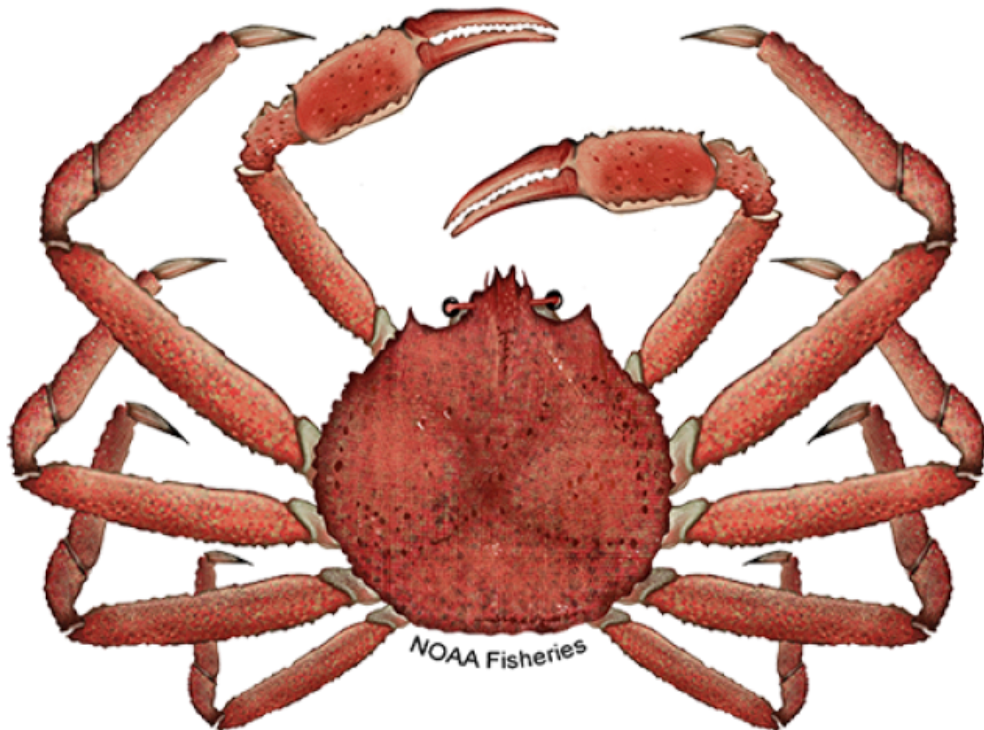# Ecosystem and Socioeconomic Profile of the Tanner Crab stock in the Eastern Bering Sea - Generalized Report Card

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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., 2023). 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.

Management Considerations

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

- Chlorophyll *a* concentration remains well below average in the south mid-outer shelf of the EBS. This suggests a less pronounced spring bloom and decline in large cell plankton like diatoms, which are a critical food source for crab larvae.
- Bottom temperature and cold pool extent are average relative to the 37-year mean following the 2018-2019 heat wave, and temperatures occupied by Tanner crab are also near-average.
- Visual prevalence of bitter crab disease increased dramatically in 2019, and peaked again in 2022, but has since declined in 2024.
- Despite depressed abundance of mature male Tanner crab from 2021 - 2023, mature male spatial extent increased and centroids of abundance have shifted northwest since 2023. Increased utilization of northern outer shelf habitats may increase competitive interactions with snow crab.
- Pacific cod density in core Tanner crab habitats reached all time lows during the 2018-2019 marine heat wave but density has increased annually since 2021, suggesting increased predator-prey interactions and reduced survival of juvenile cohorts.
- Active vessels in the BSAI Tanner crab fisheries during 2023 was moderately below the time-series average, but unchanged from the previous year and on-par with fleet size over the last five years.
- Incidental catch of Tanner crab in EBS groundfish fisheries during 2023 was the lowest in the time-series history.

