Elkhorn Slough, California:
STATE OF THE ESTUARY REPORT

A report on temporal trends in estuarine indicators monitored by the Elkhorn Slough National Estuarine Research Reserve

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How are different indicators of estuarine ecosystem health changing over time?

The focus of this report is on changes over time, using long-term monitoring data to detect trends in indicators that would suggest that aspects of ecosystem health or function at Elkhorn Slough are improving, degrading, or remaining stable. These monitoring data have been used to detect crises and stimulate management intervention, to identify local vs. regional patterns, to serve as baselines for restoration projects, and to correlate trends to weather patterns or human actions.

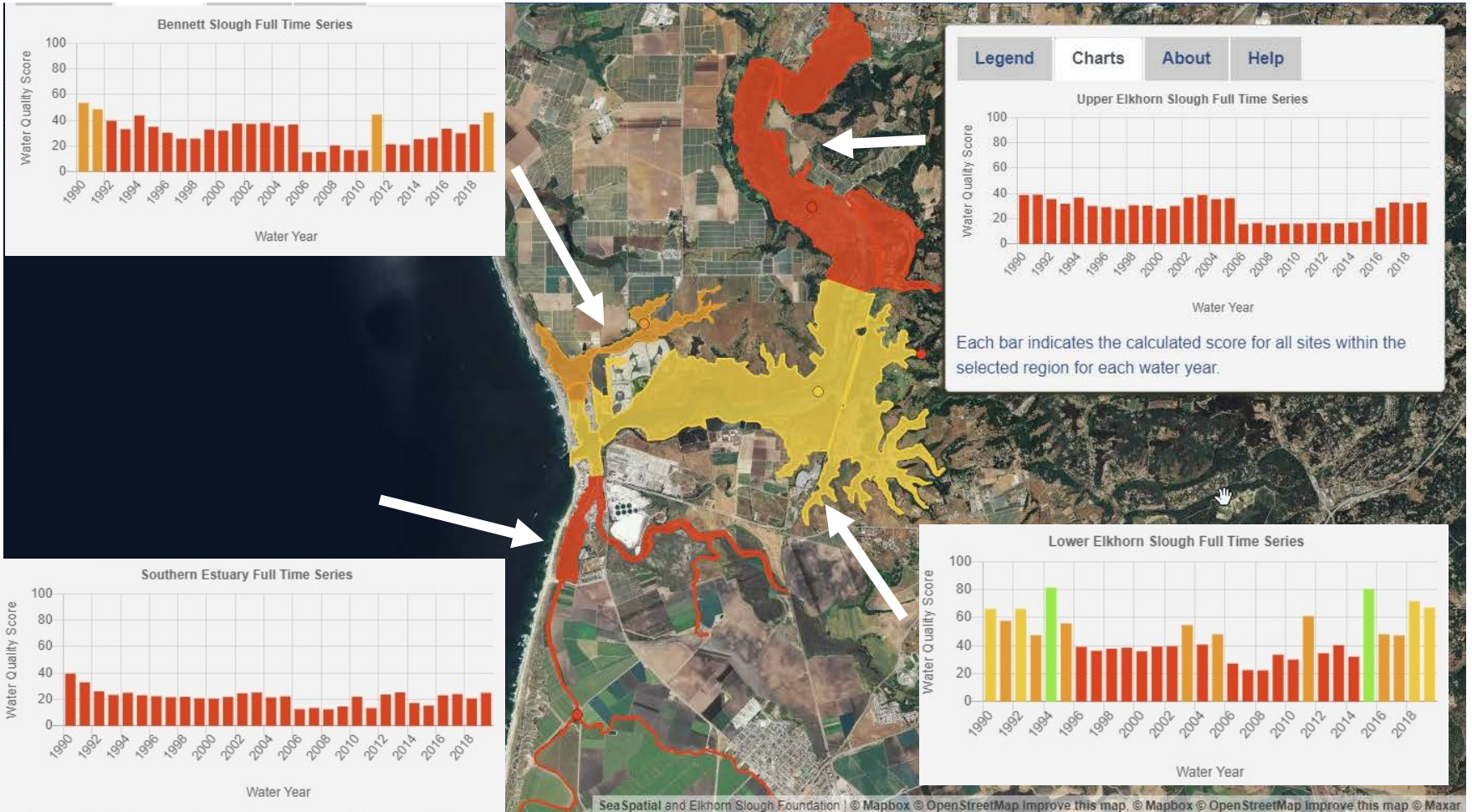
This report provides highlights of temporal trends in key indicators monitored by the Elkhorn Slough National Estuarine Research Reserve, owned and operated by the California Department of Fish and Wildlife in partnership with the National Oceanic and Atmospheric Administration and the non-profit Elkhorn Slough Foundation.

Monitoring programs are coordinated by Elkhorn Slough Reserve staff members, but many of the data are collected by Elkhorn Slough Reserve volunteers acting as highly trained community scientists.

The information here consists only of selected examples; much more information on the monitoring programs, data, and results can be found at the web links provided on each page.

WATER QUALITY REMAINS POOR OVER TIME IN ALL REGIONS EXCEPT LOWER ELKHORN

Scores are based on exceedances of thresholds of nine parameters over one water year period. High scores indicate healthier water quality. [See interactive webpage at http://elkhornslough.org/water/]



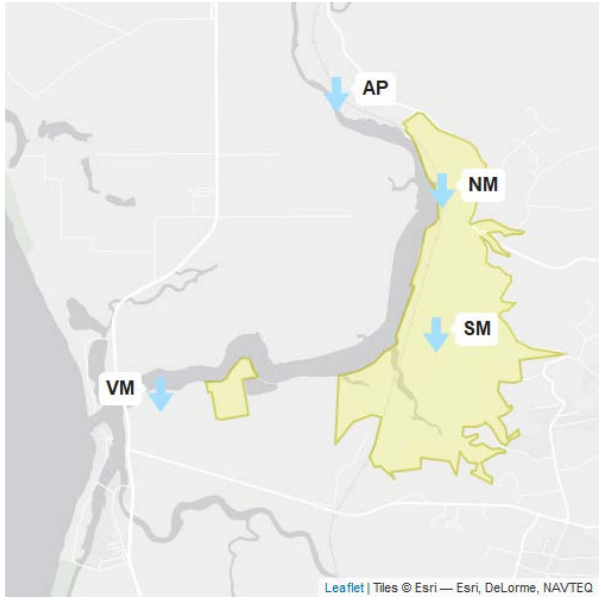
TEMPERATURE HAS INCREASED, PH HAS DECREASED, OVER PAST DECADE

Temporal trends over the past decade were analyzed from permanent stations collecting water quality data every 15 minutes. Temperature has increased and pH decreased at all four stations. Oxygen improved at two stations on the Reserve.

