Appendix xx. Ecosystem and Socioeconomic Profile of the Bristol Bay Red King Crab stock - Report Card

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Current Year Update

The ecosystem and socioeconomic profile or ESP is a standardized framework for compiling and evaluating relevant stock-specific ecosystem and socioeconomic indicators and communicating linkages and potential drivers of the stock within the stock assessment process (Shotwell et al., *In Review*). The ESP process creates a traceable pathway from the initial development of indicators to management advice and serves as an on-ramp for developing ecosystem-linked stock assessments.

Please refer to the last full ESP document (Fedewa et al., 2020, Appendix E, pp. 172-204) which is available within the Bristol Bay red king crab (BBRKC) stock assessment and fishery evaluation or SAFE report for further information regarding the ecosystem and socioeconomic linkages for this stock.

Management Considerations

The following are the summary considerations from current updates to the ecosystem and socioeconomic indicators evaluated for BBRKC:

- In 2022, bottom temperatures returned to near-average and the cold pool extended into the Bristol Bay management area. Results from the NOAA bottom trawl survey indicate that BBRKC female reproductive cycles were delayed due to relatively cold bottom temperatures. However, summer bottom temperatures were well-within the thermal range of juvenile and adult red king crab.
- Red king crab have experienced a steady decline in bottom water pH in the past two decades, reaching 7.89 in 2022. Continued declines to threshold pH levels of 7.8 could negatively affect juvenile red king crab growth, shell hardening and survival.
- BBRKC recruitment remains well below the long-term average. Concurrent declines in Pacific cod and benthic invertebrate densities in the past 7 years may suggest shared processes that drive productivity of Bristol Bay benthic communities.
- Spatial extent of mature male red king crab in Bristol Bay was above average in 2022, coinciding with increases in abundance. The relatively large spatial footprint of mature males in 2022 can be attributed to an increased use of nearshore habitats in Bristol Bay, and was likely driven by the return of cold waters <2°C following a 2018-2019 heat wave.
- The BBRKC fishery was closed to targeted fishing for the 2021-2022 season.
- Incidental catch of BBRKC biomass in EBS groundfish fisheries during 2021 increased moderately from the previous year to slightly above average for the 2010-current period,

Modeling Considerations

The following are the summary results from the intermediate and advanced stage monitoring analyses for BBRKC:

- The highest ranked predictor variables (> 0.50 inclusion probability) in the advanced stage monitoring analysis were: BBRKC recruit biomass, Pacific cod biomass, and the Arctic Oscillation. Due to concerns with autocorrelation in model-based estimates of mature male biomass, indicator importance tests in future BBRKC ESP updates will use recruitment estimates as a response variable.
- The advanced stage indicator analysis provides updates on developing research ecosystem linked models that are not yet included as a model alternative in the main stock assessment. We have not received updates on new research ecosystem linked models for BBRKC at this time.

Assessment

Ecosystem and Socioeconomic Processes

We summarize important processes that may be helpful for identifying productivity bottlenecks and dominant pressures on the stock in conceptual models detailing 1) ecosystem processes by RKC life history stage (Figure 1a) and 2) socioeconomic performance metrics (Figure 1b). The ecosystem conceptual model highlights abiotic and biotic processes identified by each life stage from the literature, process studies and laboratory rearing experiments. During early larval stages, RKC survival is dependent on spatiotemporal overlap with high densities of diatoms (Paul et al., 1989; Paul and Paul, 1980), optimal environmental conditions for development (Nakanishi, 1987) and dispersal to suitable settlement habitat (Daly et al., 2018). Specific habitat requirements for juvenile RKC include physical structure and high relief to both evade predators (Stoner, 2009; Pirtle et al., 2012) and provide increased foraging opportunities (Pirtle and Stoner, 2010). Late juvenile and adult RKC are less reliant on complex structure, and instead, spatial distributions and migration timing are driven by bottom temperatures (Loher and Armstrong, 2005; Zheng and Kruse, 2006; Zacher et al., 2018).

The socioeconomic conceptual model highlights fishery performance indicators that represent processes most directly involved in prosecution of the BBRKC fishery, and thus have the potential to differentially affect the condition of the stock, depending on how they influence the timing, spatial distribution, selectivity, and other aspects of fishing pressure. Implementation of the Crab Rationalization Program and the allocation of tradable crab harvest quota shares resulted in rapid consolidation of the BBRKC fleet and changed the timing of the fishery from short derby seasons to more extended seasons. These and other institutional changes continue to influence the geographic and inter-sectoral distribution of benefits produced by the BBRKC fleet.

Indicator Suite

The following list of indicators for BBRKC is organized by categories: three for ecosystem indicators (physical, lower trophic, and upper trophic) and two for socioeconomic indicators (fishery performance and economic). A title, short description and contact name for the indicator contributor are provided. We also include the anticipated sign of the proposed relationship between the indicator and the stock population dynamics where relevant. Please refer to the last full ESP document for detailed information regarding the ecosystem and socioeconomic indicator descriptions and proposed mechanistic linkages for this stock (Fedewa et al., 2020). Time series of the ecosystem and socioeconomic indicators are provided in Figure 2a and Figure 2b, respectively. Summer pH values reported in past ESP products differ slightly from those reported in this document due to an updated ROMS model hindcast through August 2022, which simulates less large phytoplankton than the previous hindcast and results in comparatively lower surface pH values due to less photosynthesis, but greater bottom water pH due to less respiration. Also, please note that we have added back in two socioeconomic indicators that were presented in the full BBRKC ESP. Upon further evaluation, we have determined that these two indicators are useful for understanding health and condition of the stock. The two indicators are annual incidental catch of Bristol Bay red king crab in eastern Bering Sea trawl and fixed gear fisheries and TAC utilization in the Bristol Bay red king crab fishery, which we are monitoring for potential changes due to shifts in stock distribution.

Ecosystem Indicators:

Physical Indicators (Figure 2a.a-e)

a.) The areal extent of the summer cold pool (EBS bottom trawl survey stations with bottom temperatures < 2^{o}C; contact: Erin Fedewa). Proposed sign of relationship is positive.

b.) Summer bottom temperatures in Bristol Bay from the AFSC eastern Bering Sea bottom trawl survey (contact: E. Fedewa). Proposed sign of relationship is positive.

c.) Winter-spring Arctic Oscillation index from the NOAA National Climate Data Center (contact: E. Fedewa). Proposed sign of relationship is positive.
d.) Spring pH index in Bristol Bay from the Bering10K ROMS model (Pilcher et al., 2019) (contact: D. Pilcher). Proposed sign of relationship is positive.
e.) Summer wind stress (m/s) in Bristol Bay from NOAA/NCDC blended winds and Metop-A ASCAT satellite (Zhang et al., 2006, NOAA/NESDIS, CoastWatch) (contact: D. Robinson). Proposed sign of relationship is negative.