Assessment

Indicator Suite

The following list of indicators for Tanner crab is organized by categories: three for ecosystem indicators (larval, juvenile, and adult) and three for socioeconomic indicators (fishery performance, economic, and community). The indicator name and short description are provided in the heading. We also include the anticipated sign of the proposed relationship between the indicator and the stock population dynamics where relevant. Following the indicator heading is a series of bullets that include information on the contact for the indicator, status and trends for the current year, factors influencing those trends, and implications for fishery management. This format follows the Ecosystem Status Reports. We use the following nomenclature when describing these indicators:

- If the value in the time series is at the long-term mean of the time series (or the mean), we use the term "average" (dotted green line in Figure 1).
- If the value is above/below the mean but below/above 1 standard deviation of the mean (solid green line in Figure 1) we use the terms "above average" or "below average".
- Any value within 1 standard deviation of the mean is considered "neutral" in Table 1.

- If the value is above/below 1 standard deviation of the mean (solid green line in Figure 1) we use the term "high" or "low".

Time series of the ecosystem and socioeconomic indicators are provided in Figure 1a and Figure 1b, respectively.

Ecosystem Indicators:

1. Larval Indicators
   a. Chlorophyll *a* Concentration: April – June average chlorophyll *a* concentration on the south outer-middle shelf of the eastern Bering Sea (BSIERP Regions 3 – 5, as containing mature female core area). Calculated with the ESA GlobColour blended satellite product (4km resolution, 8 day composite data). Proposed sign of the relationship is positive as an indicator of primary production for Tanner crab larvae.
      - Contact: Erin Fedewa

2. Juvenile Indicators
   a. Summer Bottom Temperature: Average summer bottom temperature in the eastern Bering Sea from the EBS bottom trawl survey. Proposed sign of the relationship is positive.
      - Contact: Erin Fedewa

   b. Summer Cold Pool Spatial Extent: The areal extent of the summer cold pool (nmi²) is calculated as the total area of all EBS bottom trawl survey stations with bottom temperatures < 2°C. Proposed sign of the relationship is negative.
      - Contact: Erin Fedewa

   c. Summer Tanner Crab Juvenile Temperature Occupancy: Mean juvenile Tanner crab temperature of occupancy; bottom temperature weighted by immature Tanner crab CPUE at each station of the EBS summer bottom trawl survey. Proposed sign of the relationship is positive.
      - Contact: Erin Fedewa

   d. Summer Pacific Cod Density: Summer Pacific cod density (kg/km²) estimated from EBS bottom trawl survey stations included in the 50th percentile of mean Tanner crab CPUE. Proposed sign of the relationship is negative as cod are a major predator of juvenile Tanner crab.
      - Contact: Erin Fedewa

   e. Summer Tanner Crab Juvenile Disease Prevalence: Prevalence (%) of immature Tanner crab showing visual symptoms of Bitter Crab Disease (BCD) during the summer EBS bottom trawl survey, calculated as the abundance of visually positive immature crab divided by total immature abundance. Proposed sign of the relationship is negative, as BCD is assumed to be fatal. Male maturity was determined using the annual carapace width size at which 50% of the population was mature.
      - Contact: Erin Fedewa

3. Adult Indicators
   a. Summer Benthic Invertebrate Density: Summer benthic invertebrate density (kg/km²), estimated from EBS bottom trawl survey stations included in the 50th percentile of mean Tanner crab CPUE across years (1988 - 2024). Invertebrates are subset to include species observed in Tanner

crab diet studies, and include brittle stars, sea stars, sea cucumber, bivalves, non-commercial crab species, shrimp and polychaetes. Proposed sign of the relationship is positive as a coarse scale indicator of benthic production and prey quantity for Tanner crab.

● Contact: Erin Fedewa

b. Annual Tanner Crab Size at Terminal Molt: Carapace width (mm) at 50% probability of having matured, as determined from maturity ogives developed from EBS bottom trawl survey data. Proposed sign of the relationship is positive.

● Contact: Jon Richar

c. Summer Tanner Crab Mature Male Area Occupied: The minimum area containing 95% of the cumulative mature male Tanner crab CPUE during the EBS summer bottom trawl survey. Male maturity was determined using the annual carapace width size at which 50% of the population was mature. Proposed sign of the relationship is positive.