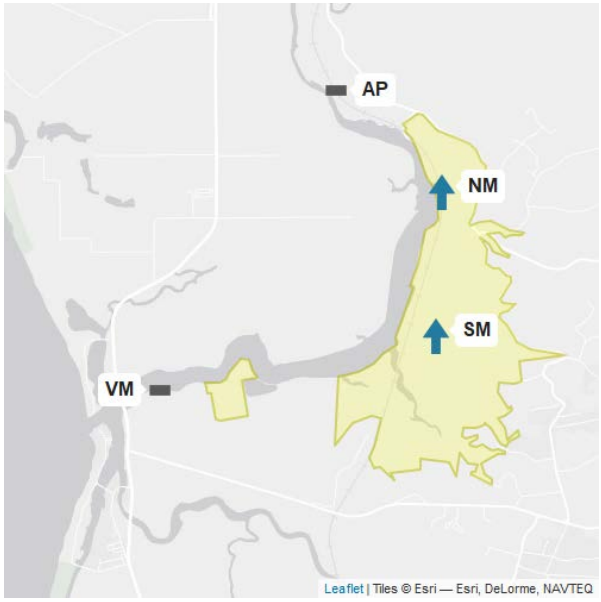
[See http://cdmo.baruch.sc.edu/ for this and all similar data collected across the NERRs]

Temperature is increasing in all four sites

pH is decreasing in all sites



Dissolved oxygen increasing in two of four sites; unchanged at the others

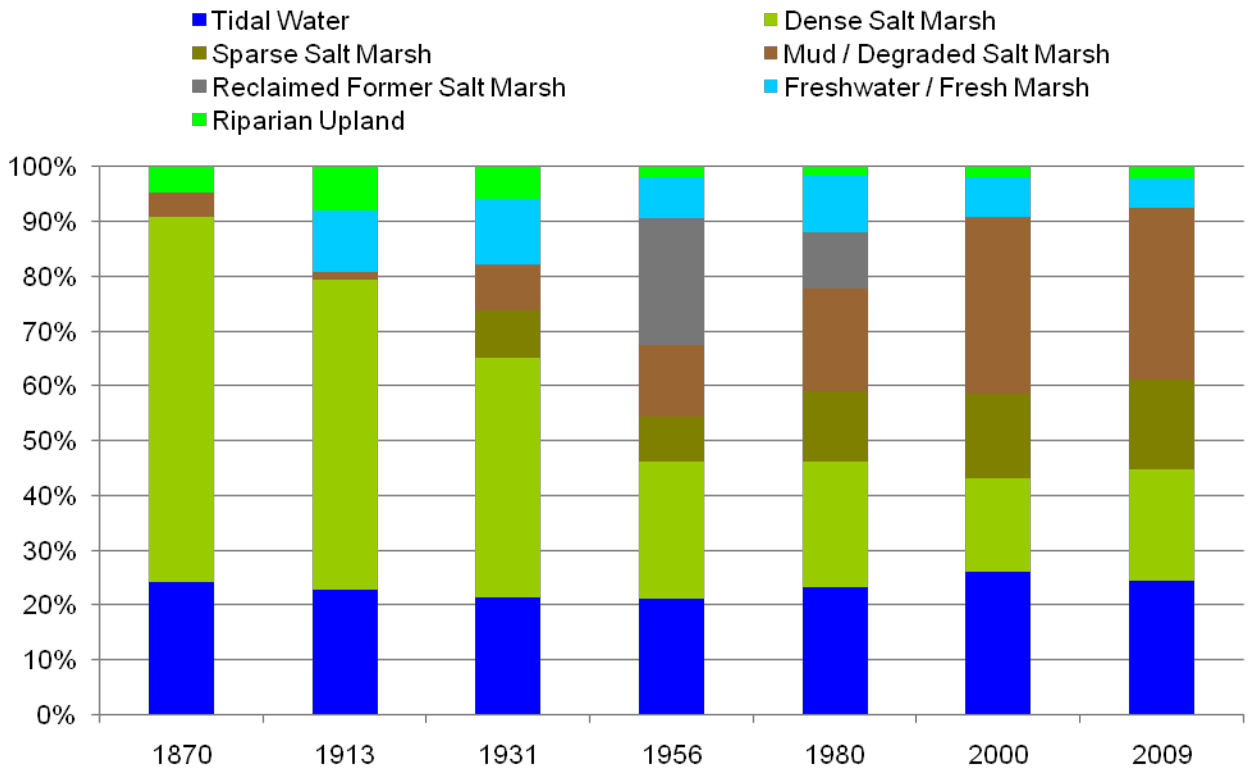


- VM = Vierra; SM = South Marsh, NM = North Marsh, AP = North Azevedo Pond

OVER THE PAST 150 YEARS, ESTUARINE HABITAT DISTRIBUTION HAS CHANGED

Analysis of maps and aerial photos reveals a significant decrease in dense salt marsh and increase in mudflat and sparse salt marsh over past 150 years, but greater stability recently. Marsh loss has multiple causes, including human changes to tidal exchange and sediment supply.

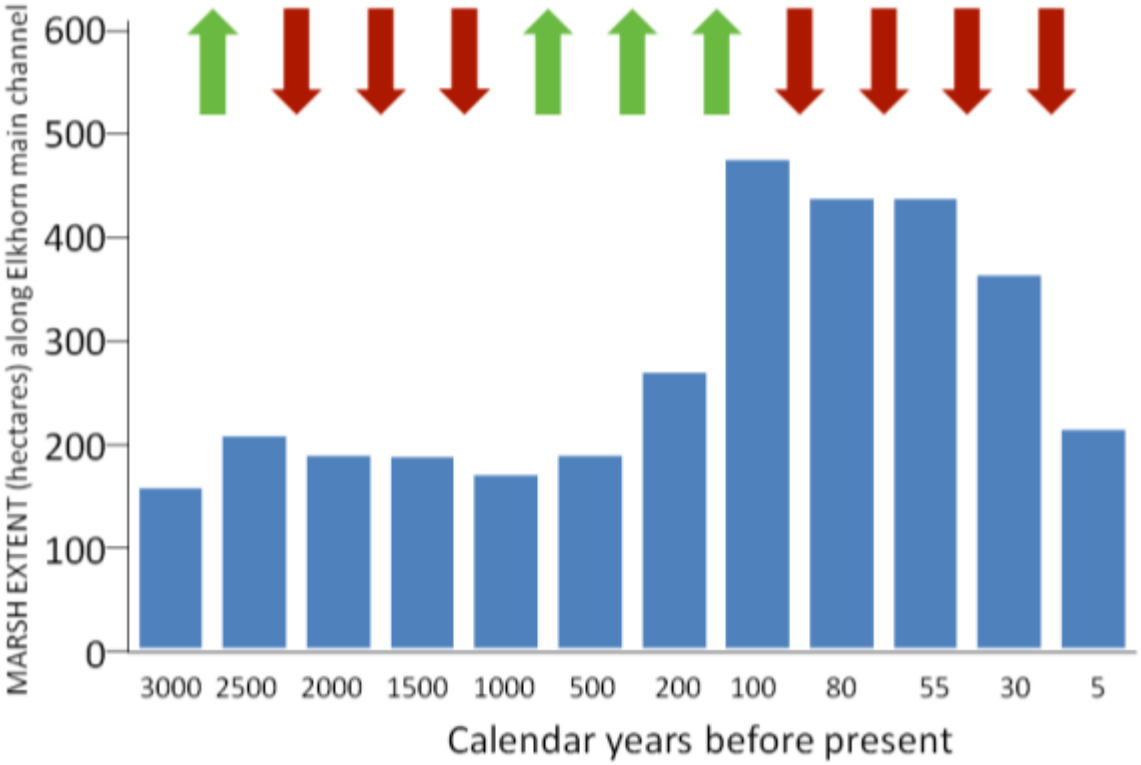
[See http://www.elkhornslough.org/research/conserv_marsh.htm for more information]