Lower Trophic Indicators (Figure 2a.f)

f.) Spring chlorophyll-a biomass in Bristol Bay from MODIS satellites (contact: M. Callahan and J. Nielsen). Proposed sign of relationship is positive

Upper Trophic Indicators (Figure 2a.g-m)

g.) September juvenile sockeye salmon abundance in the EBS from the AFSC Bering Arctic Subarctic Integrated Survey (contact: E. Yasumiishi). Proposed sign of relationship is negative.
h.) Summer Pacific cod density in Bristol Bay from the AFSC eastern Bering Sea bottom trawl survey (contact: E. Fedewa). Proposed sign of relationship is negative.
i.) Summer benthic invertebrate density in Bristol Bay. Invertebrates include brittle stars, sea stars, sea cucumber, bivalves, non-commercial crab species, shrimp and polychaetes. (contact: Erin Fedewa). Proposed sign of relationship is positive.
j.) Annual red king crab recruit abundance (110-134 mm CL) in Bristol Bay from the AFSC eastern Bering Sea bottom trawl survey (contact: E. Fedewa). Proposed sign of relationship is positive.
k.) Summer mature male red king crab area occupied in Bristol Bay from the AFSC eastern Bering Sea bottom trawl survey (contact: E. Fedewa). Proposed sign of relationship is negative.
l.) Summer mature female red king crab area occupied in Bristol Bay from the AFSC eastern Bering Sea bottom trawl survey (contact: E. Fedewa). Proposed sign of relationship is negative.
m.) Annual male red king crab catch distance from shore in Bristol Bay during the fishery (contact: L. Zacher). Proposed sign of relationship is positive.

Socioeconomic Indicators: (all monetary values are inflation-adjusted to $2021 value)

Fishery Performance Indicators (Figure 2b. a-d)

a.) Annual catch-per-unit-effort (CPUE), expressed as mean number of legal crabs per potlift, in the BBRKC fishery, representing relative efficiency of fishing effort (contact: B. Daly)
b.) Annual total potlifts in the BBRKC fishery, representing the level of fishing effort expended by the active fleet (contact: B. Daly)
c.) Annual number of active vessels in the Bristol Bay red king crab fishery, representing the level of fishing effort assigned to the fishery (contact: J. Lee)
d.) Estimated total incidental catch of BBRKC biomass (kg) in EBS groundfish fisheries (contact: J. Lee)

Economic Indicators (Figure 2b. e-h)

e.) Percentage of the annual BBRKC total allowable catch (TAC) (GHL prior to 2005) that was harvested by active vessels, including deadloss discarded at landing (contact: B. Garber-Yonts)
f.) Annual ex-vessel value ($2021) of the BBRKC fishery landings, representing gross economic returns to the harvest sector, as a principal driver of fishery behavior (contact: J. Lee)

g.) Annual ex-vessel price per pound ($2021) of BBRKC landings, representing per-unit gross economic returns to the harvest sector, as a principal driver of fishery behavior (contact: J. Lee)
h.) Annual ex-vessel revenue share, expressed as average proportion of total annual gross landings revenue from all fisheries earned from BBRKC landings by vessels active in the fishery (contact: J. Lee)

Indicator Monitoring Analysis

There are up to three stages (beginning, intermediate, and advanced) of statistical analyses for monitoring the indicator suite listed in the previous section. The beginning stage is a relatively simple evaluation by traffic light scoring. This evaluates the current year trends relative to the mean of the whole time series, and provides a historical perspective on the utility of the whole indicator suite. The intermediate stage uses importance methods related to a stock assessment variable of interest (e.g., recruitment, biomass, catchability). These regression techniques provide a simple predictive performance for the variable of interest and are run separate from the stock assessment model. They provide the direction, magnitude, uncertainty of the effect, and an estimate of inclusion probability. The advanced stage is used for testing a research ecosystem linked model and output can be compared with the current operational model to understand information on retrospective patterns, prediction performance, and comparisons of other model output such as terminal spawning stock biomass or mean recruitment. This stage provides an on-ramp for introducing an alternative ecosystem linked stock assessment model to the current operational stock assessment model and can be used to understand the potential reduction in uncertainty by including the ecosystem information.

Beginning Stage: Traffic Light Test

We use a simple scoring calculation for this beginning stage traffic light evaluation. Indicator status is evaluated based on being greater than (“high”), less than (“low”), or within (“neutral”) one standard deviation of the long-term mean. A sign based on the anticipated relationship between the ecosystem indicators and the stock (generally shown in Figure 1a and specifically by indicator in the Indicator Suite, Ecosystem Indicators section) is also assigned to the indicator where possible. If a high value of an indicator generates good conditions for the stock and is also greater than one standard deviation above the mean, then that value receives a ‘+1’ score. If a high value generates poor conditions for the stock and is greater than one standard deviation above the mean, then that value receives a ‘-1’ score. All values less than or equal to one standard deviation from the long-term mean are average and receive a ‘0’ score. The scores are summed by the three organizational categories within the ecosystem (physical, lower trophic, and upper trophic) or socioeconomic (fishery performance and economic performance) indicators and divided by the total number of indicators available in that category for a given year. The scores over time allow for comparison of the indicator performance and the history of stock productivity (Figure 3). We also provide five year indicator status tables with a color or text code for the relationship with the stock (Tables 1a,b) and evaluate the current year status in the historical indicator time series graphic (Figures 2a,b) for each ecosystem and socioeconomic indicator. Socioeconomic indicators representing the target fishery are reported, by calendar year, through 2020 (noting that virtually all active harvest activity occurs prior to January), the last year that the fishery was open (corresponding to the 2020-2021 crab season, and incidental catch is reported for the most recent full calendar year (2021).

We evaluate the status and trends of the ecosystem and socioeconomic indicators to understand the pressures on the BBRKC stock regarding recruitment, stock productivity, and stock health. We start with the physical indicators and proceed through the increasing trophic levels for the ecosystem indicators then evaluate the fishery performance and economic indicators as listed above. Here, we concentrate on updates since the last ESP. Overall, the physical and upper trophic indicators scored below average for 2022, while the lower trophic indicators were average (Figure 3). The fishery performance indicators

scored average for 2021, but this is based on only one indicator. The economic indicators were average for 2020. Compared to the previous data point, this is an increase from well below average for the physical indicators, the same for the lower trophic indicators, a decrease for the upper trophic indicators, an increase for the fishery performance indicators, and the same for the economic indicators.

Overall, trends in physical ecosystem indicators suggest a return to near-normal conditions in Bristol Bay with average bottom temperatures nearly 2°C colder than 2018-2019 heat conditions. A positive phase Arctic Oscillation index in winter 2022 may suggest favorable conditions for BBRKC productivity (Szuwalski et al., 2020), although continued declines in pH that are approaching a critical threshold for negative effects on growth and shell hardening remain concerning (Long et al., 2013). Results from the 2022 AFSC EBS bottom trawl survey indicate that reproductive cycles of mature female BBRKC were delayed due to relatively cold spring bottom temperatures in Bristol Bay (Zacher et al*., in review*). Delayed spring hatching of red king crab embryos relative to mid-May peak bloom timing may impact the spatiotemporal overlap between first-feeding larvae and preferred diatom prey, and larval retention may be reduced in relatively cold years (Daly et al., 2020). While recent year updates for juvenile sockeye salmon abundance were not yet available for this document, Bristol Bay's 2022 sockeye run was the largest on record and may be indicative of increased predation on larval RKC in recent years. However, near-average wind stress and chloropyll-*a* biomass in Bristol Bay indicate suitable conditions for larval first-feeding success and survival.

