from sales slips and harvester logbooks respectively. Potential errors were first removed based on raw CPUE values (landings/traps x soak time) by excluding records with the lowest and highest 2.5% raw CPUE values. Catches were then modelled using a separate generalized additive model (GAM) for each LFA.

As with the catch limit index above but flipped due to the nature of the units in question, the $CPUE_{std}$ index tended to indicate an initial increase early in the timeseries followed by a stable period of 10 to 15 years followed by a decreasing trend (Figure 6). Overall, the highest $CPUE_{std}$ levels are observed in LFAs 25 and 26A, while the lowest levels are observed in LFA 24. A downward trend was observed over the last 4 – 5 years in LFAs 23, 25 and 26, although because of the increases observed initially in the timeseries, the confidence intervals around the most recent estimates overlap those earlier estimates, except in LFA 26A.

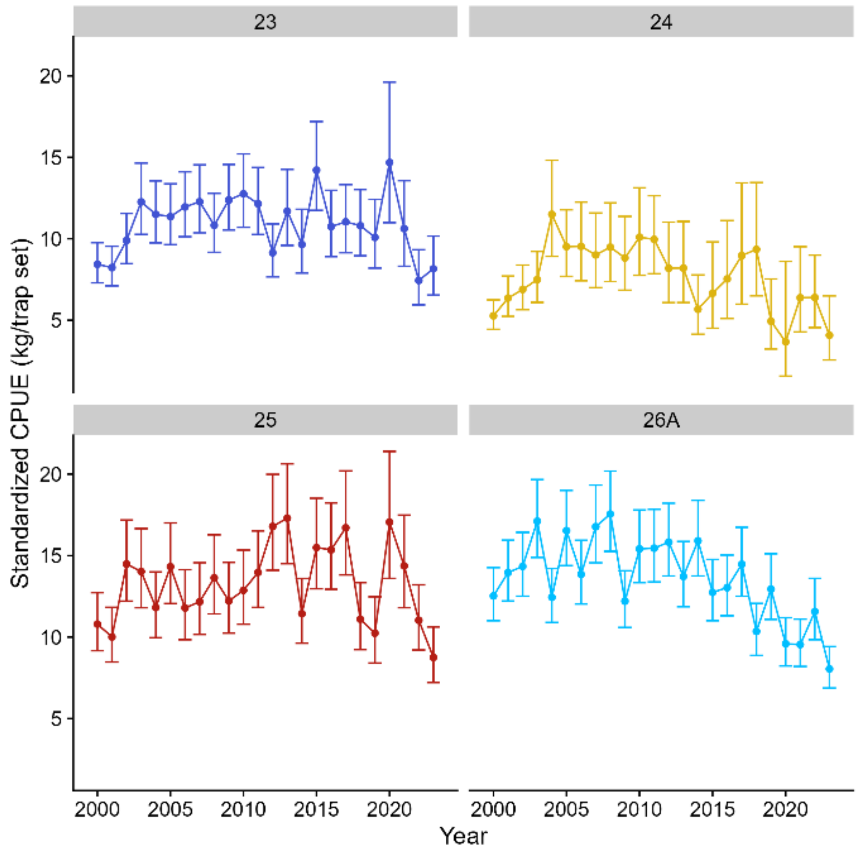


Figure 6. CPUE estimates for each of the four main LFAs within the sGSL, corrected to a standard commercial trap set for 24 hours on the eighth day of the fishing season.

To scale CPUE up to the entire sGSL, a predict-then-aggregate method was used (Hoyle et al. 2024). Area-weighted average CPUE for the entire sGSL was calculated from the LFA specific CPUE estimates according to the total area within each LFA within the optimal depth range for rock crab (10 – 40 m, Rondeau et al. 2014, Figure 7, left). Confidence intervals were produced via bootstrapping. The resulting trend (Figure 7, Right) indicates an initial increase by 30% over the first 3 years from its initial level of ~9 kg/trap to a new level near 12 kg/trap where it remained for 11 years before gradually decreasing to current levels of 7.38 kg/trap.