OVER THE PAST 3000 YEARS, SALT MARSH EXTENT HAS VARIED GREATLY

Analysis of paleo-ecological cores reveals that marsh extent has been variable over time. There was a significant increase in marsh extent following European colonization, but this has been followed by a sharp decline.

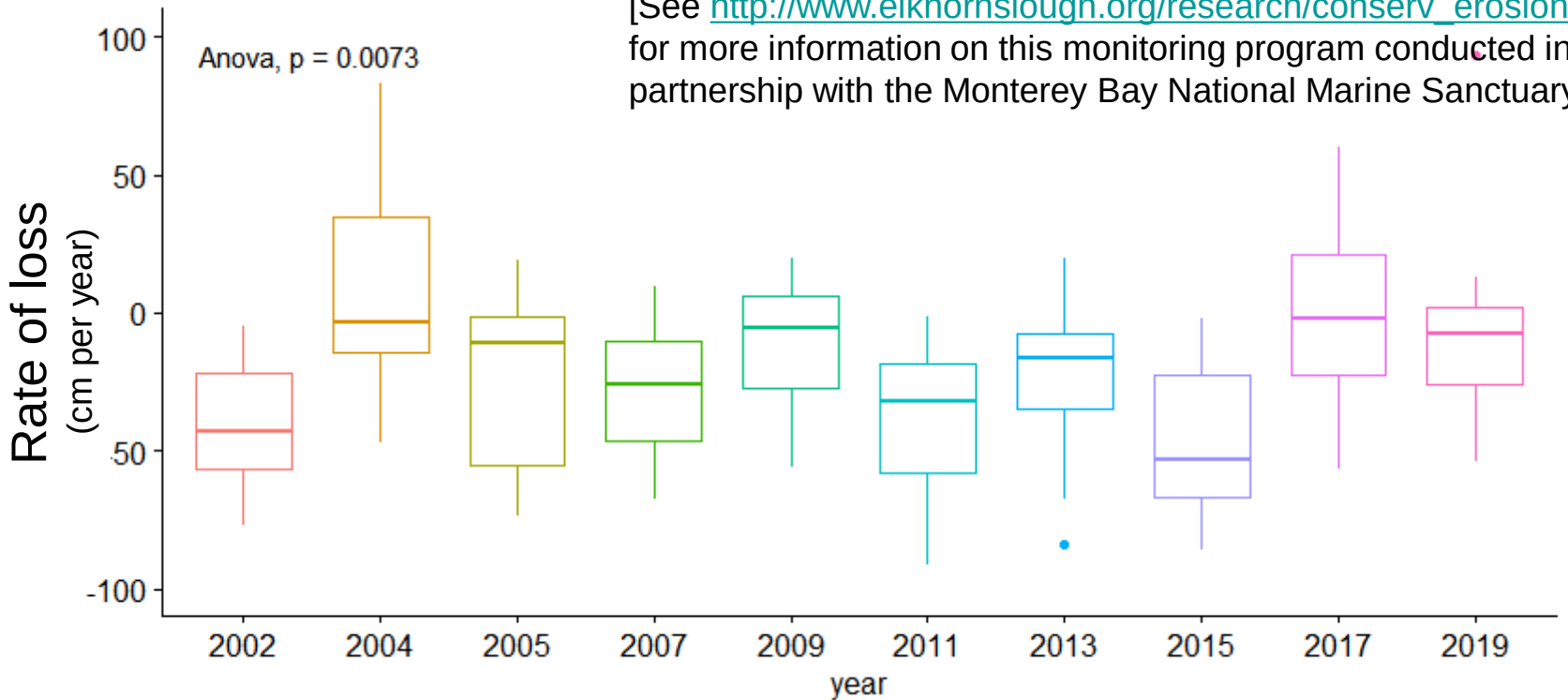
[See http://www.elkhornslough.org/research/conserv_marsh.htm for more information]



CHANNEL BANKS CONTINUE TO ERODE

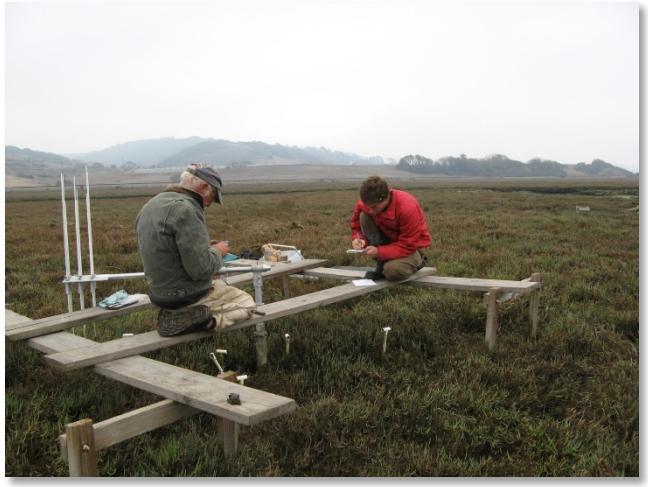
Along the channels of Elkhorn Slough, bank edges continue to erode, at variable rates over time and space, but averaging around 30 cm/year. Erosion rates are affected by algal wrack, crab burrows, wind waves and tidal currents.