Current-year values for upper trophic level Pacific cod and benthic invertebrate indicators are not yet available following the conclusion of the 2022 EBS bottom trawl survey. However, both indicators are on a downward trend and Pacific cod biomass has been below average since 2016 in Bristol Bay. BBRKC recruitment still remains well below average as well, and concurrent declines with Pacific cod and invertebrates may be suggestive of bottom-up forcing on benthic communities in Bristol Bay. Although inference on fall BBRKC distributions is limited due to a 2021/2022 fishery closure, mature male area occupied during the summer NOAA bottom trawl survey was above-average. This likely coincides with relatively high catches along the Alaska Peninsula (Zacher et al., *in review*), and may point to the importance of near-shore habitat in years when the cold pool extends south into the management area (Zacher et al., 2018).

Trends in fishery performance and economic indicators correspond to ongoing decline in TACs issued in the BBRKC fishery since 2014. Effort in the fishery, as indicated by the number of active vessels and total number of potlifts, both of which continued the downward trends observed in recent years, and reached the lowest points on record during the 2020-2021 fishing season, while CPUE increased somewhat relative to the previous three seasons, but remained at a relative low compared to the post-rationalization period overall. Ex-vessel price declined slightly for the 2020-2021 season, but remained relatively high compared to the post-rationalization period overall. Consistent with substantial declines in TACs since 2016-2017, gross ex-vessel revenue aggregated over all landings, and the percentage share of total annual landings revenue represented by BBRKC landings for those vessels active in the fishery during 2020-2021 continued the sharp declining trend observed over the recent period, with both reaching historical lows and aggregate revenue reaching the lowest level on record.

Intermediate Stage: Importance Test

We plan to update the second stage indicator analysis in 2023 and are exploring additional importance methods for BBRKC.

Advanced Stage: Research Model Test

At this time we do not have any ecosystem research models to report for BBRKC.

Data Gaps and Future Research Priorities

Environmental conditions are rapidly changing in the eastern Bering Sea and continued research is needed to identify temperature thresholds and characterize responses across BBRKC life stages to changes in bottom temperatures. Specifically, future laboratory and field research should focus on clarifying the range of optimal temperatures for embryo survival and successful settlement in juvenile nursery areas. In addition, potential climate-driven shifts in phenology and spatial distribution underscore the importance of assessing fishery interactions with trawl and pot gear relative to BBRKC migration patterns, molt-mate timing and spawning habitat.

Given the dramatic increase in Bristol Bay sockeye salmon coinciding with declines in BBRKC recruitment in recent years, we emphasize the importance of understanding predator-prey interactions and spatiotemporal overlap of major pelagic predators with BBRKC larval stages. Juvenile salmon diet studies conducted from 1984-1992 (Farley 2001, unpublished data) reported that juvenile sockeye salmon consumption of red king crab zoea exceeded 45% in several years, suggesting potential links between salmon predation and BBRKC recruitment. In more recent years, the Bering-Aleutian Salmon International Survey has taken place in late-September following peak settlement of BBRKC, and there appears to be no ongoing efforts to characterize diets of juvenile sockeye salmon in earlier summer months when BBRKC are likely important prey items. Furthermore, because the survey is biennial and occurs in September, data gaps across the time series preclude use of the indicator in monitoring analyses, and indicator updates are unavailable for the current-year ESP. Future efforts should focus on exploring additional larval predator datasets that are more timely and consistent. In addition, additional groundfish stomach data outside of the summer survey time series would inform predation mortality during the molt when RKC are highly vulnerable.

Low stock recruitment in the past decade also warrants a better understanding of early life history processes and bottlenecks to aid in developing meaningful larval indicators as early warning signs. Evaluating RKC phenology relative to spring bloom timing may be useful for predicting larval condition and subsequent survival to settlement. Additionally, evaluating larval drift patterns and identifying essential fish habitat for benthic juvenile RKC may support the development of a larval retention or settlement success indicator. Overall, we highlight the continued importance of developing a mechanistic understanding of driver-response relationships to facilitate the inclusion of ecosystem indicators in future management strategies for BBRKC.

BBRKC ESP developments for 2023 include: 1) updating the intermediate stage indicator analysis, 2) producing a Request for Indicators in January 2023 to highlight data gaps and propose new indicator contributions, 3) developing an indicator to quantify potential BBRKC-gear interactions using the Fishing Effects model, and 4) updating ecosystem and socioeconomic indicators and considerations prior to the 2023 Crab Plan Team meeting to inform BBRKC management.

We plan to further evaluate the information provided in the Economic SAFE and ACEPO report to determine what socioeconomic indicators could be provided in the ESP that are not redundant with those reports and related directly to stock health. This may result in a transition of socioeconomic indicators currently reported in this ESP to a different series of indicators. Additional consideration of the timing of the economic and community reports, which are delayed by 1-2 years (depending on the data source) from the annual stock assessment cycle, should also be undertaken. The Scientific and Statistical Committee (SSC) recently recommended that local knowledge, traditional knowledge, and subsistence information may be helpful for understanding recent fluctuations in stock health, shifts in stock distributions, or changes in size or condition of species in the fishery. We could include this information as supportive evidence and perspective on many indicators monitored within the ESP.

As indicators are improved or updated, they may replace those in the current set of indicators to allow for refinement of the BAS model and potential evaluation of performance and risk within the operational stock assessment model. The annual request for indicators (RFI) for the BBRKC ESP will include these data gaps and research priorities along with a list of potential new indicators that could be developed for the next full ESP assessment.

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Tables

Table 1a. First stage ecosystem indicator analysis for BBRKC, including indicator title and the indicator status of the last five available years. The indicator status is designated with text, (greater than = "high", less than = "low", or within 1 standard deviation = "neutral" of time series mean). Fill color of the cell is based on the sign of the anticipated relationship between the indicator and the stock (blue or italicized text = good conditions for the stock, red or bold text = poor conditions, white = average conditions). A gray fill and text = "NA" will appear if there were no data for that year.