● Contact: Erin Fedewa

d. Summer Tanner Crab Mature Male Centroid of Abundance: CPUE-weighted average longitude of the mature male Tanner crab stock during the EBS summer bottom trawl survey. Male maturity was determined using the annual carapace width size at which 50% of the population was mature. Proposed sign of the relationship is negative.

● Contact: Erin Fedewa

Socioeconomic Indicators:

1. Fishery Performance Indicators
a. Annual Tanner Active Vessels EBS Fishery: Annual number of active vessels in the Tanner crab fishery to represent the level of fishing effort assigned to the fishery

● Contact: Brian Garber-Yonts

b. Annual Tanner Incidental Catch EBS Fishery: Annual incidental catch of Tanner crab in federally-managed BSAI groundfish fisheries.

● Contact: Brian Garber-Yonts

2. Economic Indicators

3. Community Indicators

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, growth, 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 providing visibility on current research ecosystem models and may be used for testing a research

ecosystem linked stock assessment model where output can be compared with the current operational stock assessment model to understand information on retrospective patterns, prediction performance, and comparisons to model outputs.

Beginning Stage: Traffic Light Test

We use a simple scoring calculation for this beginning stage traffic light evaluation on the indicators listed in the Indicator Suite section. Please refer to Shotwell et al., 2023 for more details on the simple scoring calculation. The scores are summed by the ecosystem or socioeconomic indicator categories 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 2). We also provide five year indicator status tables with a color (ecosystem indicators only) for the relationship with the stock (Tables 1a,b). Socioeconomic indicators representing the target fishery are reported by calendar year through 2023, the most recent full calendar year.

Intermediate Stage: Importance Test

Importance tests are not available for generalized ESP report cards.

Advanced Stage: Research Model Test

We are currently not aware of any ecosystem-linked models in development for Tanner crab.

Data Gaps and Future Research Priorities

While this generalized ESP is an important first step in providing ecosystem and socioeconomic indicators for Tanner crab, a full literature review, identification of drivers of stock productivity and recruitment, and the development of an indicator suite specific to Tanner crab are critical next steps.

Tables

Table 1a. First stage ecosystem indicator analysis for snow crab, 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	2020 Status	2021 Status	2022 Status	2023 Status	2024 Status
Larval	Chlorophyll *a* Concentration	neutral	**low**	neutral	**low**	**low**
Juvenile	Summer Bottom Temperature	NA	neutral	neutral	neutral	neutral
	Summer Cold Pool Extent	NA	*low*	neutral	neutral	neutral
	Summer Juvenile Tanner Temperature of Occupancy	NA	neutral	neutral	neutral	neutral
	Summer Pacific Cod Density	NA	*low*	neutral	neutral	neutral
	Summer Juvenile Tanner Disease Prevalence	NA	neutral	**high**	**high**	neutral
Adult	Summer Benthic Invertebrate Density SEBS Tanner Survey	NA	neutral	neutral	neutral	neutral
	Tanner Male Size at Terminal Molt	NA	neutral	neutral	**low**	neutral
	Summer Tanner Male Area Occupied	NA	neutral	neutral	*high*	*high*
	Summer Tanner Male Center of Abundance	NA	neutral	neutral	*low*	*low*

Table 1b: First stage socioeconomic indicator analysis for snow crab, 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. A red color indicates a fishery closure and the text = "Closed" will appear.