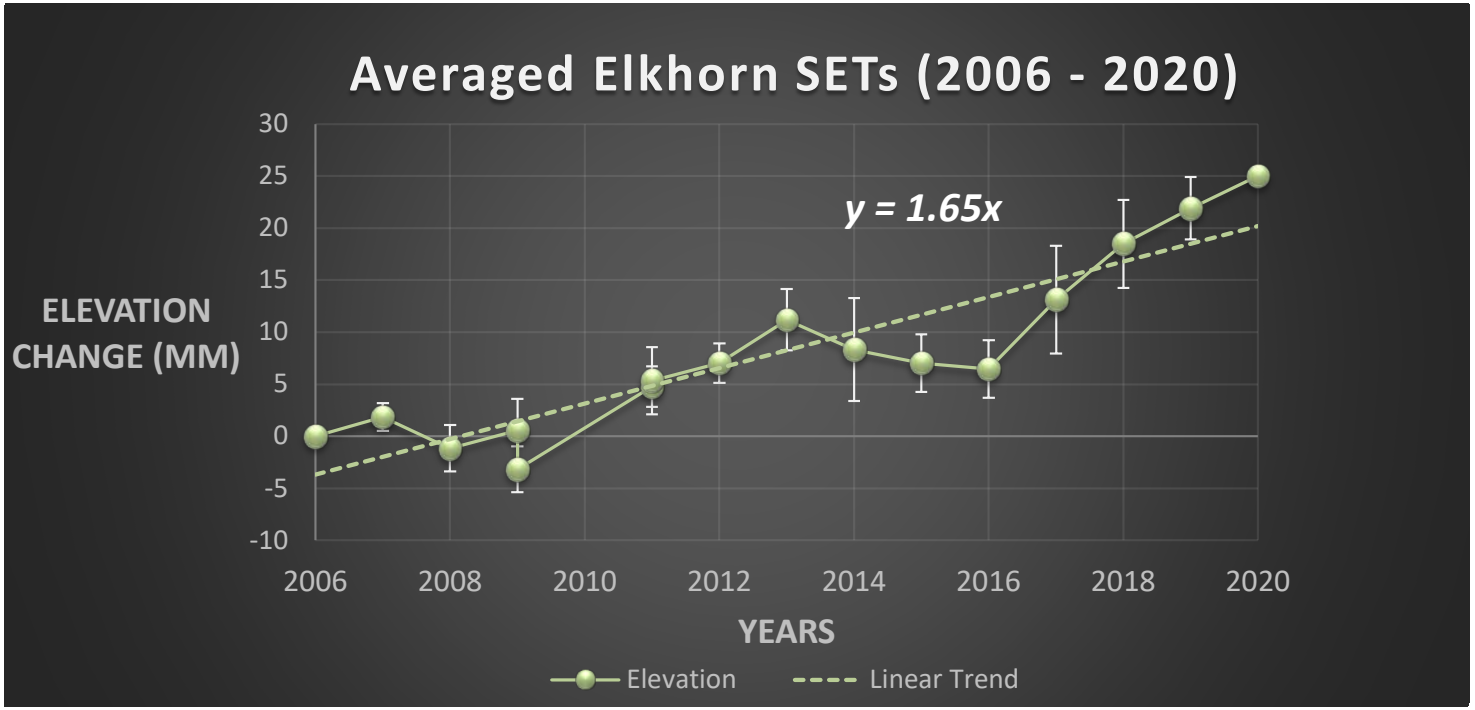
[See http://www.elkhornslough.org/research/conserv_erosion.htm for more information on this monitoring program conducted in partnership with the Monterey Bay National Marine Sanctuary]



SALT MARSH ELEVATION GAIN IS NOT KEEPING UP WITH SEA LEVEL RISE

Surface Elevation Tables (SETs) measure precise changes in the elevation of the marsh surface. Averaged together, results show that marsh elevation gain (1.65 mm/yr) is not keeping pace with sea level rise (1.71 mm/yr), due to subsidence.