Indicator category	Indicator	2018 Status	2019 Status	2020 Status	2021 Status	2022 Status
Physical	Summer Cold Pool SEBS BBRKC Survey	**low**	**low**	NA	**low**	neutral
	Summer Temperature Bottom BBRKC Survey	*high*	*high*	NA	neutral	neutral
	Winter Spring Arctic Oscillation Index Model	neutral	neutral	*high*	neutral	neutral
	Spring pH BBRKC Model	**low**	**low**	**low**	**low**	**low**
	Summer Wind Stress BBRKC Satellite	neutral	**high**	neutral	**high**	neutral
Lower Trophic	Spring Chlorophylla Biomass SEBS Inner Shelf Satellite	neutral	neutral	neutral	neutral	neutral
Upper Trophic	Summer Sockeye Salmon Abundance EBS Survey	**high**	NA	NA	NA	NA
	Summer Pacific Cod Density BBRKC Survey	neutral	*low*	NA	neutral	NA
	Summer Benthic Invertebrate Density BBRKC Survey	neutral	neutral	NA	neutral	NA
	Annual Red King Crab Recruit Abundance BBRKC Survey	**low**	**low**	NA	**low**	**low**
	Summer Red King Crab Male Area Occupied BBRKC Model	**high**	**high**	NA	neutral	**high**

Indicator category	Indicator	2018 Status	2019 Status	2020 Status	2021 Status	2022 Status
	Summer Red King Crab Female Area Occupied BBRKC Model	neutral	**high**	NA	**high**	neutral
	Annual Red King Crab Catch Distance Shore BBRKC Fishery	neutral	*high*	neutral	NA	NA

Table 1b. First stage socioeconomic indicator analysis for BBRKC, including indicator title and the indicator status of the last five available years. The indicator status is designated with text, (greater than = "high", less than = "low", or within 1 standard deviation = "neutral" of time series mean). A gray fill and text = "NA" will appear if there were no data for that year.

Indicator category	Indicator	2017 Status	2018 Status	2019 Status	2020 Status	2021 Status
Fishery Performance	Annual Red King Crab CPUE BBRKC Fishery	neutral	neutral	neutral	neutral	NA
	Annual Red King Crab Total Potlift BBRKC Fishery	neutral	neutral	neutral	low	NA
	Annual Red King Crab Active Vessels BBRKC Fishery	neutral	neutral	neutral	neutral	NA
	Annual Red King Crab Incidental Catch EBS Fishery	high	neutral	neutral	neutral	neutral
Economic	Annual Red King Crab TAC Utilization BBRKC Fishery	neutral	neutral	neutral	neutral	NA
	Annual Red King Crab Exvessel Value BBRKC Fishery	neutral	low	low	low	NA
	Annual Red King Crab Exvessel Price BBRKC Fishery	neutral	high	high	high	NA
	Annual Red King Crab Exvessel Revenue Share BBRKC Fishery	neutral	neutral	neutral	neutral	NA

Figures

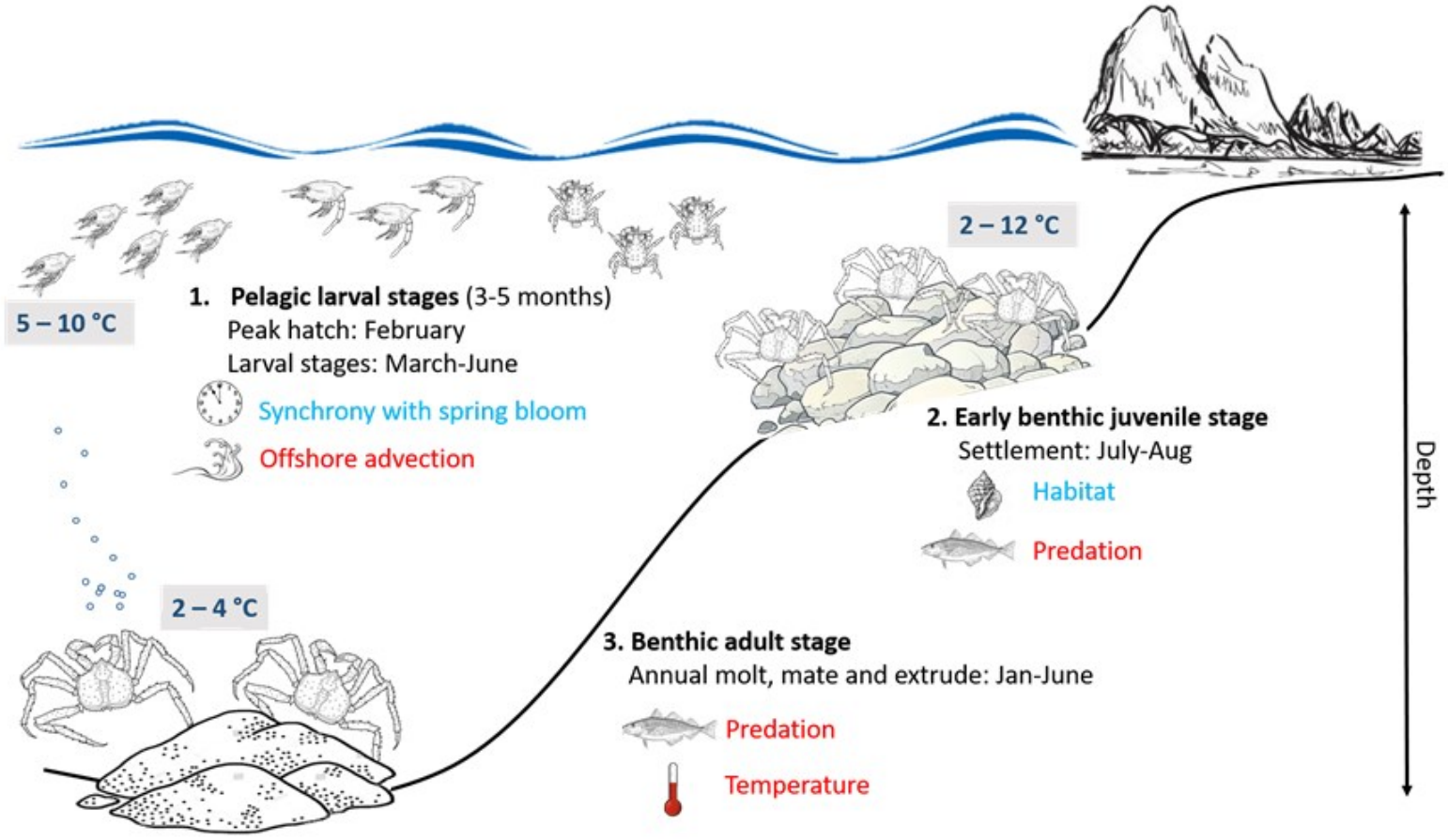

Figure 1a: Life history conceptual model for BBRKC summarizing ecological information and key ecosystem processes affecting survival by life history stage. Thermal requirements by life history stage were determined from RKC laboratory studies. Red text means increases in process negatively affect survival, while blue text means increases in process positively affect survival.