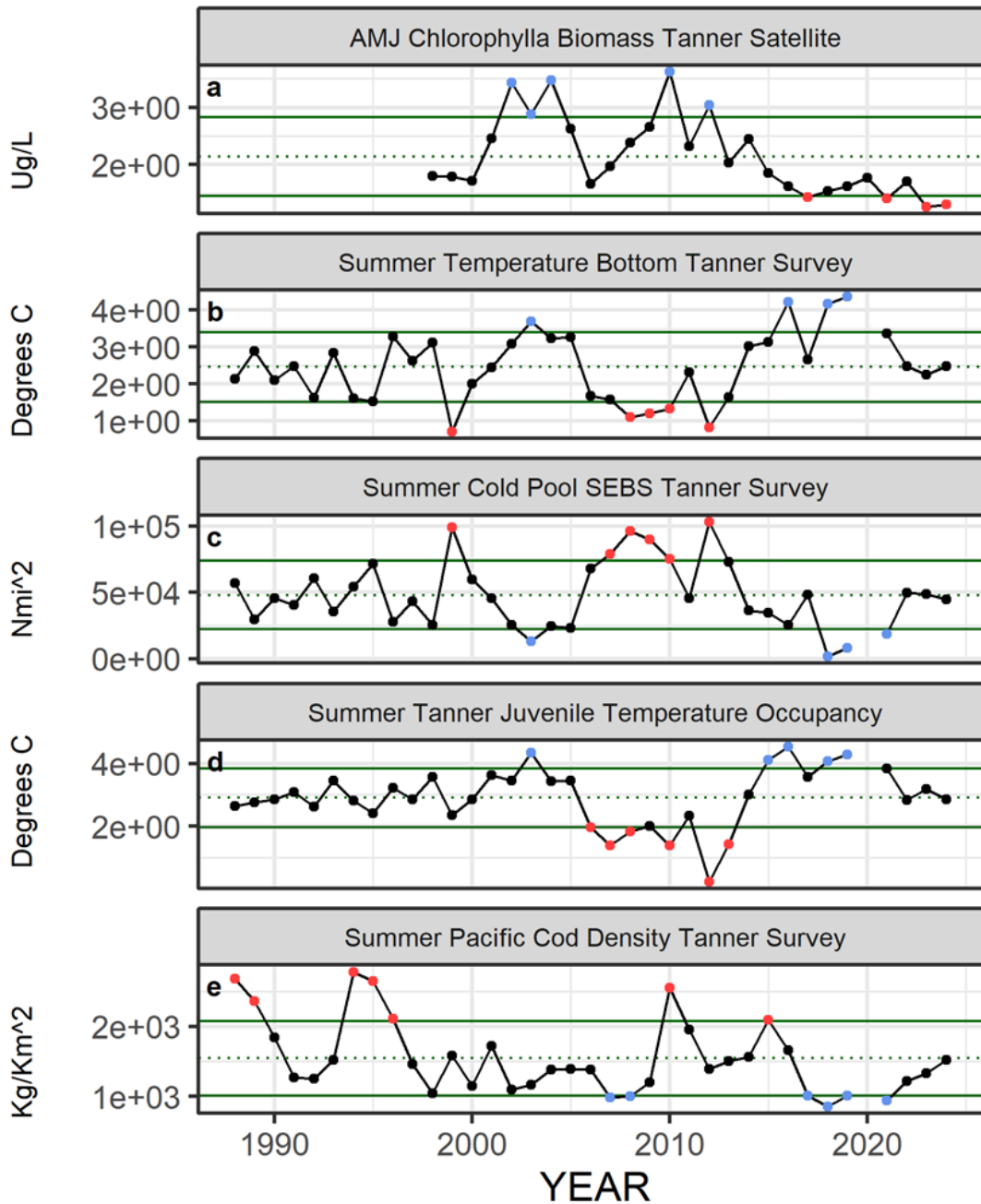| Indicator category	Indicator	2019 Status	2020 Status	2021 Status	2022 Status	2023 Status
Fishery Performance	Annual Tanner Active Vessels	neutral	neutral	neutral	neutral	neutral
	Annual Tanner Incidental Catch	low	neutral	neutral	neutral	low

