The University of Rhode Island
Graduate School of Oceanography

2017 ANNUAL FISH TRAWL SURVEY REPORT

The Graduate School of Oceanography (GSO) Fish trawl survey began weekly sampling two stations in Narragansett Bay, Rhode Island, USA weekly in 1959. One station is located in the mid-bay, near Fox Island, at about 7m depth; the other station is located in the lower bay, near Whale Rock, at about 23 meters depth (Fig. 1, Collie et al. 2008).

Weekly sampling was missed occasionally for poor weather conditions and boat repair. Of the 708 months since the start of the survey in 1959 through 2017, all but ten contained two or more surveys; 96% had three or more surveys. The GSO trawl survey recorded numerous changes in the bay over the last five decades including water temperature and species composition. The following report contains a brief summary of the data including updates of the most recent survey publication, Collie et al. (2008).

Sea surface temperatures

Surface and bottom water temperatures were recorded at the beginning of each trawl. A Niskin bottle and bucket thermometer was used until 2006; since then, a conductivity, temperature, and depth (CTD) probe began use through the present. Water temperatures at both stations warmed by about approximately 2°C between 1959 and 2017 (Fig. 1).

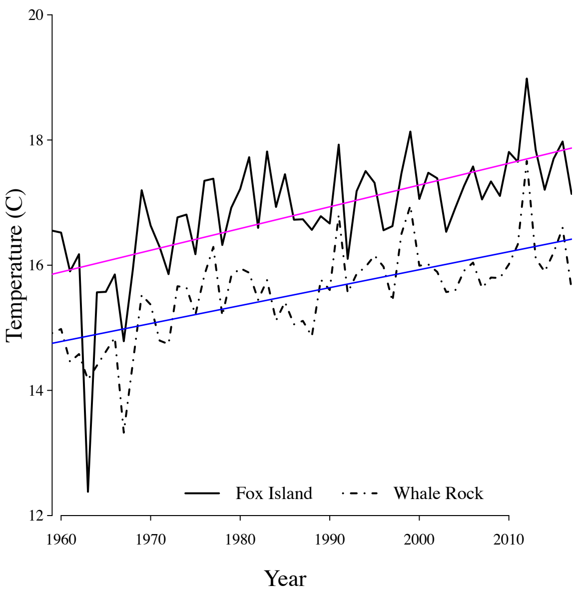


Figure 1. Average spring-summer sea surface temperature and corresponding linear regression lines (mid-bay station, solid lines; lower bay station, broken lines) (based on Fig. 7a, Collie et al. 2008).

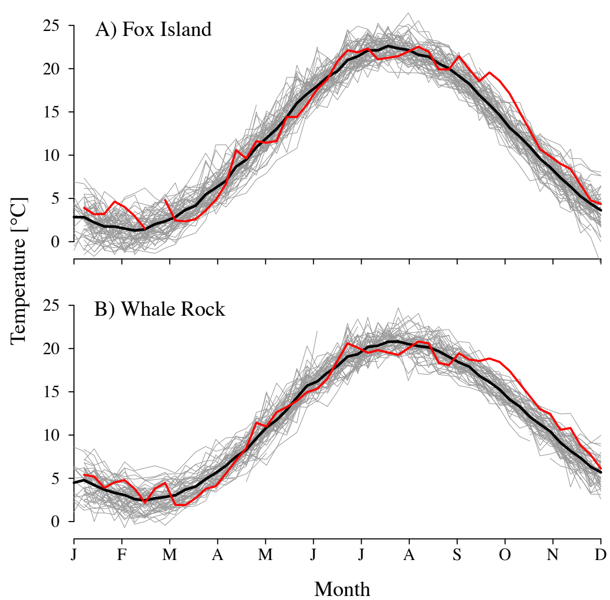


Figure 2. Weekly sea surface temperature at Fox Island (a) and Whale Rock (b). Time series mean weekly temperature (black), individual year weekly temperatures (gray), 2017 (red).