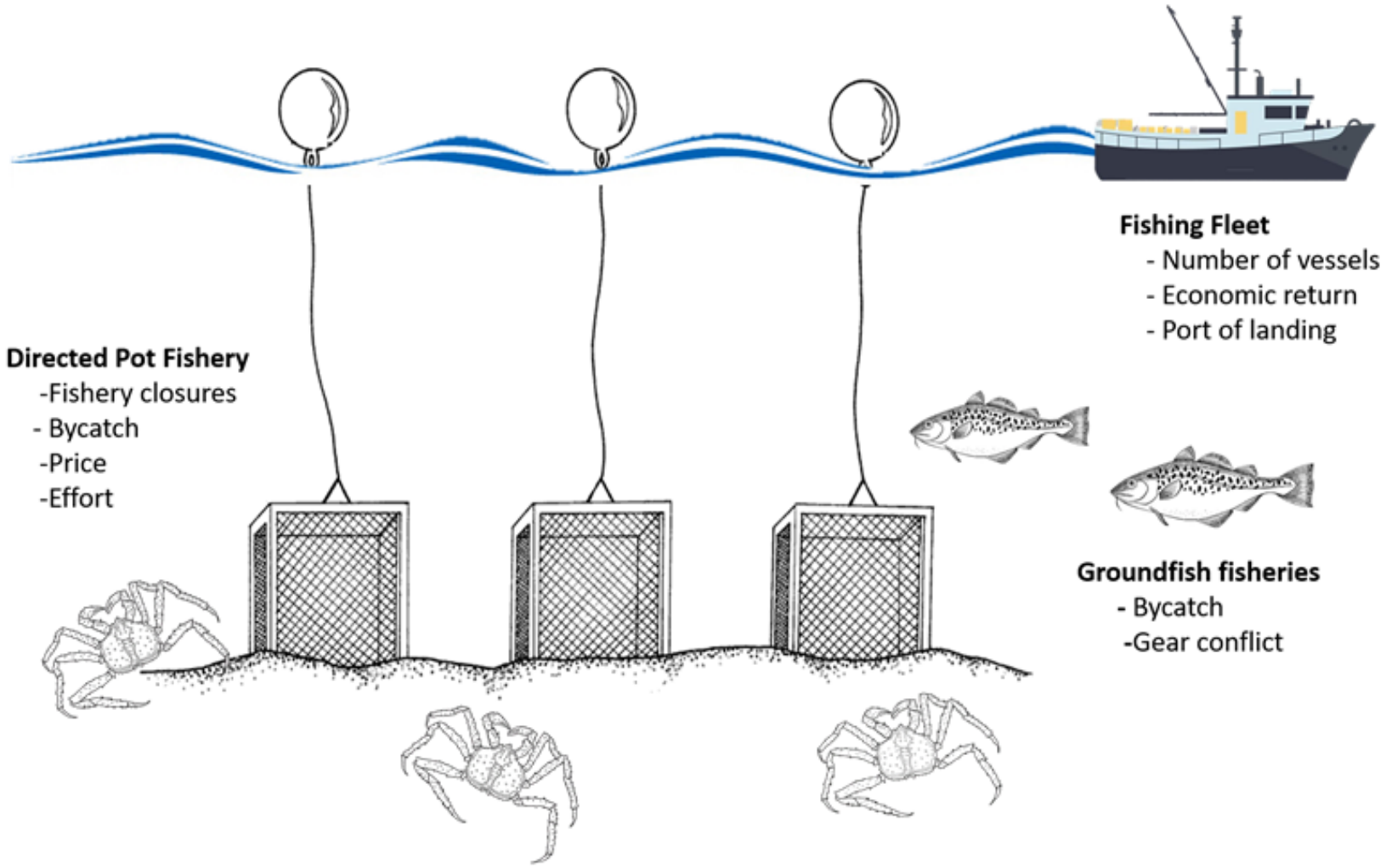

Figure 1b: Conceptual model of socioeconomic performance metrics for BBRKC that may identify dominant pressures on the Bristol Bay red king crab stock.

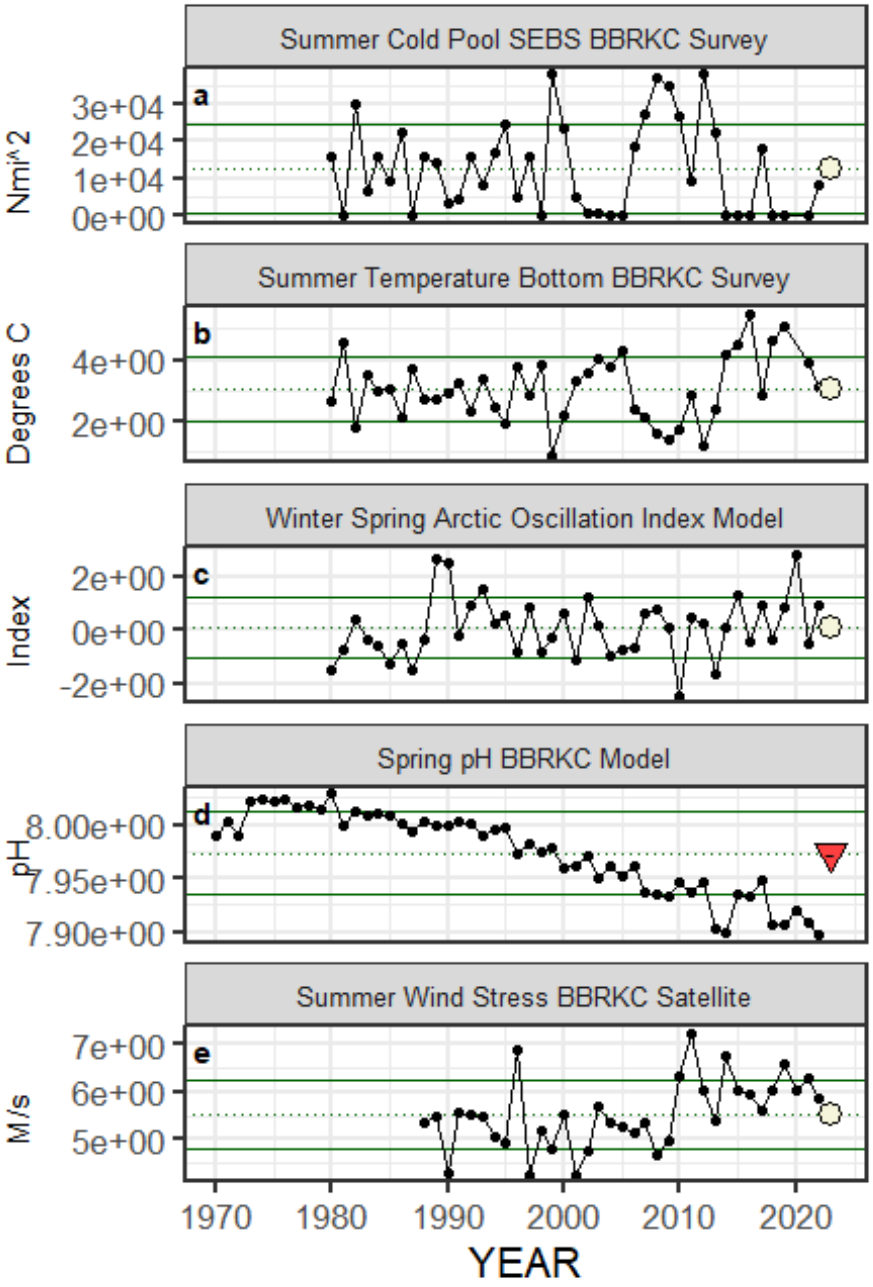

Figure 2a. Selected ecosystem indicators for BBRKC with time series ranging from 1970 – present. Upper and lower solid green horizontal lines represent 1 standard deviation of the time series mean. Dotted green horizontal line is the mean of the time series. A symbol appears when current year data are available and follows the traffic light status table designations (triangle direction represents if above or below 1 standard deviation of the time series mean, color represents proposed relationship for stock, white circle for neutral).