Figures

Figure 1a. Selected ecosystem indicators for Tanner crab 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. Dots in the time series are colored if above or below 1 standard deviation of the time series mean and the color represents the proposed relationship for stock (blue for good conditions, red for poor conditions), black circle for neutral. If "NA" then a gap will appear in the time series.
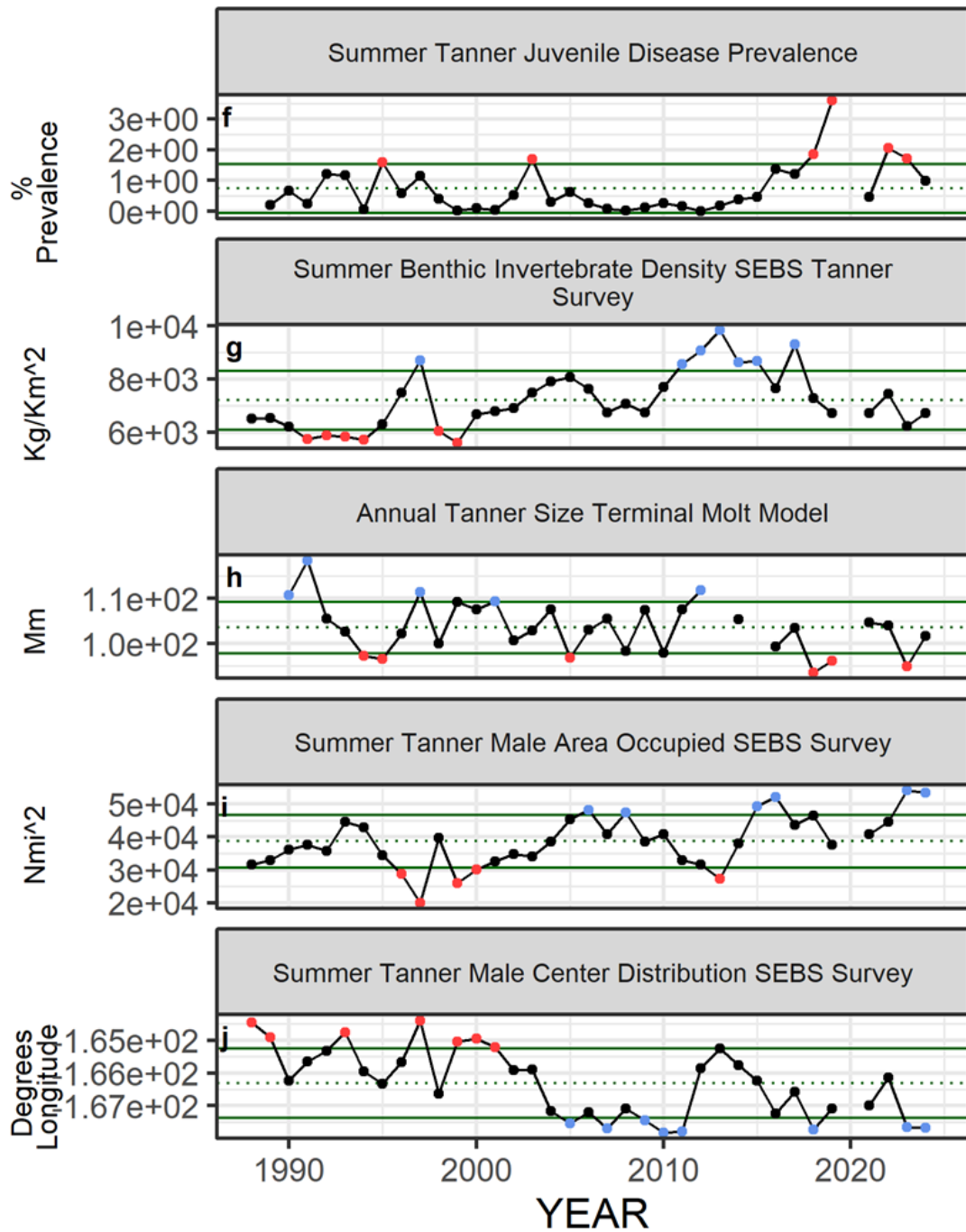