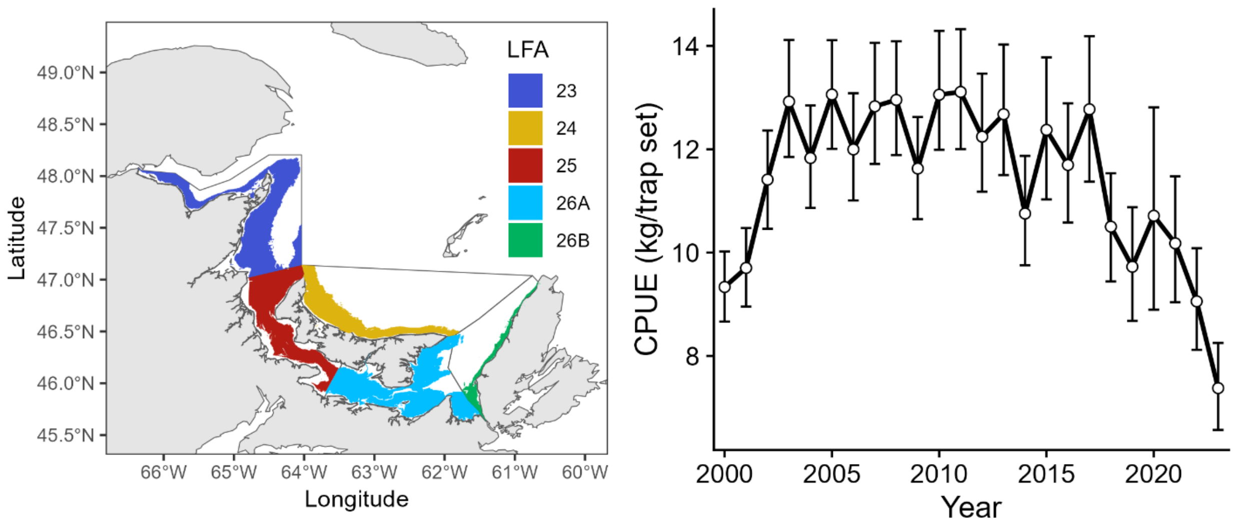


Figure 7. Left: Areas within the sGSL within the optimal depth range for rock crab (10 – 40 m) according to trawl surveys between 2010 – 2011 (Rondeau et al. 2014). Right: Area-weighted CPUE estimates with bootstrapped confidence intervals for rock crab in the sGSL.

Size Frequency Analysis

From 2021 to 2023, a dockside sampling program measured rock crab sizes throughout the fishing season (2-3 months) in each LFA. With the exception of LFA 26A, regression models fit to the size distributions through time do not indicate consistent decreases in average rock crab size over the season, suggesting that the directed fishery does not significantly reduce the mean size of commercially sized male crabs (Figure 8). In LFA 26A, where a negative trend was consistently present, the predicted decrease in size over the season was less than 1 mm per month, with the mean predicted size at the end of the fishing season (114.1, 116.6, and 115.4 mm in 2021, 2022, and 2023 respectively) still well above the minimum legal size (MLS) for that LFA (108 mm).