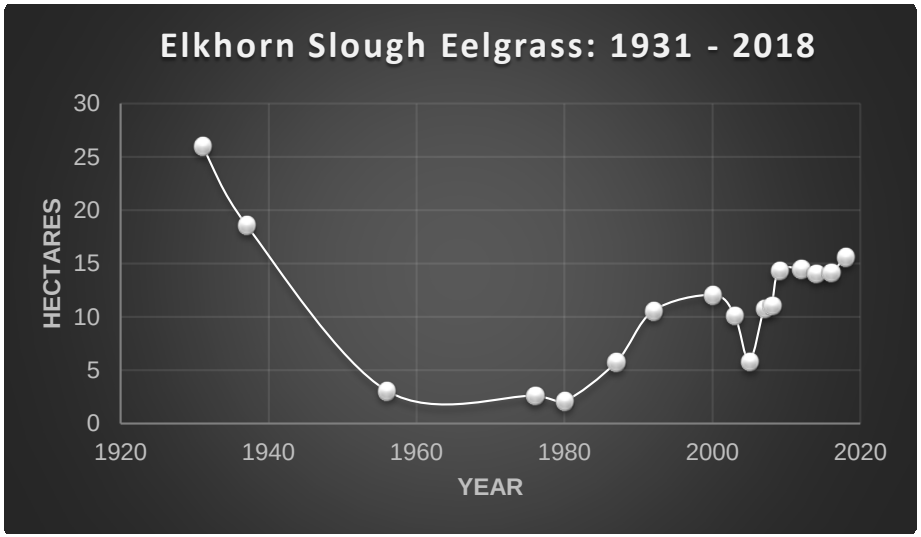


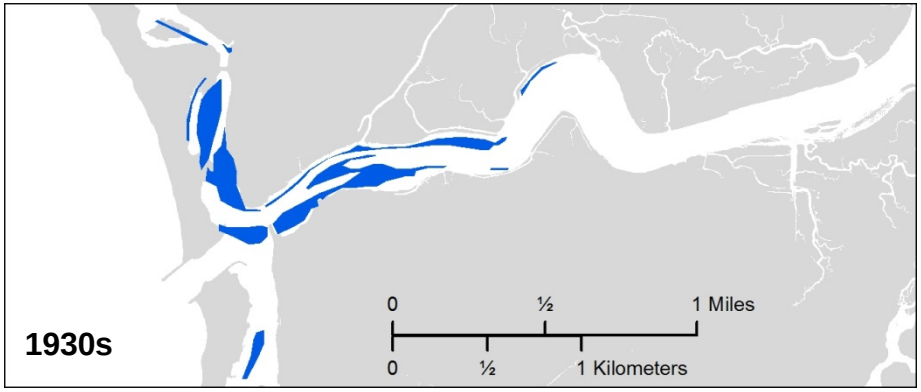


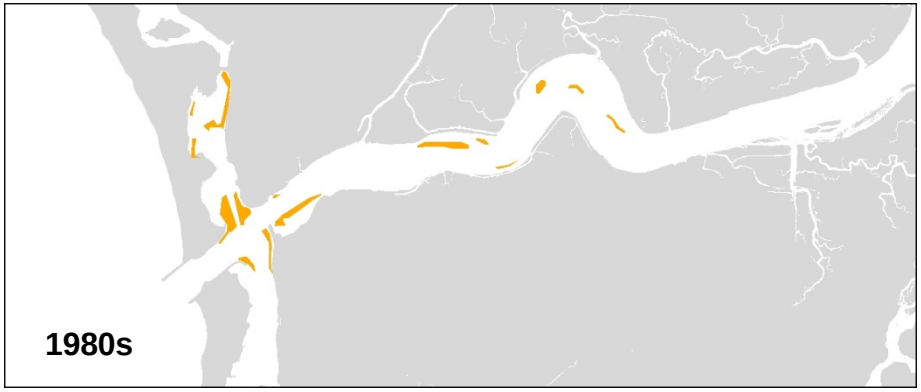
EELGRASS HAS RECOVERED IN PAST DECADES

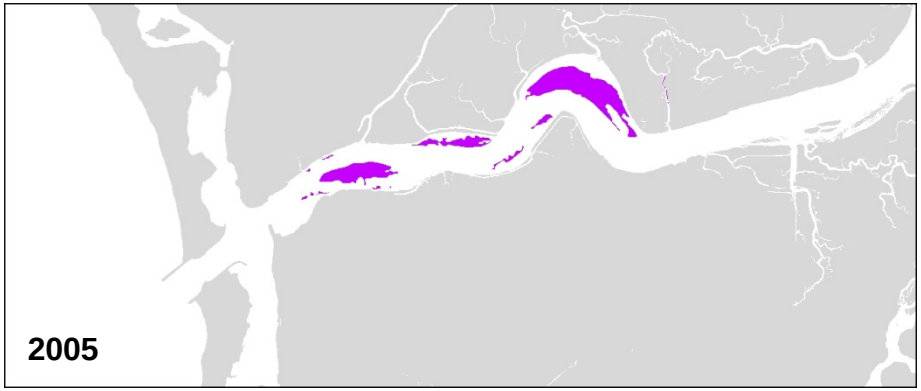
Analysis of aerial photos reveals dramatic loss of eelgrass beds in harbor area and lower Elkhorn Slough, followed by a period of recovery in the 1990s to the present.

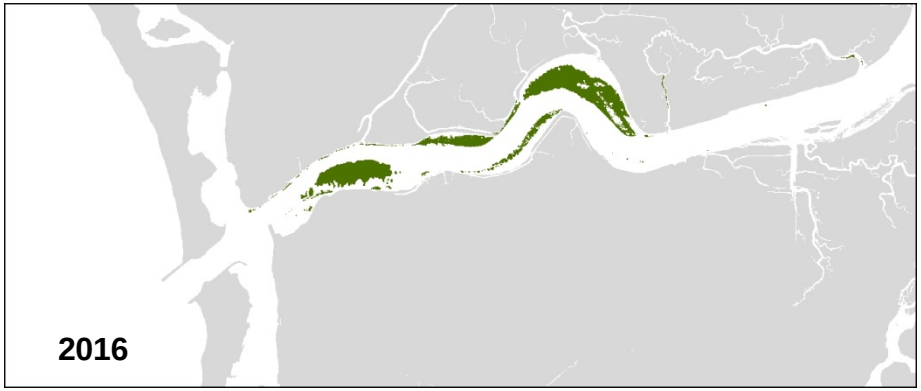
[See http://www.elkhornslough.org/research/gis.htm for more information]





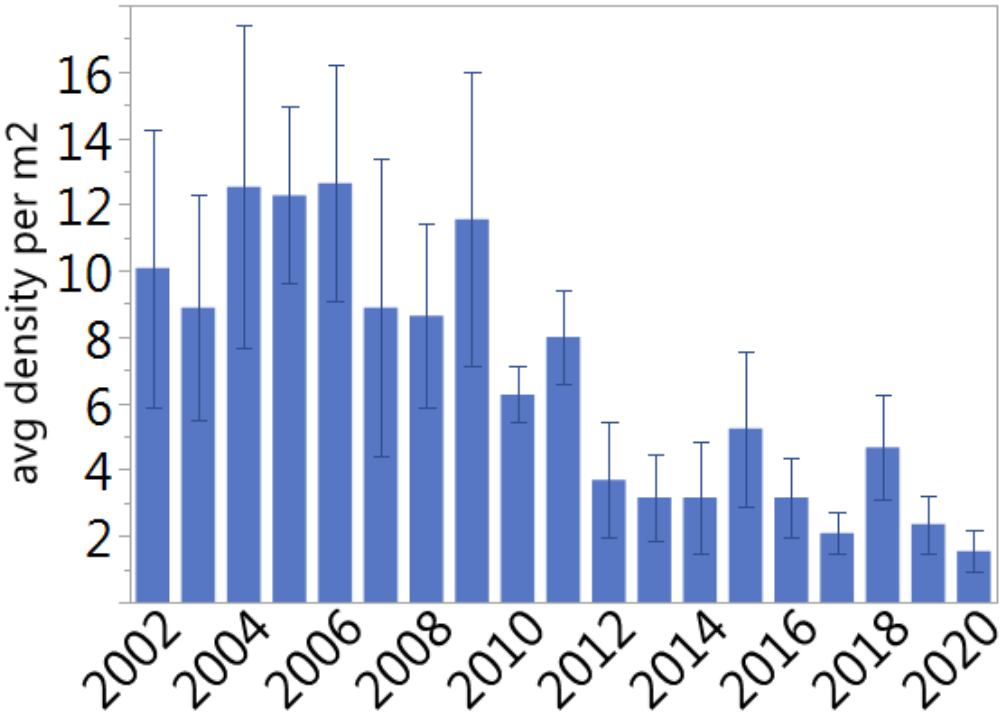






LARGE MUDFLAT CLAMS AND WORMS ARE LESS ABUNDANT IN THE LOWER ESTUARY

Field surveys at permanent transects have shown that number of large burrowing invertebrates (fat innkeepers, gaper clams, and butter clams) has decreased over the past years. Nevertheless, clams and large worms remain quite abundant in the lower estuary. [See http://www.elkhornslough.org/research/biomonitor_invert.htm for more information]