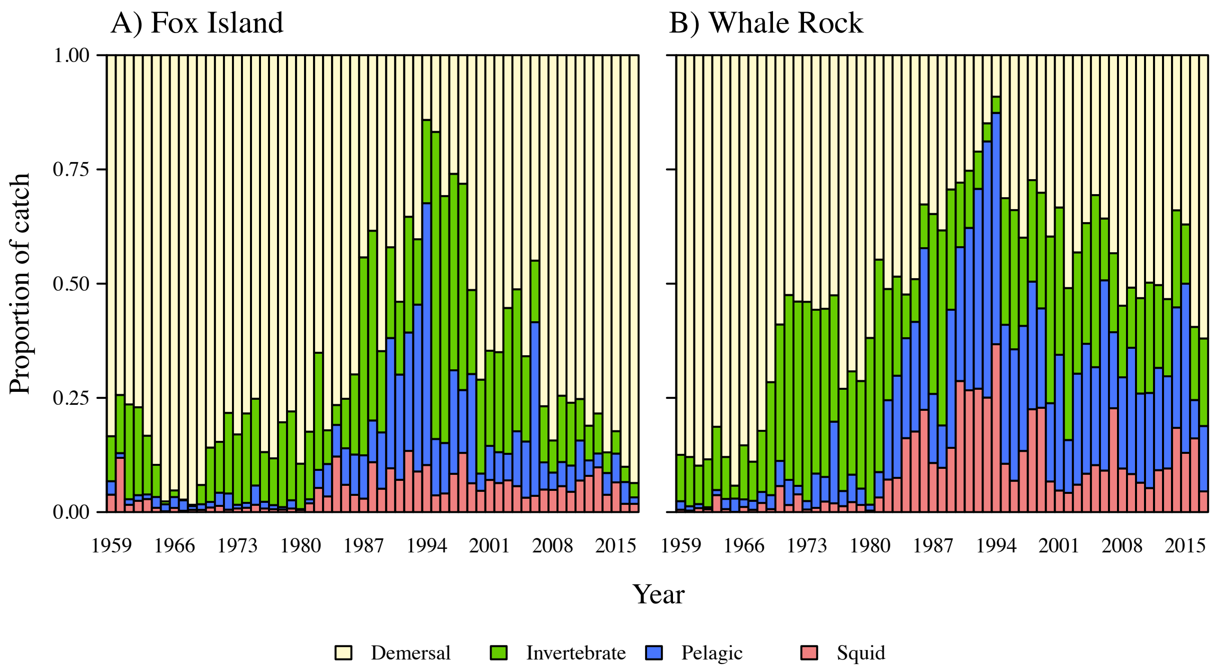
Average weekly sea surface temperatures ranged from about 2°C in winter to 23°C in summer (Fig. 2). The most recent year, 2017, was comparable to the weekly mean from previous years with an abnormally warm fall and early February (Fig. 2).

Species composition (based on Collie et al. 2008)

Species composition in Narragansett Bay changed several times over the last five decades (Collie et al. 2008). Here, the top 25 species (as determined in Collie et al. 2008) are used to summarize changes in the bay.

Catch composition shifted from mostly demersal fish species in the first twenty years to more pelagic and squid species from the 1980s through present (Fig. 3). The proportion of pelagic species declined slightly in the past ten years, possibly indicating a shift back towards a demersal fish species dominated system. Furthermore, comparisons of annual species compositions at both stations indicate two clusters of 60% similar years, corresponding to the demersal and pelagic species regimes (Fig. 4). The similarity comparison also indicates that the present annual trajectory may be leading to a third species composition regime in the future (Fig. 4).

Figure 3. Shifts in the relative abundance of species at (a) mid-bay station and (b) lower bay station (based on Fig. 2, Collie et al. 2008)