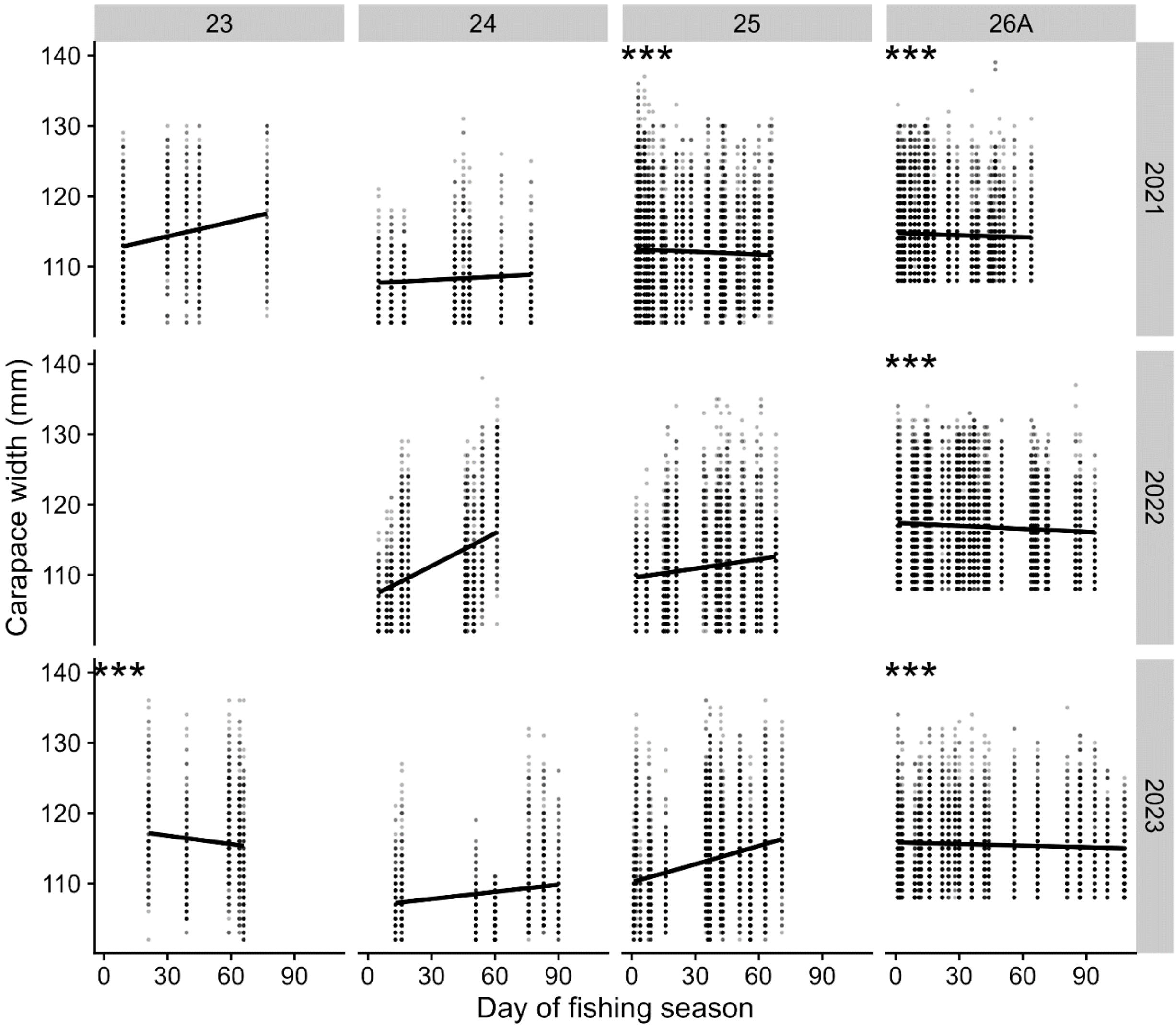


Figure 8. Sampled carapace widths from commercially landed crab at multiple ports throughout each LFA. Lines are predicted fits from a generalized linear regression (Gamma distribution). Asterisks indicate significant negative slopes.

Additionally, size distributions collected during the annual rock crab trap survey, prior to the fishing season opening, indicate that in most sites (23, 25, and 26A), the mean size exceeds the legal size limit (Table 1). While exploitation rates could not be calculated with the available data, the abundance of crabs well over the MLS (>130 mm) potentially indicate the presence of residual crabs (uncaught legal-sized crabs from previous fishing seasons).

Table 1. Summary statistics for the size distribution of male rock crab captured during the annual rock crab trap survey conducted throughout the sGSL. Sizes correspond to CW measured to the nearest millimeter. The minimum legal size for the rock crab in LFAs 23, 24, and 25 is 102 mm, while in LFAs 26A and 26B, the minimum legal size is 108 mm. Two sub-areas of LFA 23 were sampled (23A and 23C).

Year	Area	N	% Legal	Minimum	Mean	Median	Maximum
2021	23A	-	-	-	-	-	-
	23C	592	93.92	46	116.5	118	138
	24	1040	28.17	56	97.4	97	130
	25	-	-	-	-	-	-
	26A	1598	61.89	64	110.6	111	133
	26B	1	100	111	111	111	111
2022	23A	1353	42.05	19	97.8	100	130
	23C	-	-	-	-	-	-
	24	-	-	-	-	-	-
	25	1387	51.05	22	102.5	103	134
	26A	-	-	-	-	-	-
	26B	-	-	-	-	-	-
2023	23A	3632	27.15	41	88.5	91	132
	23C	57	94.74	97	118.4	120	132
	24	908	27.42	45	97.5	97	140
	25	233	80.69	50	111.2	113	134
	26A	1544	69.3	66	112.3	113	135
	26B	-	-	-	-	-	-
2024	23A	-	-	-	-	-	-
	23C	144	97.92	90	121	122	137
	24	1370	23.43	51	95	96	131
	25	-	-	-	-	-	-
	26A	4030	72.26	42	113.2	114	143
	26B	-	-	-	-	-	-

Juvenile Recruitment

In locations where bio-collectors consistently catch rock crab (Figure 9), the recruitment index suggests juvenile density has decreased in recent years (2015 – 2023). During the earlier period (2008 – 2014), juvenile density in all three LFAs was higher but exhibited considerable year-to-year variability, with alternating years of high and low abundance. Since 2015, however, juvenile density has decreased in some cases by over 50%, with much less inter-annual variation.