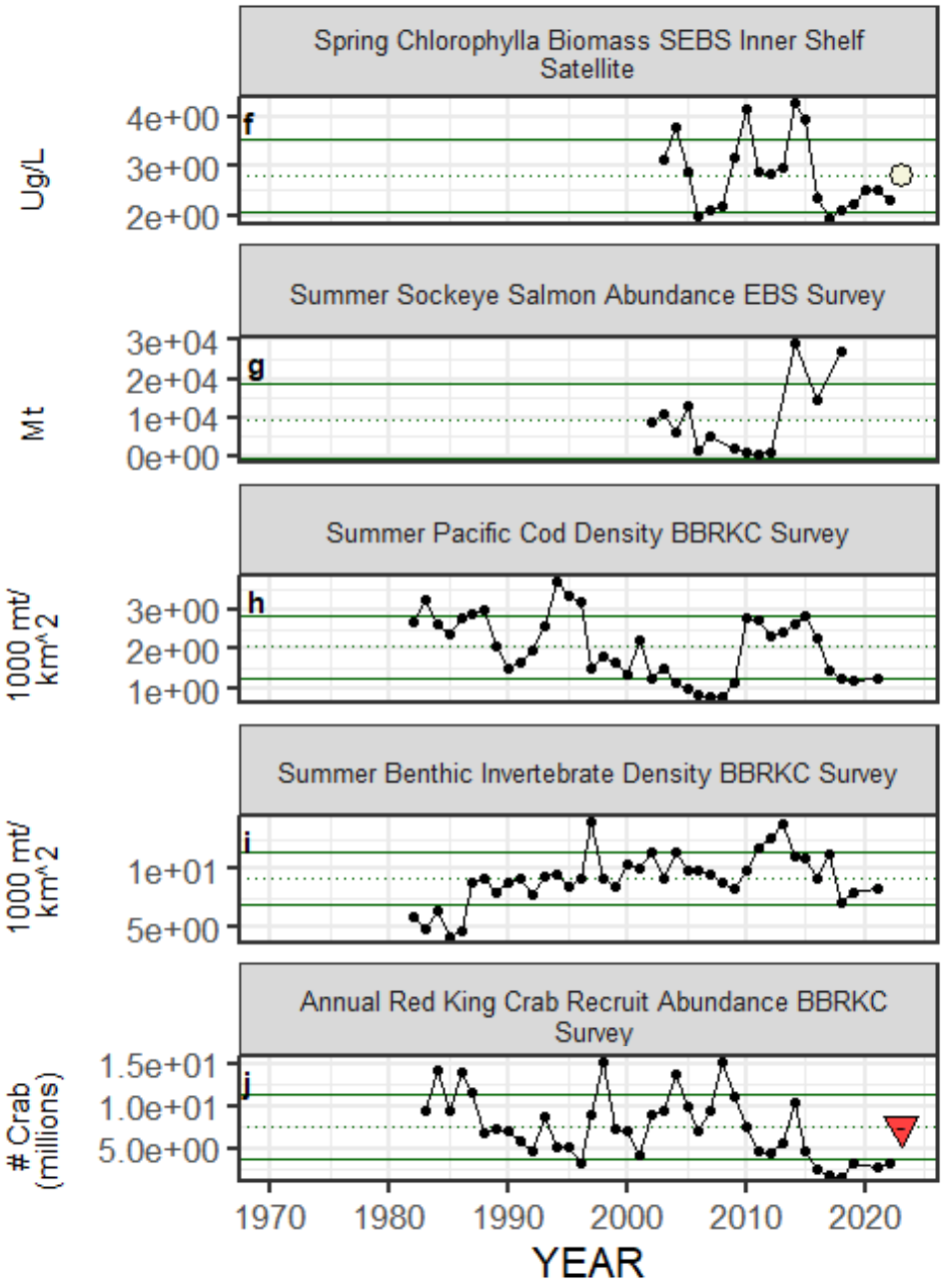

Figure 2a (cont.). Selected ecosystem indicators for BBRKC with time series ranging from 1970 – present. Upper and lower solid green horizontal lines represent 1 standard deviation of the time series mean. Dotted green horizontal line is the mean of the time series. A symbol appears when current year data are available and follows the traffic light status table designations (triangle direction represents if above or below 1 standard deviation of the time series mean, color represents proposed relationship for stock, white circle for neutral).