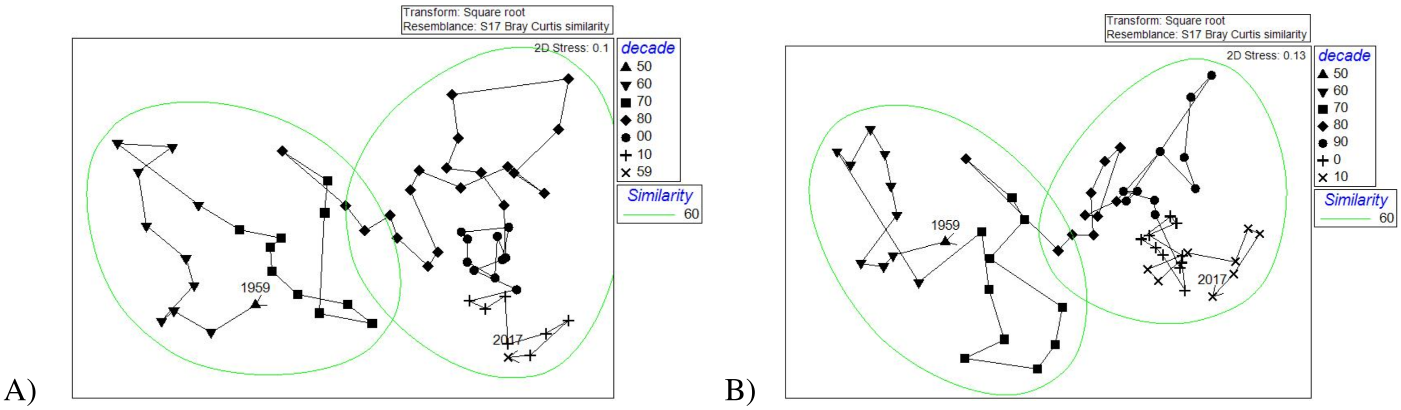


Figure 4. Ordination of abundances of 25 species in 59 years: (a) mid-bay station (Fox Island); (b) lower bay station (Whale Rock). The non-metric multidimensional scaling (MDS) was based on the Bray-Curtis similarity of square-root-transformed data. Each point represents one year; points that are closer to together have more similar species composition than distant points. Symbols indicate the decades: inverted triangles, 1960s; squares, 1970s; diamonds, 1980s; circles, 1990s; crosses, 2000s; Xs, 2010s. The contours enclose clusters with > 60% similarity (based on Fig. 3, Collie et al. 2008).

Most species changed abundance dramatically since 1959 (Fig. 4; Collie et al. 2008). This suggests that the changes in species composition were driven by large magnitude shifts in the dominant bay species. Additionally, the nine species accounting for most of the shifts in the bay indicated dramatic changes in annual mean catch per tow (Fig. 6).