Figure 1a (cont.). Selected ecosystem indicators for Tanner crab with time series ranging from 1970 – present. Upper and lower solid green horizontal lines represent 1 standard deviation of the time series mean. Dotted green horizontal line is the mean of the time series. Dots in the time series are colored if above or below 1 standard deviation of the time series mean and the color represents the proposed relationship for stock (blue for good conditions, red for poor conditions), black circle for neutral. If "NA" then a gap will appear in the time series.
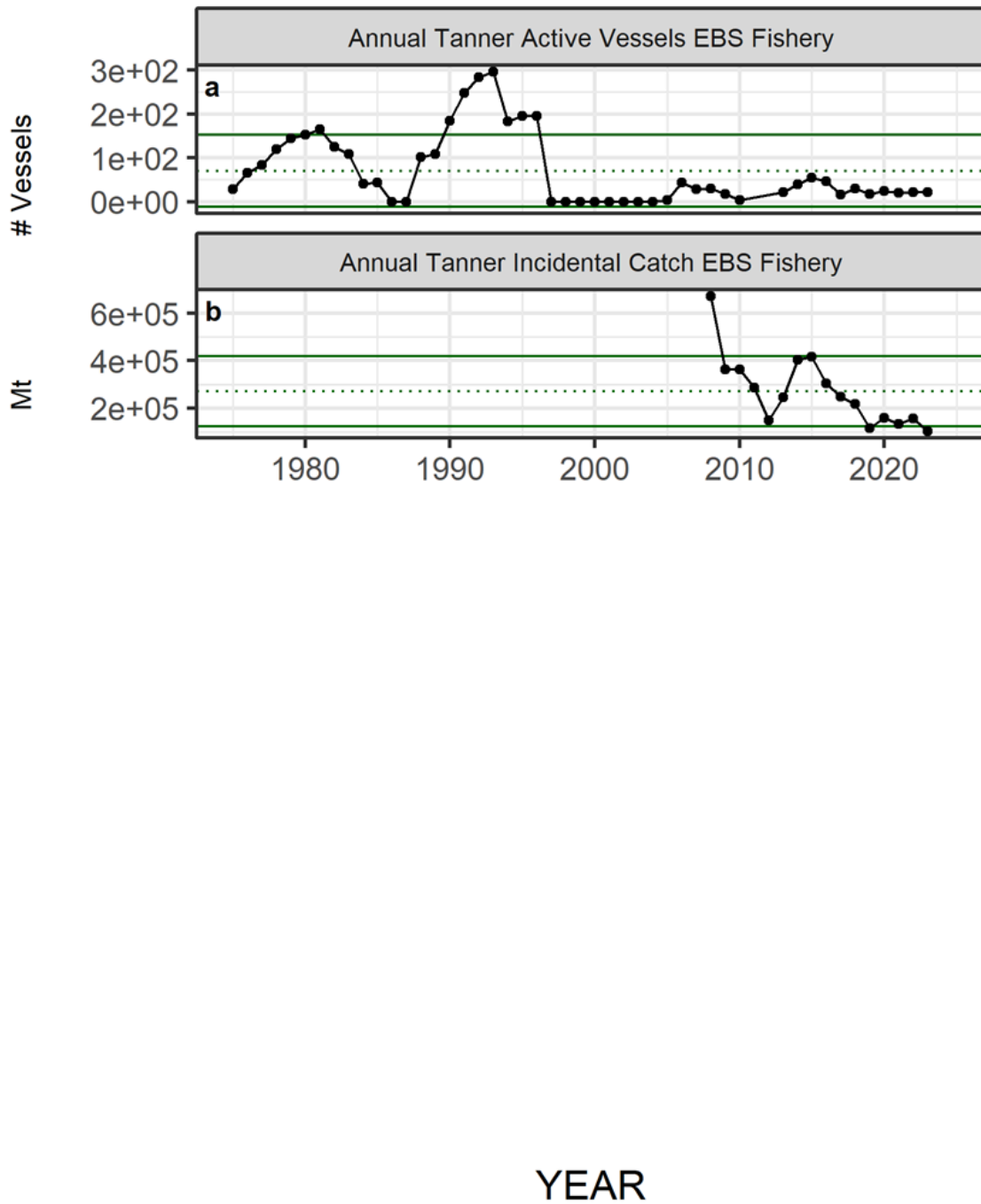
Figure 1b. Selected socioeconomic indicators for Tanner crab with time series ranging from 1977 – present. Upper and lower solid green horizontal lines represent 1 standard deviation of the time series mean. Dotted green horizontal line is the mean of the time series. If "NA" then a gap will appear in the time series.
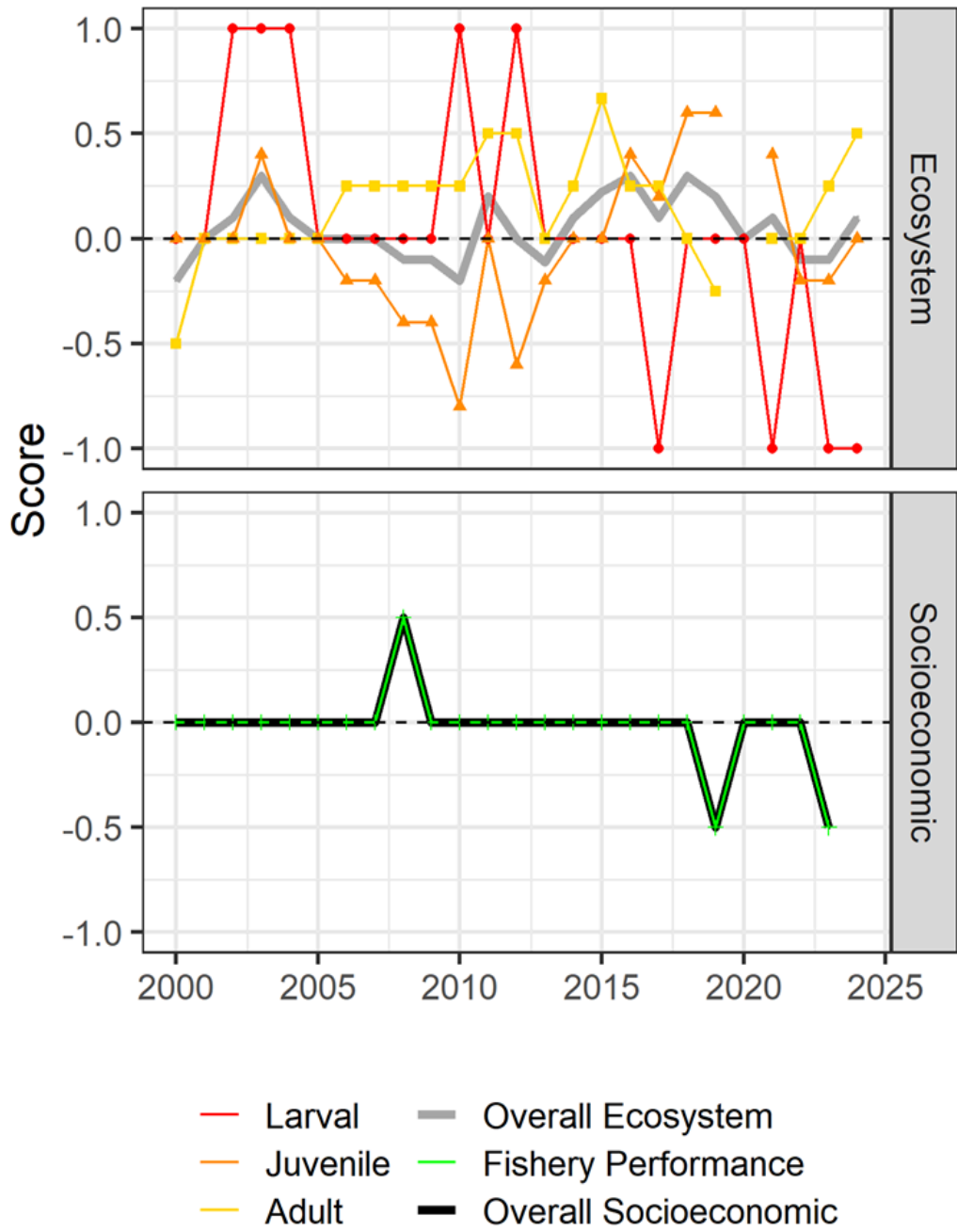
Figure 2. Simple summary traffic light score by category and overall for ecosystem and socioeconomic indicators from 2000 to present.