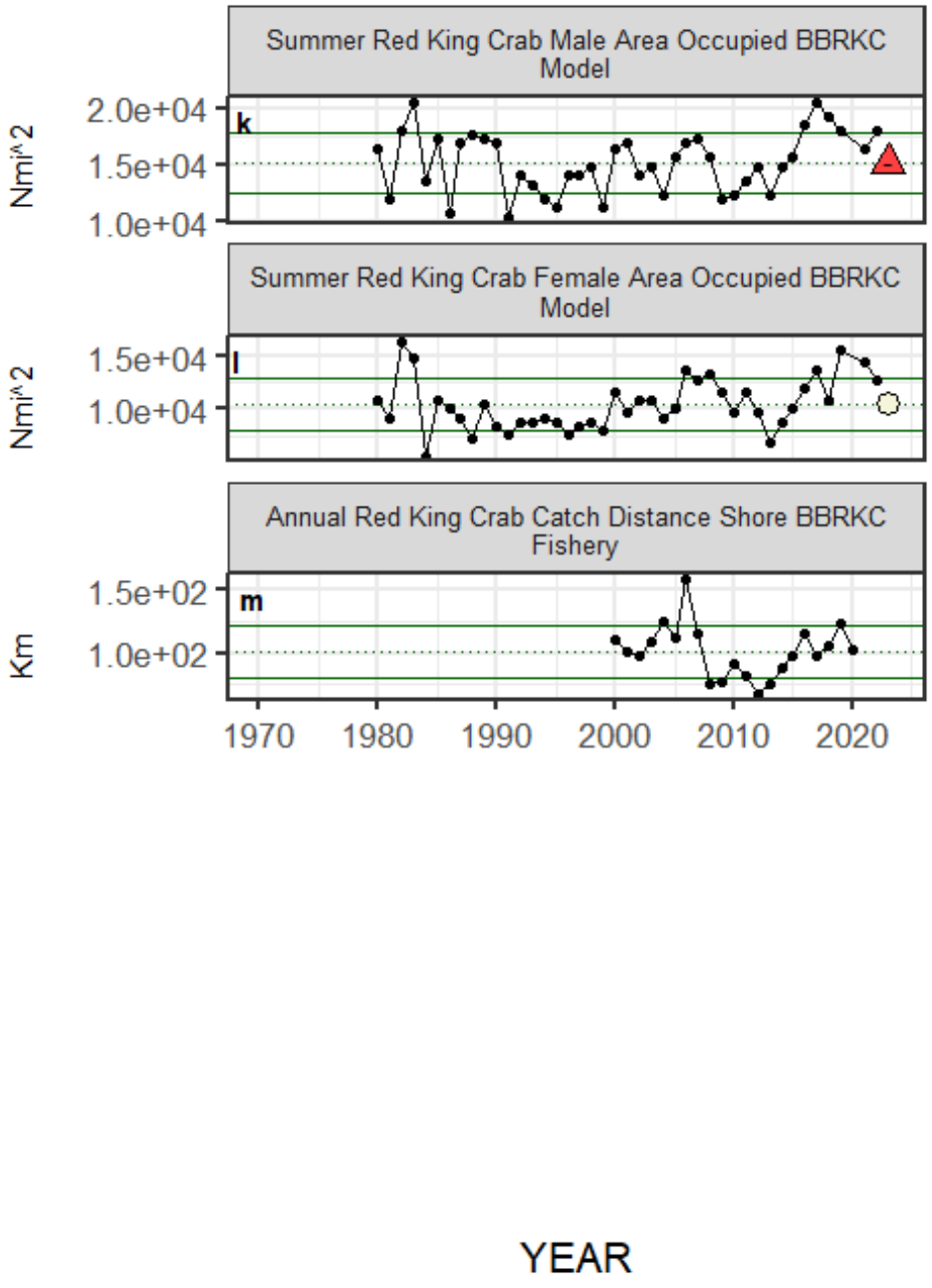

Figure 2a (cont.). Selected ecosystem indicators for BBRKC with time series ranging from 1970 – present. Upper and lower solid green horizontal lines represent 1 standard deviation of the time series mean. Dotted green horizontal line is the mean of the time series. A symbol appears when current year data are available and follows the traffic light status table designations (triangle direction represents if above or below 1 standard deviation of the time series mean, color represents proposed relationship for stock, white circle for neutral).

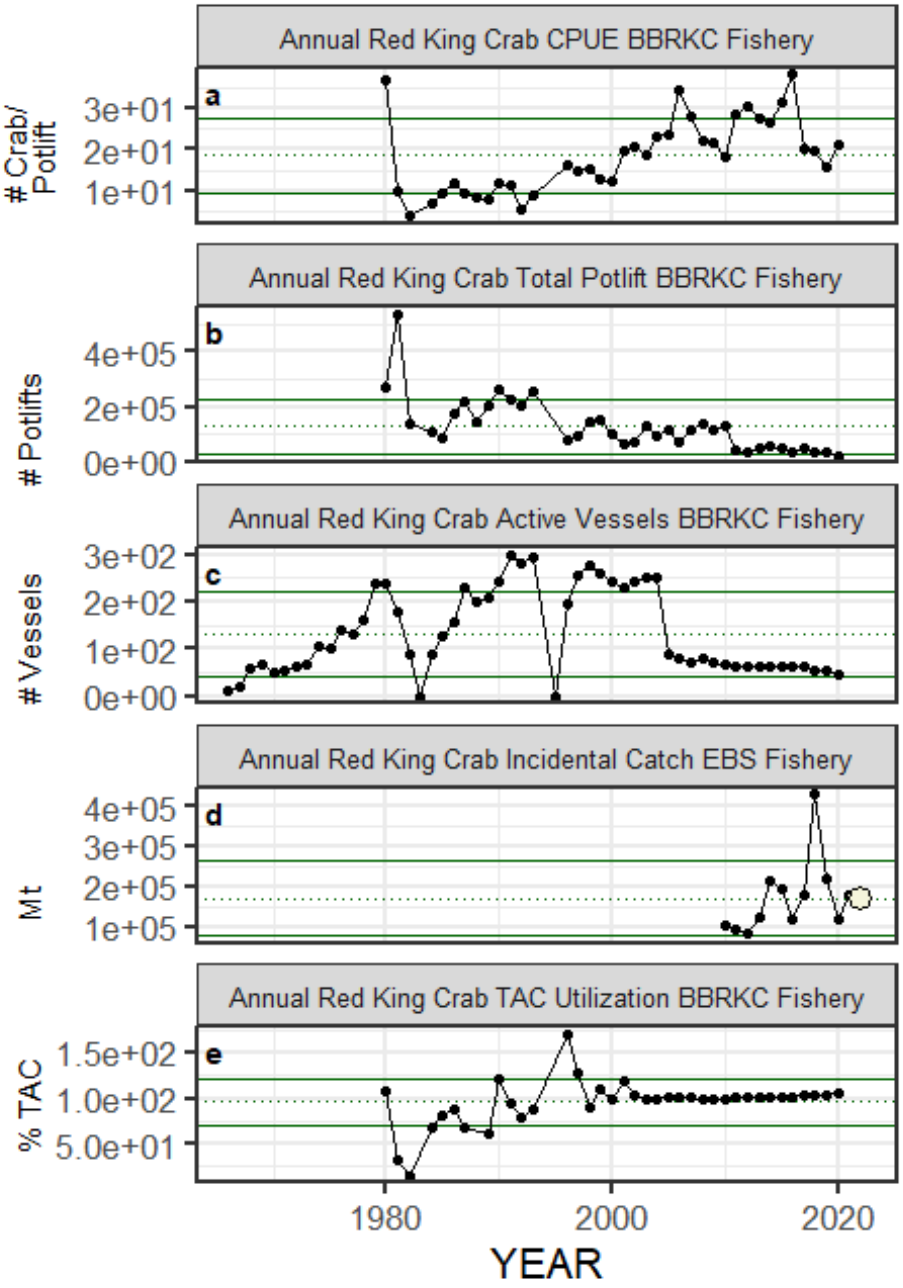

Figure 2b. Selected socioeconomic indicators for BBRKC with time series ranging from 1966 – present. Upper and lower solid green horizontal lines represent 1 standard deviation of the time series mean. Dotted green horizontal line is the mean of the time series. A symbol appears when current year data are available and follows the traffic light status table designations (triangle direction represents if above or below 1 standard deviation from the time series mean, color represents proposed relationship for stock, white circle for neutral).