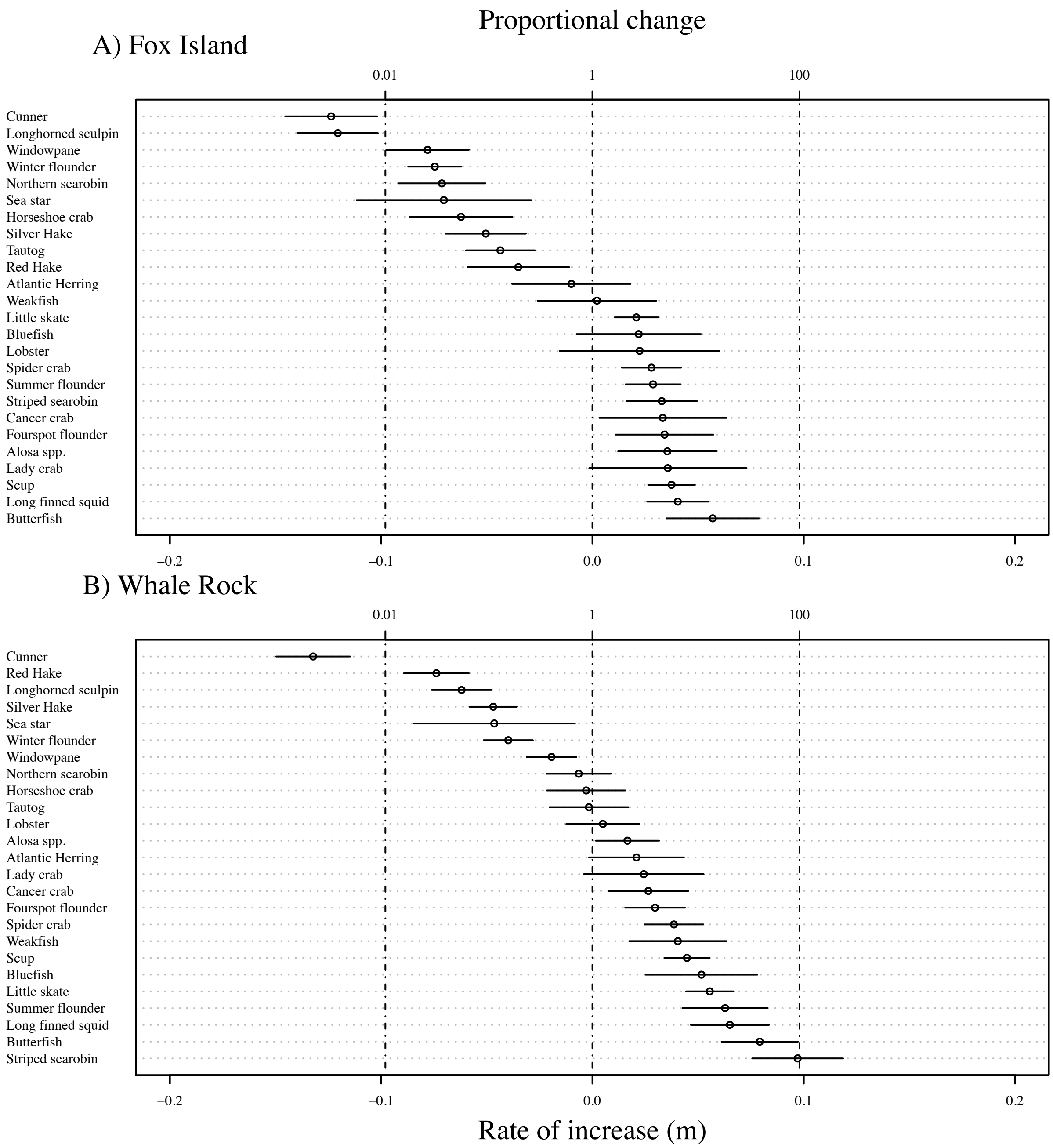


Figure 5. Rates of increase or decrease of 25 species: (a) mid-bay station; (b) lower bay station. The open circles represent the slopes (m) from regression of log-transformed abundances against time; the horizontal solid lines are the 95% confidence intervals of the slopes. The broken vertical lines indicate a 100-fold decrease (0.01), no change (1), and 100-fold increase (100) (based on Fig. 4, Collie et al. 2008).