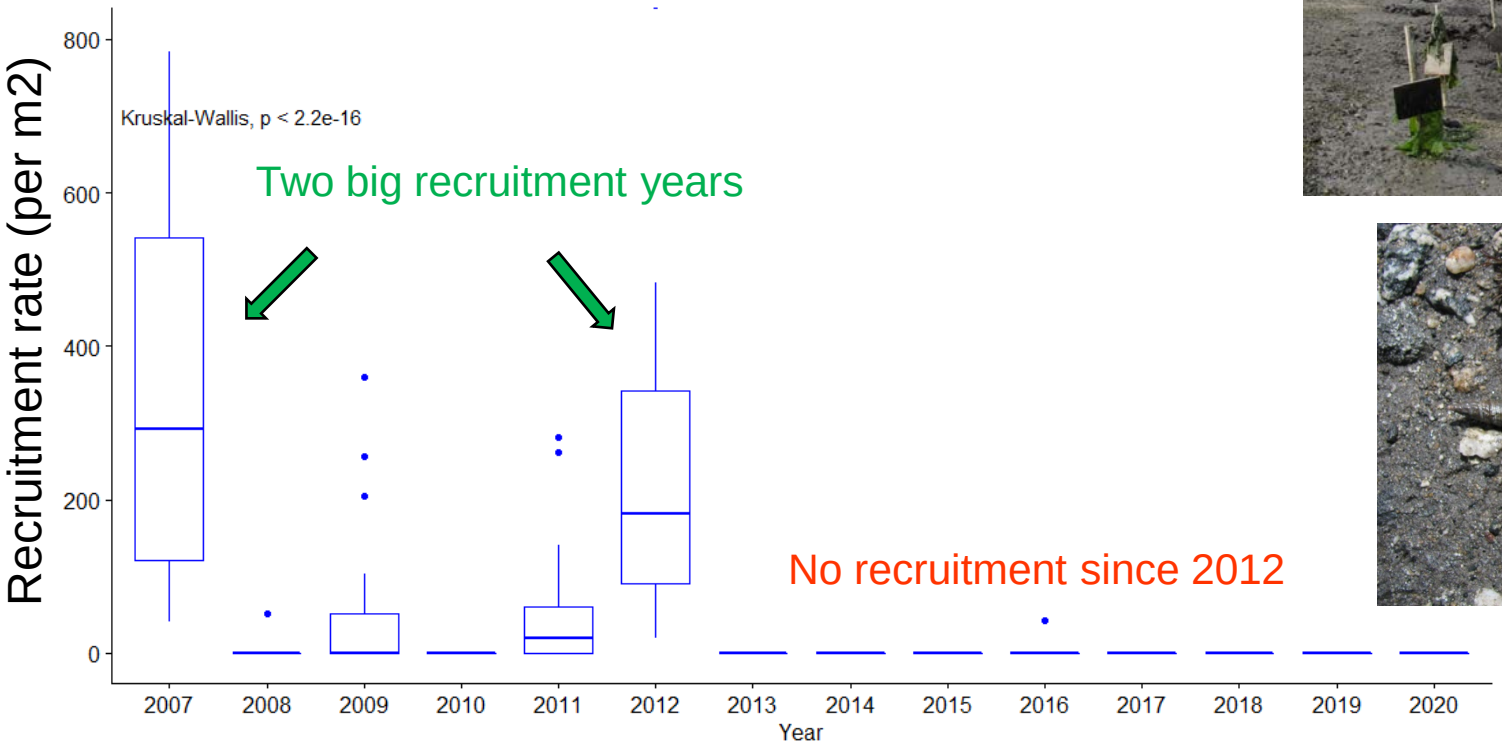
Fat innkeeper

Gaper clam

NATIVE OYSTER SHOW RECRUITMENT FAILURE IN MOST YEARS

In most monitoring years, there was zero recruitment of juveniles (on tiles being monitored). This low recruitment poses risk for sustainability of oysters in the estuary, and is being addressed by raising juveniles at MLML's aquaculture facility to outplant.

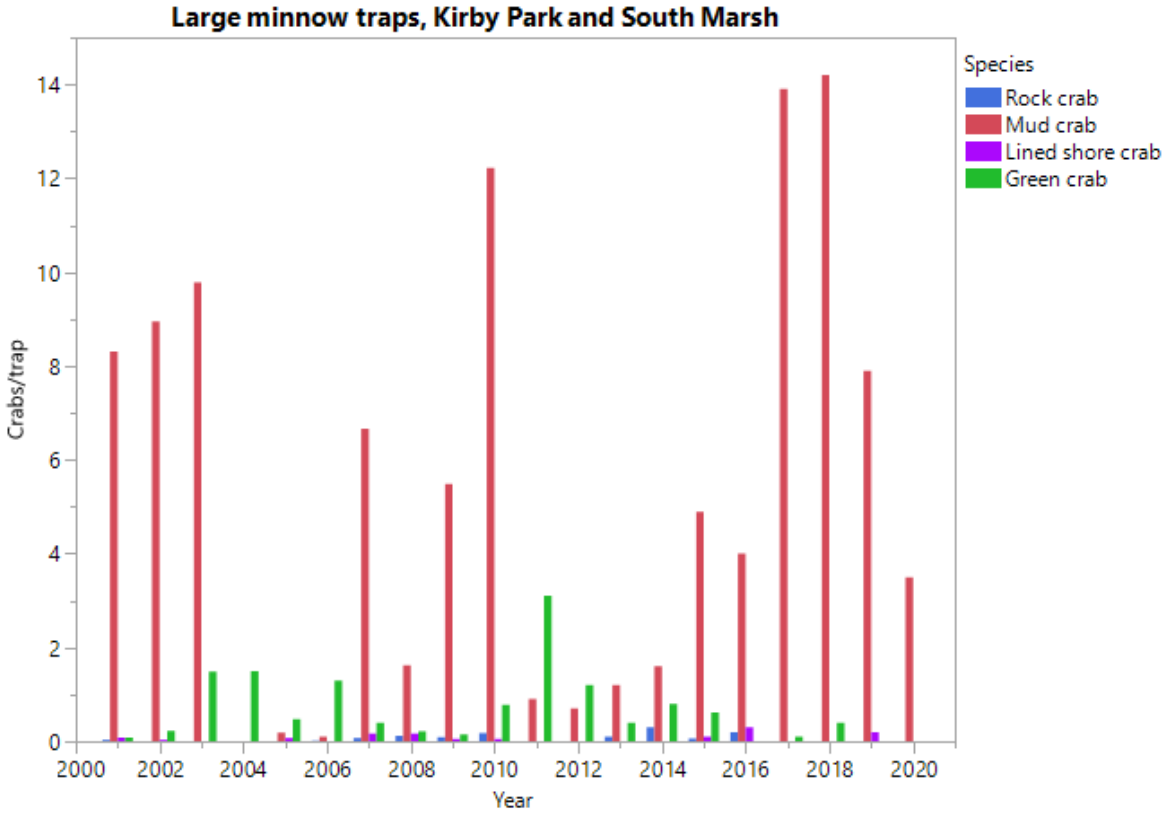
[See http://www.elkhornslough.org/research/conserv_oysters.htm for more information]



CRAB NUMBERS ARE HIGHLY VARIABLE

We monitor crabs annually at two sites. Generally, abundance of native mud crabs is high while abundance of non-native green crabs is lower. Green crabs were at their lowest in 2016, 2019 and 2020.