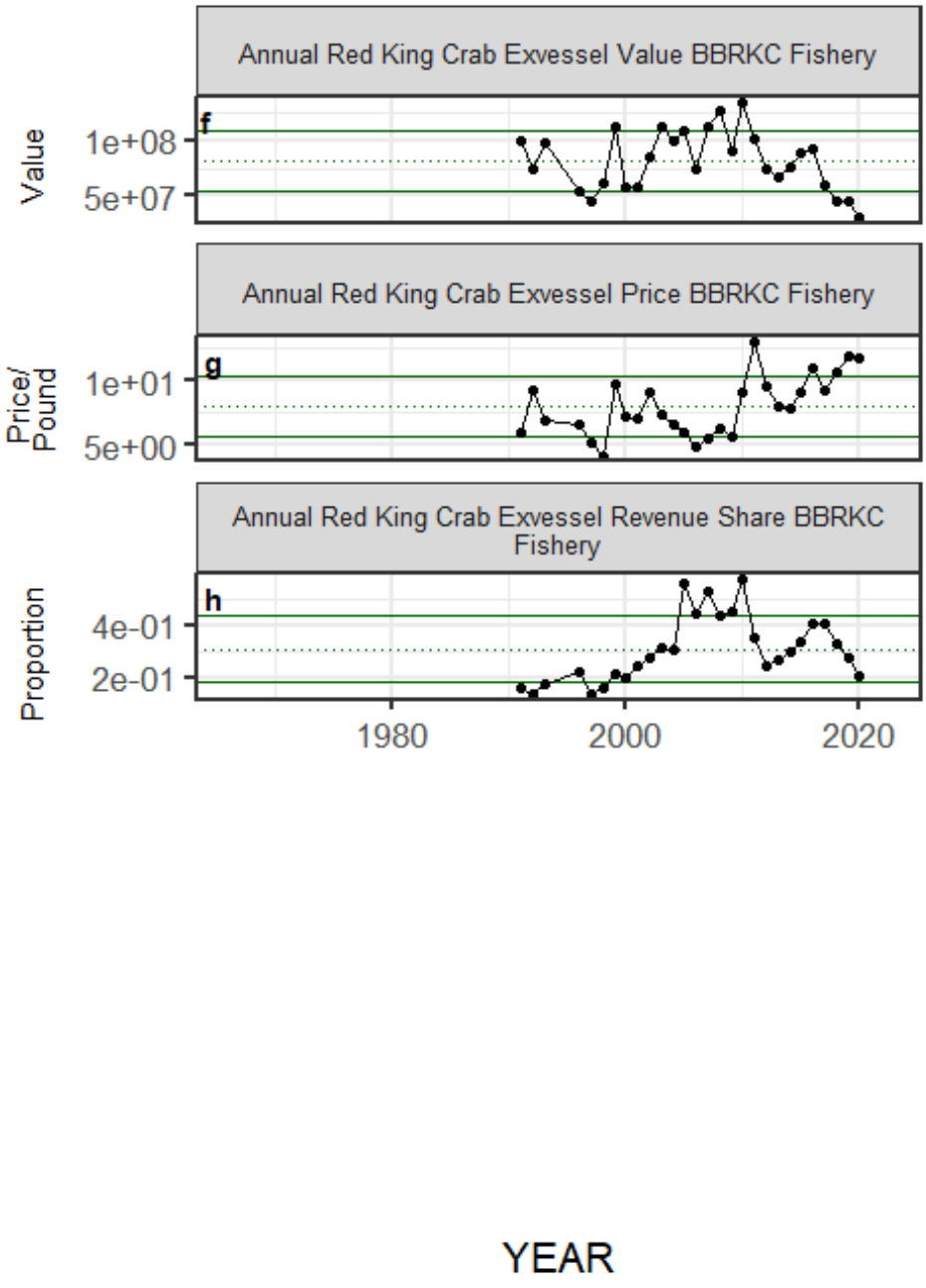

Figure 2b (cont.). Selected socioeconomic indicators for BBRKC with time series ranging from 1966 – present. Upper and lower solid green horizontal lines represent 1 standard deviation of the time series mean. Dotted green horizontal line is the mean of the time series. A symbol appears when current year data are available and follows the traffic light status table designations (triangle direction represents if above or below 1 standard deviation from the time series mean, color represents proposed relationship for stock, white circle for neutral).

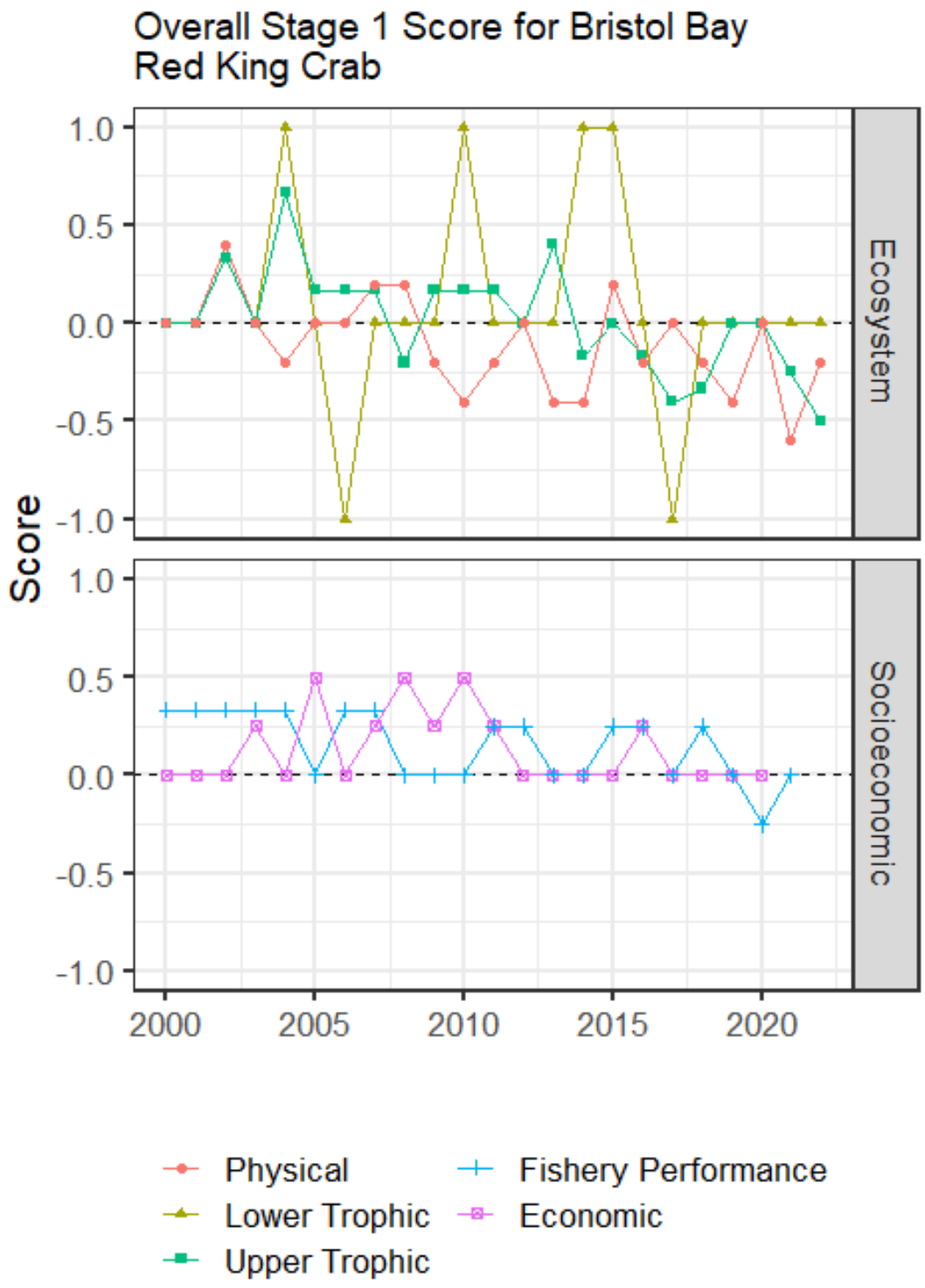

Figure 3: Simple summary traffic light score by category for ecosystem and socioeconomic indicators from 2000 to present.