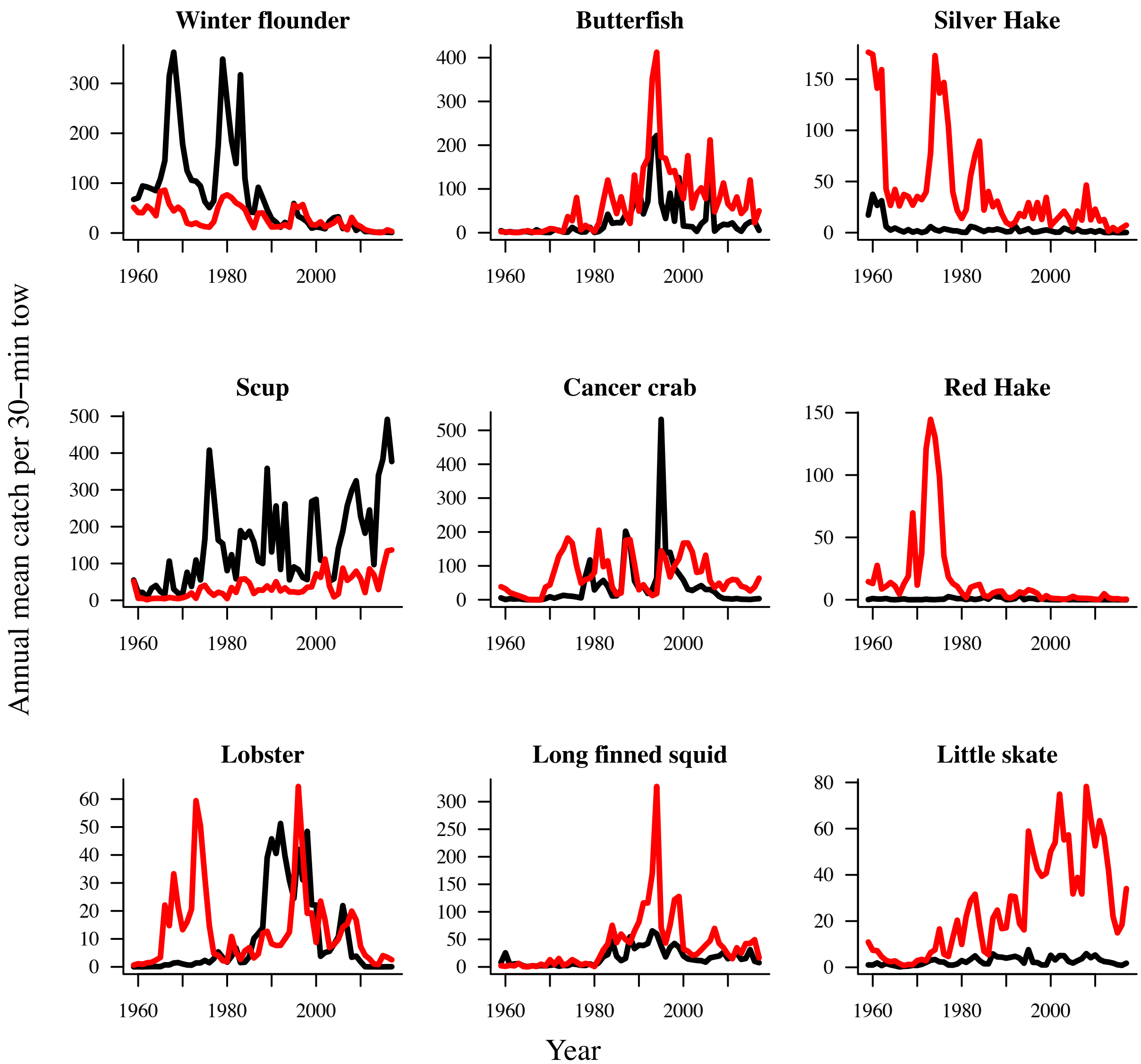


Figure 6. Annual mean abundances of the nine species that are primarily responsible for the ordinations in Fig. 3: mid-bay station, black; lower bay station, red. These nine species account for most of the pattern at the mid-bay station. The six species in the middle and right columns explain the pattern seen at the lower bay station (based on Fig. 5, Collie et al. 2008).

Mean catch per tow of all 25 species increased at both stations over the time series (Fig. 7a). Peak abundances were reached sometime between 1993 and 1995 and have declined since. Despite variability, there seemed to be an increase in taxonomic distinctness since 1959 (Fig. 7b). Annual pelagic-demersal ratios indicate a shift to pelagic species at both stations by the mid-1990s (Fig. 7c). Despite catch per tow increasing since 1959, species caught in recent years have smaller body size (Fig. 7d). Weighted mean maximum length declined at both stations. Weighted temperature preferences also increased at both stations, indicating the species caught in recent years tend to prefer warmer temperatures that are more commonly found in the bay (Fig. 1, 7e, 7f).