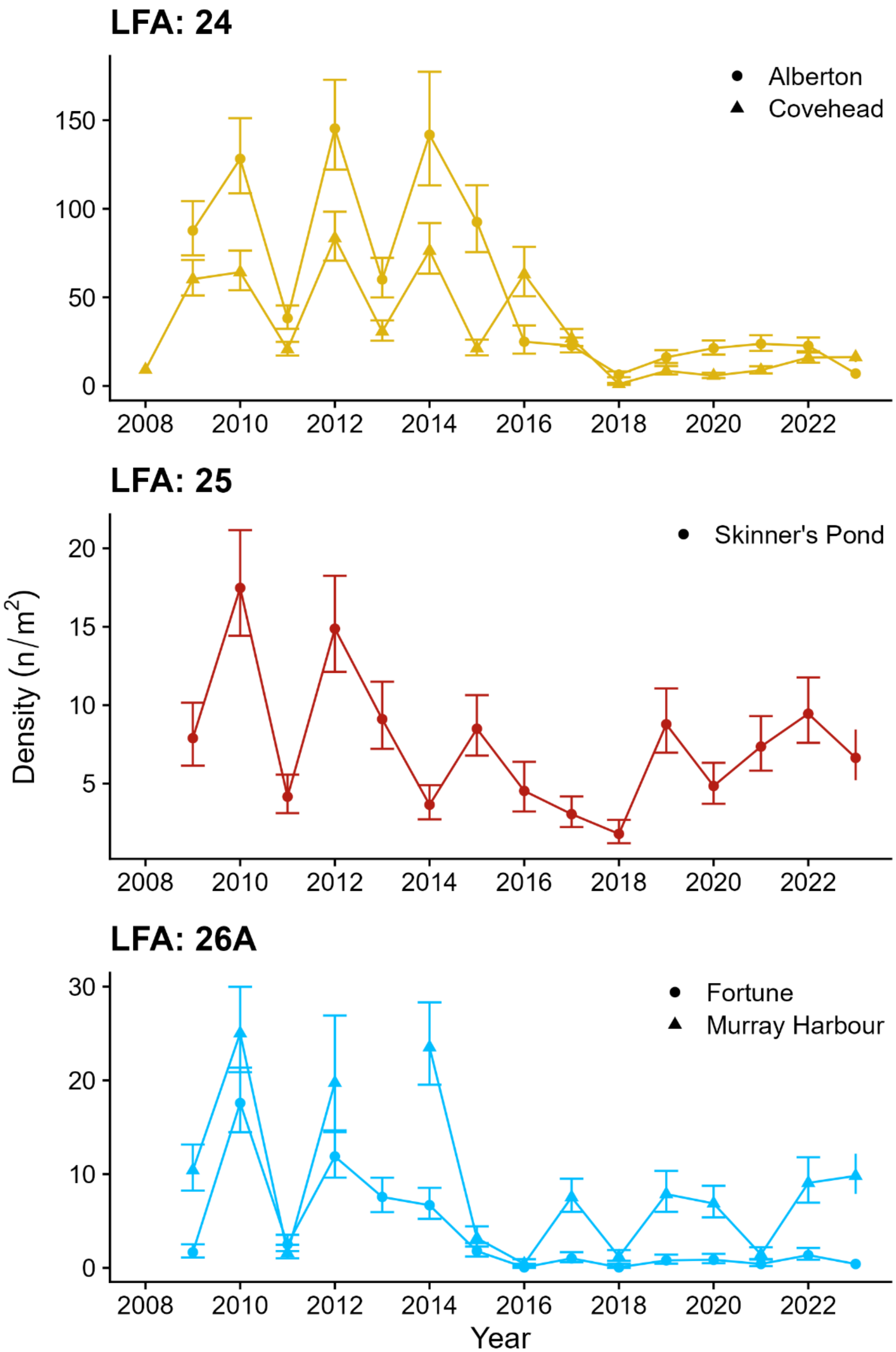


Figure 9. Juvenile rock crab density estimates predicted by a generalized linear model fit to count data from bio-collectors.

Ecosystem Indicators

Predator Abundance

Rock crab serve as a primary prey species for American lobster in the sGSL and play a critical role in lobster reproduction (Hanson et al. 2014). Sampling of lobster stomach contents from 1999 to 2006 indicated that rock crab constitutes 29–50% of the total stomach content by weight. To assess the impact of lobster predation on rock crab, an index of total lobster biomass was calculated for the highest-producing areas of the sGSL (LFAs 25 and 26A) using data from the Northumberland Strait multi-species trawl survey.