[See http://www.elkhornslough.org/research/biomonitor_invert.htm for more information]



Rock crab

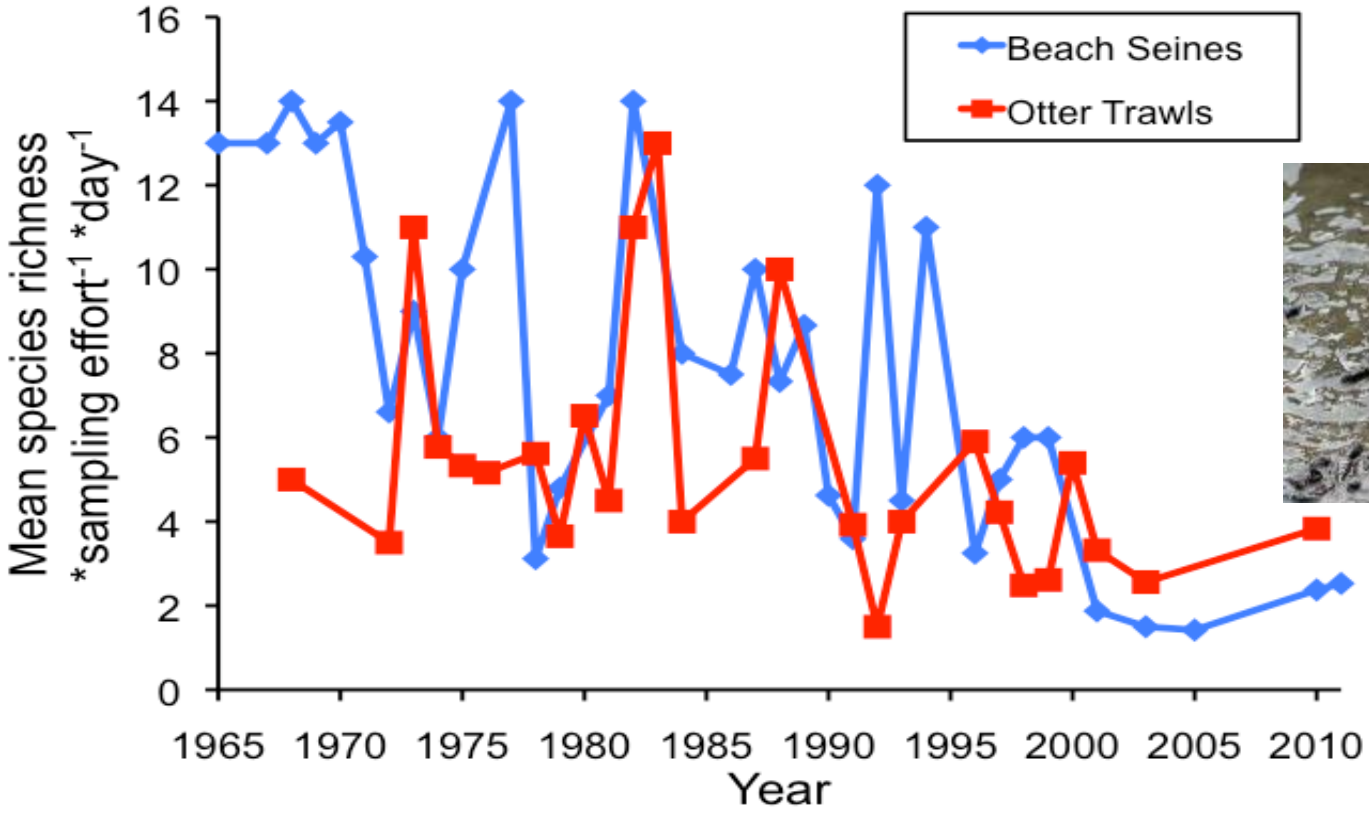
Mud crab

Lined shore crab

European green crab

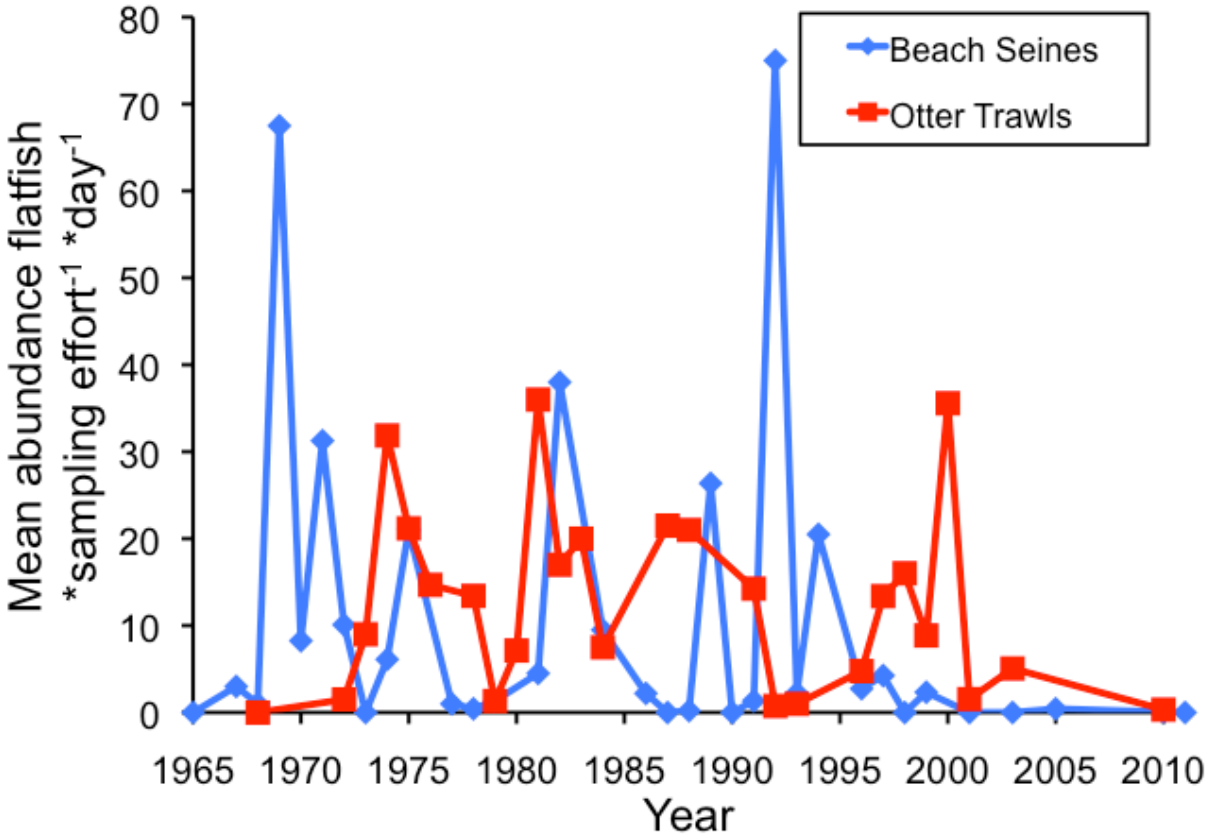
FISH DIVERSITY HAS DECLINED IN ELKHORN SLOUGH OVER THE PAST DECADES

Both beach seines and otter trawls reveal a decrease in average fish species richness (number of species) in the Elkhorn Slough main channel over time. Peak diversity observed in 1970s-1980s has not been observed in past two decades.[Data from multiple sources made available by the Monterey Bay National Marine Sanctuary's Integrated Monitoring Network, analyzed by B. Hughes.]