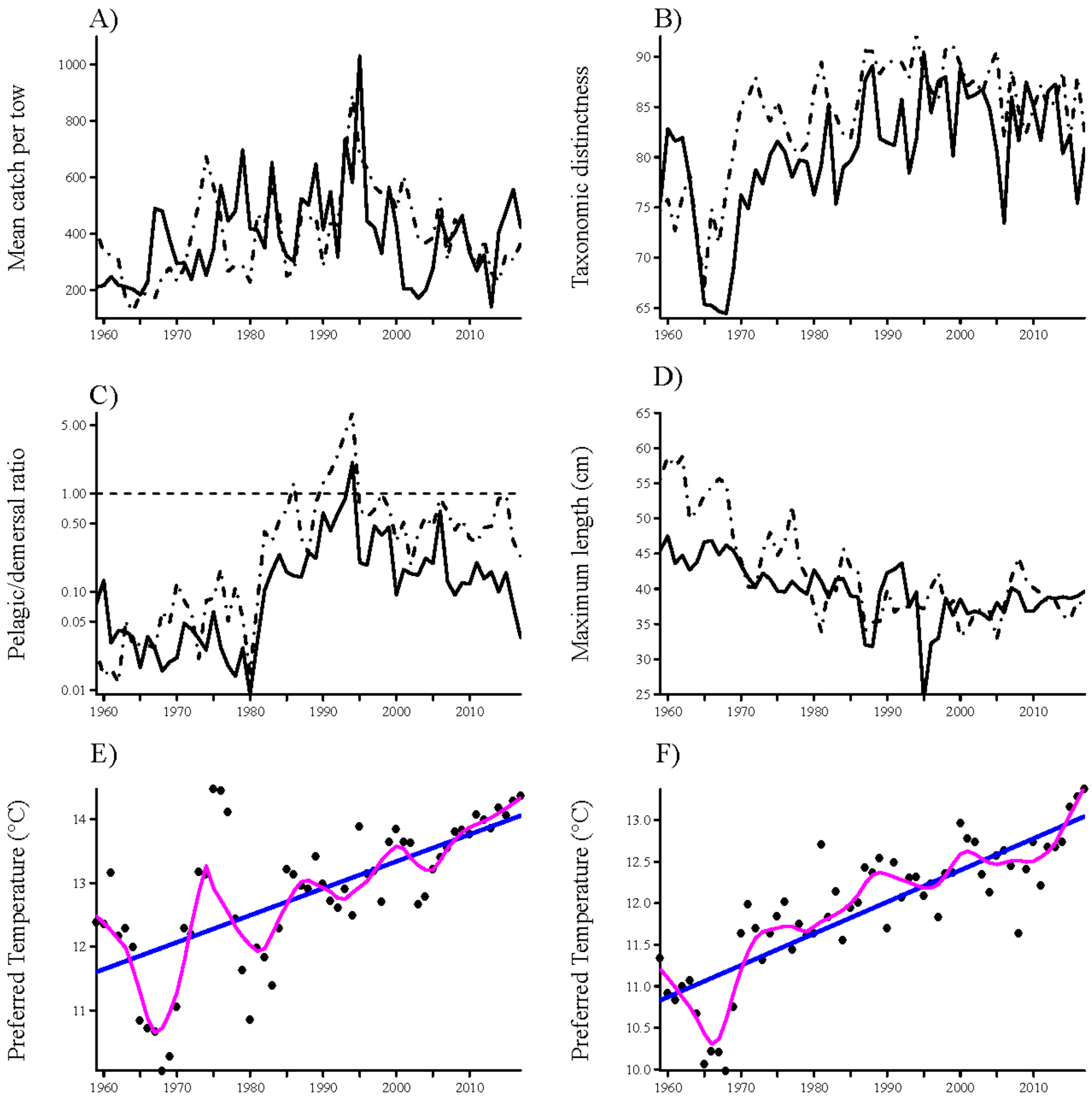


Figure 7. Community metrics calculated for the mid-bay station (solid lines) and lower bay station (broken lines): (a) total mean catch pet 30-min tow; (b) taxonomic distinctness; (c) pelagic-demersal ratio; (d) weighted mean maximum length, L_{max}; (e and f) weighted mean preferred temperature, T_{pref}, at (e) the mid-bay station and (f) the lower bay station. The violet lines in (e) and (f) are lowess smoothers and the blue lines are the linear time trends (based on Fig. 6, Collie et al. 2008).

2017: The most recent year

Sampling was severely limited during the beginning of 2017. Just three sampling trips occurred between January 1 and May 2 using the R/V John H. Chafee. In total, there were 14 weeks of missed tows. Fortunately, this time period typically produces very little catch for most species. After the missing data were replaced, the mean preferred temperature of the lower-bay community was the highest ever estimated. 2017 was also unique because summer-like water surface temperatures extended well into the fall, resulting in one of the warmest Septembers ever recorded. No new species were encountered during the year but notable catches include a pinfish, 2 hogchoker, and three adult cod during the 3 winter sampling trips.

The missing data for 2017 was replaced in the following ways:

Other than sampling on 1/25/17, 1/30/17, and 2/6/17:

A. The number of organisms caught at <u>each station separately</u> during the entire time period was replaced in one of two ways.

1. For species generally caught in the survey during the beginning of the missing data period but not at the end (March-April), we calculated the mean proportion of the year's total caught during the gap over previous 7 years (p7) after normalizing each year to ensure equal weighting. We then multiplied (1 - p7) by the number caught in 2016 since May 1st to estimate how many individuals we expected to catch during the time period.
2. For species generally caught in the survey during the end of the missing data period but not the beginning, and species caught consistently throughout the gap, we calculated the mean proportion of the year's total caught during the gap over the previous 7 years (p7) after normalizing each year to ensure equal weighting. We then multiplied (1-p7) by the number caught in the remainder of 2017 to estimate how many individuals we expected to catch during the time period.