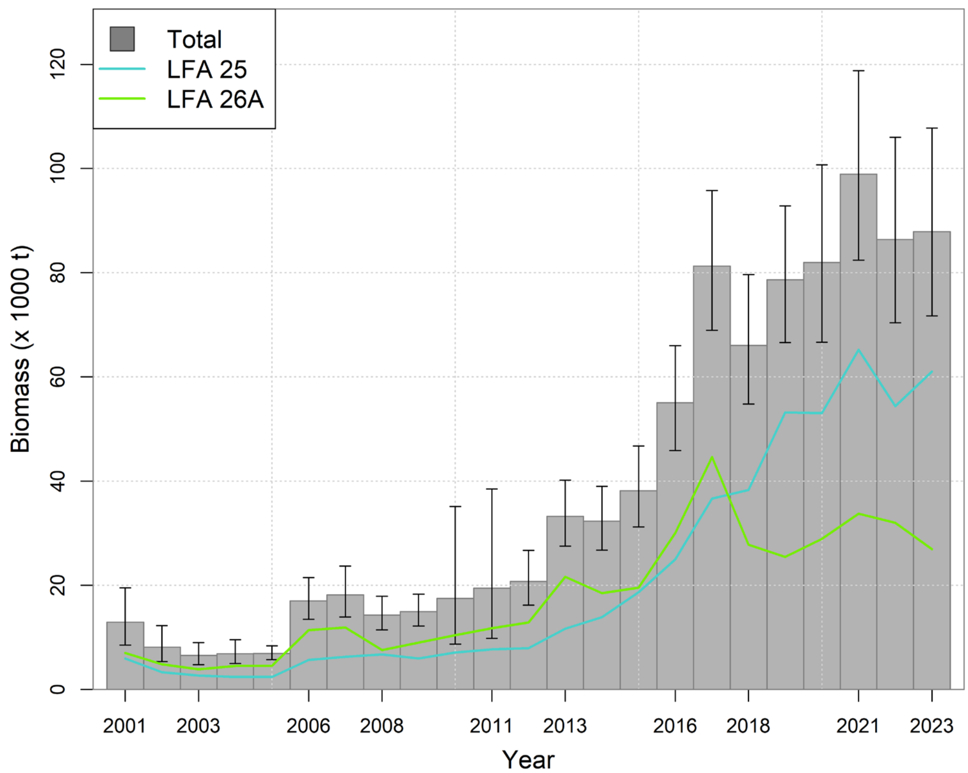


Figure 10. Lobster biomass estimates for LFAs 25 and 26 based on abundances in the Northumberland Strait trawl survey.

Following methods detailed in Asselin et al. (2024), the resulting lobster biomass estimates reveal a steady increase in LFAs 25 and 26A, rising from a low of 6,500 t in 2003 (95% CI 5,000 – 9,000) to a high of 99,000 t in 2021 (95% CI 82,500 – 119,000; Figure 10). This increase results from both greater lobster density and expanded distribution within each LFA (Figure 11). Notably, densities have risen most sharply in the central regions of the strait, which previously exhibited sparse lobster populations but now show densities above 250 kg/km². These results suggest that natural mortality among rock crab in the most productive area of the sGSL (LFAs 25 and 26A) is likely increasing as a result of predation by lobster. As additional indicators of lobster abundance (i.e., landings) have been increasing throughout the entire sGSL (Asselin et al. 2024), it seems probable that lobster abundance, and therefore lobster predation on rock crabs, is likely increasing across the entire sGSL.

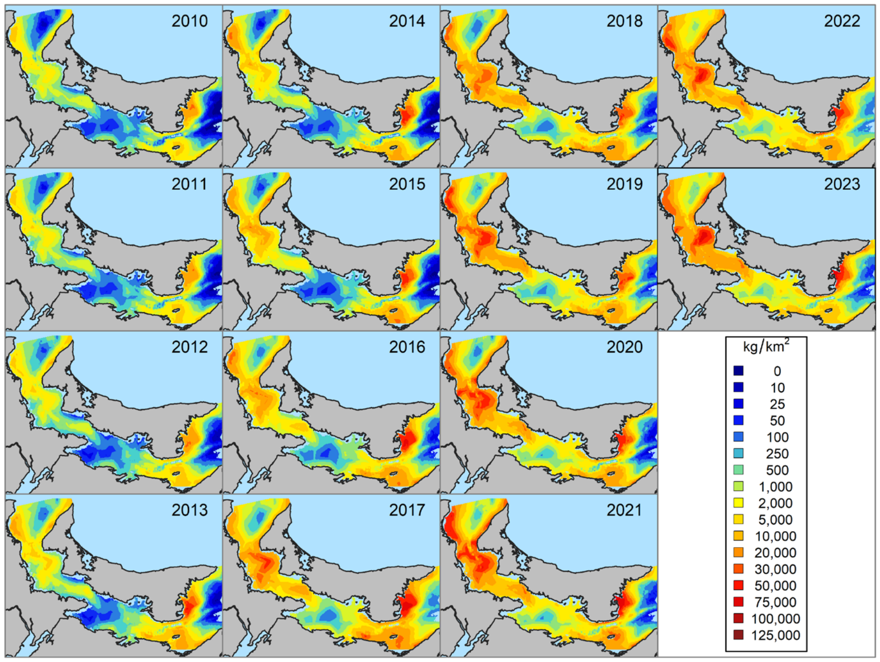


Figure 11. Density distribution maps for lobster within LFAs 25 and 26A of the sGSL according to a spatio-temporal model fit to abundance data from the Northumberland Strait trawl survey.

Limit Reference Point (LRP)

Among the possible stock status indices for the rock crab stock in the sGSL, the fishery based standardized CPUE estimates provide the longest, and most complete picture of the stock population dynamics in the Gulf. While the catch limit rate (the average time required for total catch in an LFA to reach 9,000 kg) is promising as an indicator of abundance, the use of harvester-level data can result in small sample sizes and low certainty levels, particularly when few harvesters participate in the fishery, like in LFA 24. Conversely, the trip-level data used for standardized CPUE produces more data points, despite low harvester participation. Additionally, the use of random effects (harvester FIN and statistical district) in the CPUE model facilitates information sharing across years and among groups, enhancing estimation accuracy in years or strata with fewer observations. Alternative indices from fishery-independent data sources (i.e., trap survey, bio-collectors) may be candidates at a later point but their current level of coverage, both temporally and spatially, limit their ability to accurately describe the stock at this time. This may change as additional years or sampling sites are added.

To use the standardized CPUE estimates as a basis for setting an LRP, an initial reference point must be set at a level that represents a stable population density. Assuming constant catchability (q) and a proportional relationship between CPUE and biomass (Schaefer 1954), a period with stable catches and stable CPUE would be indicative of a stock at or near biomass at maximum sustainable yield (B_{MSY}). For the sGSL rock crab population, a stable period occurred between 2004 and 2011 when catches remained stable at around 4,300 t while the $CPUE_{std}$ remained stable near a mean of 12.56 kg/trap (Figure 12). With this proxy for abundance at $CPUE_{MSY}$, we can set an LRP at 0.4 $CPUE_{MSY}$, or 5.02 kg/trap. Following with the suggested reference points of the Precautionary Approach, an upper stock reference point (USR) of 0.8 $CPUE_{MSY}$, or 10.05 kg/trap, would place the stock between the LRP and USR - in the cautious zone in 2022 and 2023.

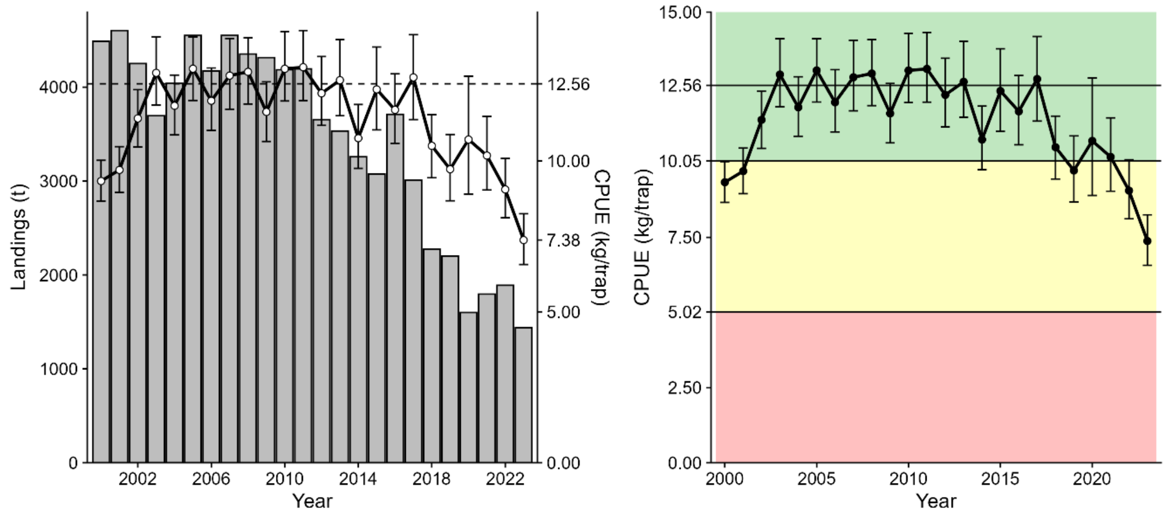


Figure 12. Left: Area-weighted mean $CPUE_{std}$ values for sGSL rock crab (lines) and total catches from the directed fishery (bars). The dashed line represents a proxy for B_{MSY}. Right: Precautionary approach stock status zones for sGSL rock crab.

CLIMATE CHANGE CONSIDERATIONS

In addition to shifts in the abundance of rock crab’s primary predator, rising temperatures may also impact rock crab abundance through numerous ecological means. Throughout the fishery's duration, mean bottom temperatures in June has shown no consistent warming trend. Relatively stable temperature patterns exist in the southern Gulf, with LFAs 24 and 26B consistently on the cooler side, while LFAs 25 and 26A are the warmest LFAs (Figure 13). These patterns become even more pronounced in September. These patterns also mirror the abundance indices, with LFAs 25 and 26A showing the highest levels of abundance while LFAs 24 shows the lowest abundance levels and rock crab are no longer harvested in 26B due to low catches.