B. Next we distributed the catch by week in one of two ways:

1. For species generally caught in the survey during the beginning of the missing data period but not the end (March-April), we calculated the mean weekly cumulative sum since May 1 over the previous 7 years after normalizing each year to ensure equal weighting. We then calculated expected weekly catch rounded to the nearest whole fish based on the mean weekly cumulative sum and expected total sum from part A.
2. For species generally caught in the survey during the end of the missing data period but not the beginning, and species caught consistently throughout the gap, we calculated the mean weekly cumulative sum since January 1 over the previous 7 years after normalizing each year to ensure equal weighting. We then calculated expected weekly catch rounded to the nearest whole fish based on the mean weekly cumulative sum and expected total sum from part A.

C. The biomass of each species caught was calculated by multiplying the expected number caught each week by the mean individual weight over the previous 7 years after standardizing each year to ensure equal weighting

D. The water quality data for Fox Island was replaced using data from the GSO weekly Plankton Survey. Surface temperatures at Whale Rock were replaced with observations at NOAA weather bouy NWPR1 located in the East Passage off of Newport. Bottom temperatures at Whale Rock were then estimated with a Generalized Additive Model using a factor for stations and 2 predictors, a spline fit to the day-of-year and a spline fit to surface temperature (in this case the NOAA buoy data). This model explains nearly 98% of the deviance in bottom temperature over the history of the trawl survey.

The following species were likely affected by the gap and were replaced with values as calculated above:

Station	Species
FI	WINTER FLOUNDER (Pseudopleuronectes americanus)
FI	SUMMER FLOUNDER (Paralichthys dentatus)
FI	SQUID (Loligo peali)
FI	SPOTTED HAKE (Urophycis regia)
FI	SPONGE (Suberites spp)
FI	SPIDER CRAB (Libinia emarginata)
FI	SMALLMOUTH FLOUNDER (Etropus microstomus)
FI	SILVERSIDE (Menidia menidia)
FI	SILVER HAKE (Merluccius bilinearis)
FI	SAND FLOUNDER (Scophthalmus aquosus)
FI	ROCK CRAB (Cancer irroratus)
FI	MENHADEN (Brevootia tyrannus)
FI	LOBSTER (Homarus americanus)
FI	LITTLE SKATE (Raja erinacea)
FI	HORSESHOE CRAB (Limulus polyphemus)
FI	HERMIT CRABS (Pagurus pollicaris)
FI	CONCH (Busycon canaliculatum & B. carica)
FI	COCKLE
FI	ATLANTIC (SEA) HERRING (Clupea harengus harengus)
FI	ALEWIFE (Alosa pseudoharengus)
WR	WINTER FLOUNDER (Pseudopleuronectes americanus)
WR	TAUTOG (Tautoga onitis)
WR	SUMMER FLOUNDER (Paralichthys dentatus)
WR	STRIPED SEAROBIN (Prionotus evolans)
WR	STRIPED BASS (Morone saxatilis)
WR	SQUIRREL (RED) HAKE (Urophycis chuss)
WR	SQUID (Loligo peali)
WR	SPOTTED HAKE (Urophycis regia)
WR	SPIDER CRAB (Libinia emarginata)
WR	SMALLMOUTH FLOUNDER (Etropus microstomus)
WR	SILVER HAKE (Merluccius bilinearis)
WR	SCUP (Stenotomus chrysops)
WR	SAND FLOUNDER (Scophthalmus aquosus)
WR	ROCK CRAB (Cancer irroratus)
WR	NORTHERN SEAROBIN (Prionotus carolinus)
WR	MENHADEN (Brevootia tyrannus)
WR	LONGHORN SCULPIN (Myoxocephalus octodecimspinosus)
WR	LOBSTER (Homarus americanus)
WR	LITTLE SKATE (Raja erinacea)
WR	JUVENILE SKATE (unidentifiable)

WR	JONAH CRAB (Cancer borealis)
WR	HORSESHOE CRAB (Limulus polyphemus)
WR	HERMIT CRABS (Pagurus pollicaris)
WR	GOOSEFISH (Lophius americanus)
WR	FOURSPOT FLOUNDER (Paralichthys oblongus)
WR	CRAB (Neopanope texana sayi)
WR	BUTTERFISH (Peprilus triancanthus)
WR	BLUE CRAB (Callinectes sapidus)
WR	ATLANTIC (SEA) HERRING (Clupea harengus harengus)
WR	ALEWIFE (Alosa pseudoharengus)

References

Collie, J. S., Wood, A. D., & Jeffries, H. P. (2008). Long-term shifts in the species composition of a coastal fish community. Canadian Journal of Fisheries and Aquatic Sciences, 65(7), 1352-1365.