With this correlation in mind, we then assessed whether warmer years produced higher abundance estimates on a lagged scale according to $CPUE_{std}$. An analysis of correlation between $CPUE_{std}$ values and bottom temperatures at varying lag intervals (1-5 years) did not identify a significant correlation between this index of abundance and mean bottom temperatures for either June or September.

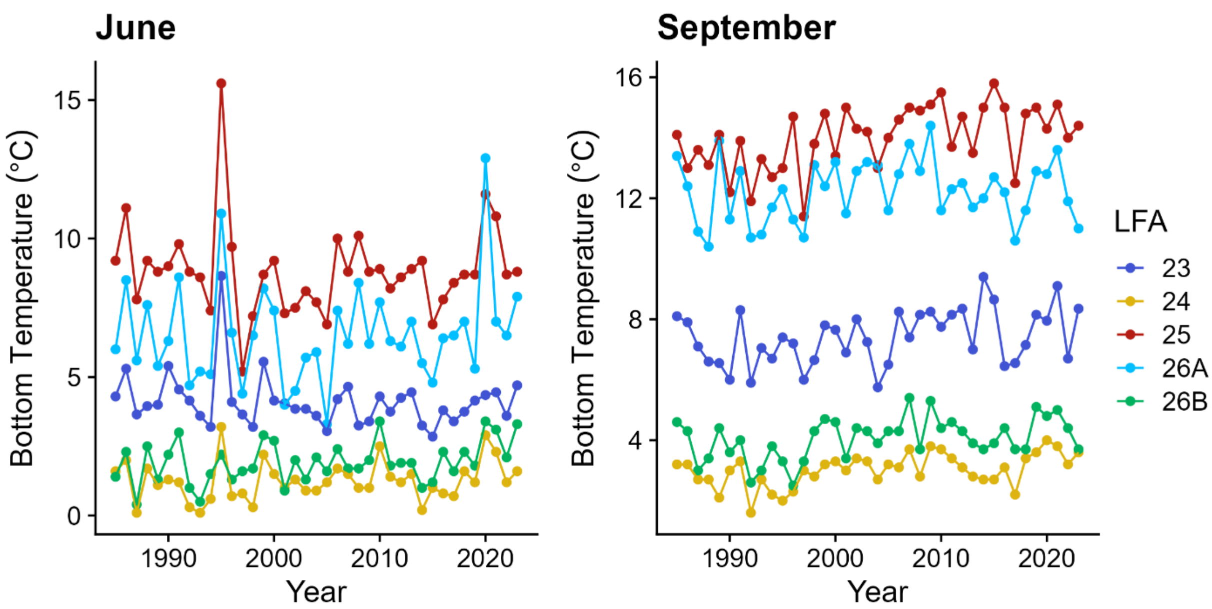


Figure 13. Mean monthly seabed temperatures in June and September averaged collected during DFO surveys and interpolated to a 500 m resolution grid.

Within the timeseries of bottom temperatures in September, a significant warming trend is present, whereby all LFAs warm by an average of 0.03 °C per year (linear regression, $\beta = 0.0259$, $p < 0.01$). This indicates that bottom temperatures experience by rock crab, especially in late summer, are expected to continue to warm in the near future. As with any aquatic system, the consequences of warming water temperatures are still largely unknown, but as bottom temperatures in the sGSL rise, the number of ice free days decreases, and Gulf-wide average temperatures reach record highs (Galbraith et al. 2023), it seems likely this will have an effect on rock crab abundance one way or another. Given that the geographical range of the rock crab extends south of the Carolinas (Williams 1965), it seems unlikely that this stock is approaching its thermal limit. However, since rock crab in more southern latitudes often inhabit deeper waters relative to more northern latitudes (Williams 1965), continued warming in the sGSL may result rock crab distributions shifting into deeper waters. Concurrently, warming temperatures may also produce shifts in the distribution of rock crab predators (i.e., lobsters), competitors (i.e., green crab), prey, or parasites.

SOURCES OF UNCERTAINTY

As with most fishery-dependent data sources, the standardized CPUE values calculated in this report rely on information from multiple distinct data sources (sales slips and logbooks), which are subject to delays, gaps, and errors, all of which may propagate uncertainty or errors into the resulting science-based advice. Additionally, the use of CPUE to set biological reference points requires the assumption that catchability of rock crabs remains stable temporally and spatially, and that a linear relationship exists between rock crab abundances and CPUE. This assumption carries with it the risk of potentially setting reference points at levels which do not achieve the desired goals of the precautionary approach, namely preventing stocks from declining into the critical zone (DFO 2013b), as CPUE hyperstability could cause the MSY proxy to be inaccurate (Maunder et al. 2006). In the attempt to validate this relationship, the continued exploration of fishery-independent indices desirable.

In the rock crab fishery, there is a considerable amount of unrealized effort in the form of inactive licenses and underutilized personal allocations. If market and/or industry conditions were to shift, activating this latent effort could dramatically increase removals beyond their current levels. Such an increase would have the immediate effect of reducing rock crab abundance, which would only be detected after the removals had taken place.

With the dockside length frequency monitoring program, only legal-size landed rock crabs are being measured, rather than rock crab catch as a whole. Future work with size frequency distributions may benefit from an at-sea sampling program to expand the coverage of the sampling area and sample population.

Currently, with the limited catches of small rock crab by the annual trap survey, the only source of information on juvenile density is from the bio-collectors program. While the bio-collector project has shown itself to be a suitable means of assessing relative juvenile crab density through time, the program was initially set-up to quantify lobster recruitment rather than rock crab. Future work could include expanding the project to include new sites throughout the sGSL. In so doing, we may gain a better understanding of rock crab recruitment throughout the entire sGSL while potentially providing more context to the time series already collected.

CONCLUSIONS AND ADVICE

The rock crab is a robust and highly fecund species which inhabits a wide habitat range and habitats across a broad thermal gradient. Males matures at 1 – 2 years of age, at a much smaller size than the legal fishing limit in the sGSL and only male crabs are harvested by the directed and bycatch fisheries. Furthermore, effort by the directed fishery has been declining over the past decade in the sGSL, as has the use of rock crab as bait by lobster fishers (lobster harvester, personal communication, 2024). These characteristics, of both the species and the fishery, combine to make it unlikely that this stock is experiencing high fishing mortality. In contrast, natural mortality rates among rock crab in the sGSL is believed to have increased in recent years due to the dramatic increase in American lobster, a predator of rock crab.

While multiple indices of abundance, recruitment, and fishing pressure were explored in this report, the fishery dependent $CPUE_{std}$ was identified as the most comprehensive index with which to set an LRP. A proxy for CPUE at MSY was identified as 12.56 kg/trap and from this, an LRP at 0.4 MSY was calculated as 5.02 kg/trap. Currently, the standardized CPUE for the sGSL as a whole is estimated to be at 7.38 kg/trap, which places the stock above the LRP, but in the Cautious Zone if a USR is set to 0.8 MSY (10.05 kg/trap).

While standardized CPUE is the most suitable candidate with which to monitor the status of this stock at this time, there are inherent risks associated with using a fishery-based data source as the primary index of abundance. For this reason, the additional indices explored above will be included in future reviews of this stock to provide additional supporting information to guide the science-based advice. Ideally, as additional years of study are added to the trap survey, it may become possible to combine the two. Regardless, the rock crab is likely to remain a data-limited species into the future and as such, a multi-indicator approach, where trends within supplemental indicators are used to support results from a primary indicator, is likely to be the safest path forward when setting or adjusting regulations for this stock.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
Alfred Young	The Confederacy of Mainland Mi'kmaq
Amélie Rondeau	DFO Science - Gulf Region
Andrew Harbicht	DFO Science - Gulf Region
Benjamin Moore	DFO - Fisheries and Harbour Management- Gulf Region
Brendan Aulthouse	DFO Science - Pacific Region
Corinne Truesdale	Rhode Island Department of Environmental Management
Daniel Momberquette	Provincial Government of Nova Scotia
Fabiola Akaishi	DFO Science - Gulf Region
George Sark	Maritimes Aboriginal People Council (MAPC)-MAARS
James Brow	North of Smokey Fishermen's Association
Joshua Carloni	New Hampshire fish and game
Krista Baker	DFO Science - Newfoundland and Labrador Region
Kristin Dinning	Government of New Brunswick
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Marco Morency	DFO Fisheries and Harbour Management- Gulf Region
Mathieu Vienneau	DFO Fisheries and Harbour Management- Gulf Region
Melanie Giffin	Prince Edward Island Fishermen's Association
Mélanie Roy	DFO Science - Gulf Region
Natalie Asselin	DFO Science - Gulf Region
Nicholas Levangie	DFO Fisheries and Harbour Management- Gulf Region
Reagan MacDonald	Government of Prince Edward Island
Ryan MacDonald	Maritime Fishermen's Union local 4
Tina Sonier	Maritime Fishermen's Union
Venitia Joseph (chair)	DFO Science - Gulf Region
Victoria Cluney	Mi'gmawe'l Tplu'taqnn

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E-Mail: dfo.glfcsa-casglf.mpo@dfo-mpo.gc.ca
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