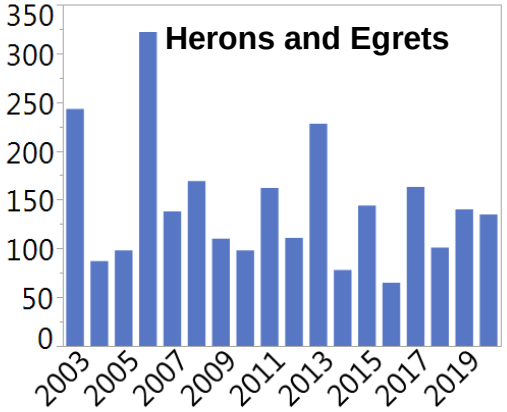


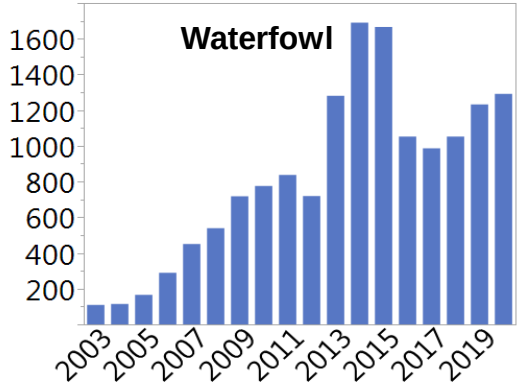
FLATFISH ABUNDANCE HAS DECLINED IN ELKHORN SLOUGH OVER THE PAST DECADES

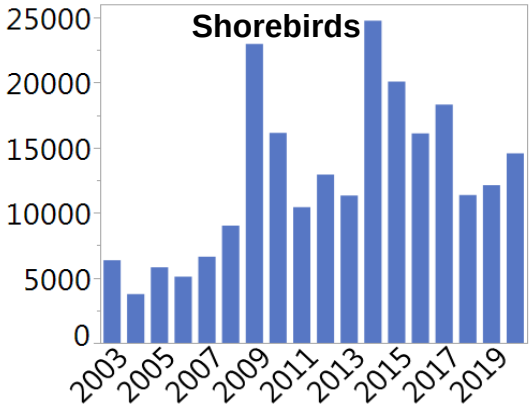
Both beach seines and otter trawls reveal a decrease in average abundance of flatfish in the Elkhorn Slough main channel over time. Numbers have been especially low in the past decade.[Data from multiple sources made available by the Monterey Bay National Marine Sanctuary's Integrated Monitoring Network, analyzed by B. Hughes.]



WATERBIRDS ARE ABUNDANT IN THE ESTUARY







Thousands of shorebirds and hundreds of waterfowl and waders are detected in annual bird surveys. There is considerable interannual variation in abundance, not synchronized between bird groups, and no clear trends.

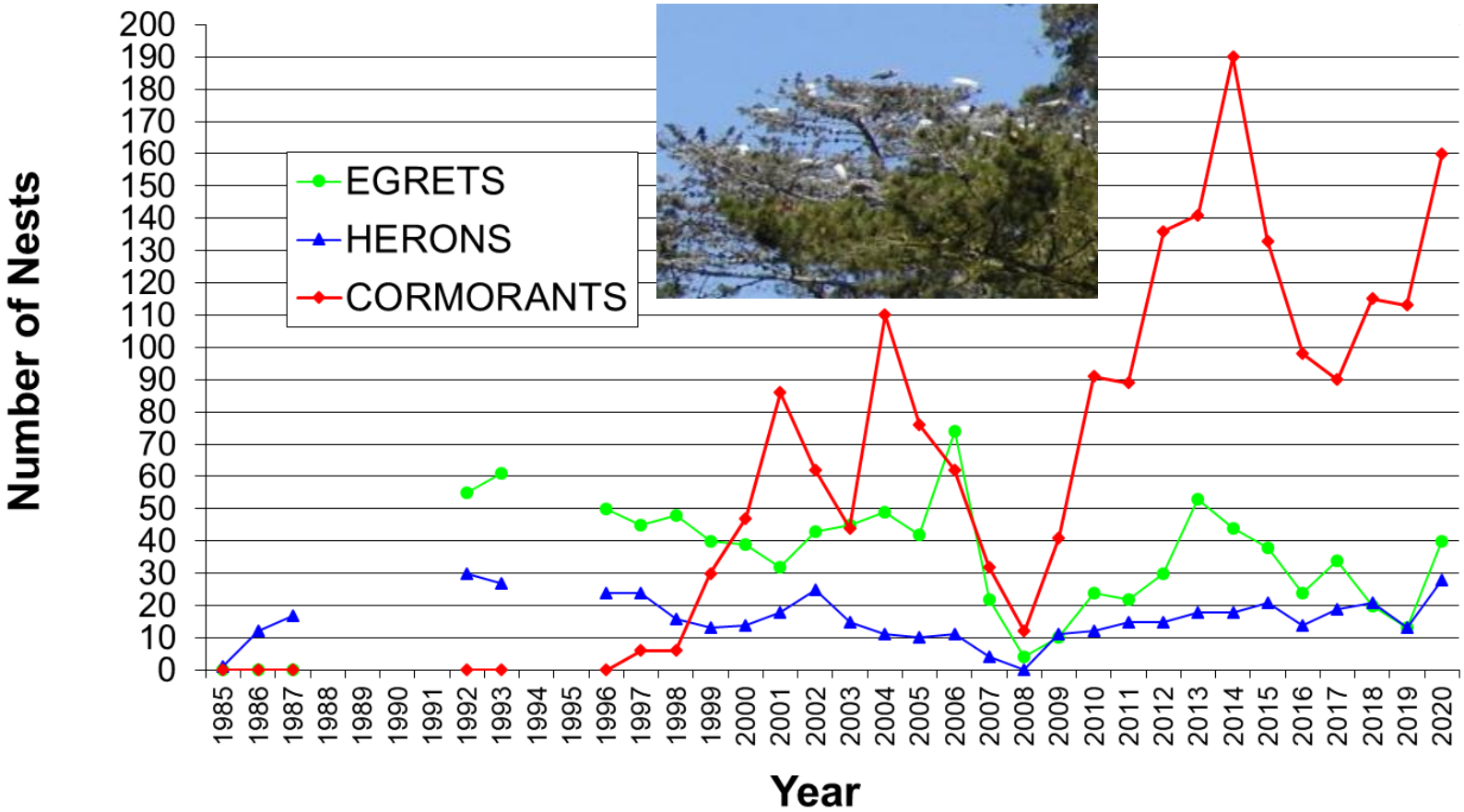
(Main Channel excluded from analysis).

[See http://www.elkhornslough.org/research/bird_esnerr.htm for more information on this monitoring program conducted in partnership with Moss Landing Marine Laboratories]

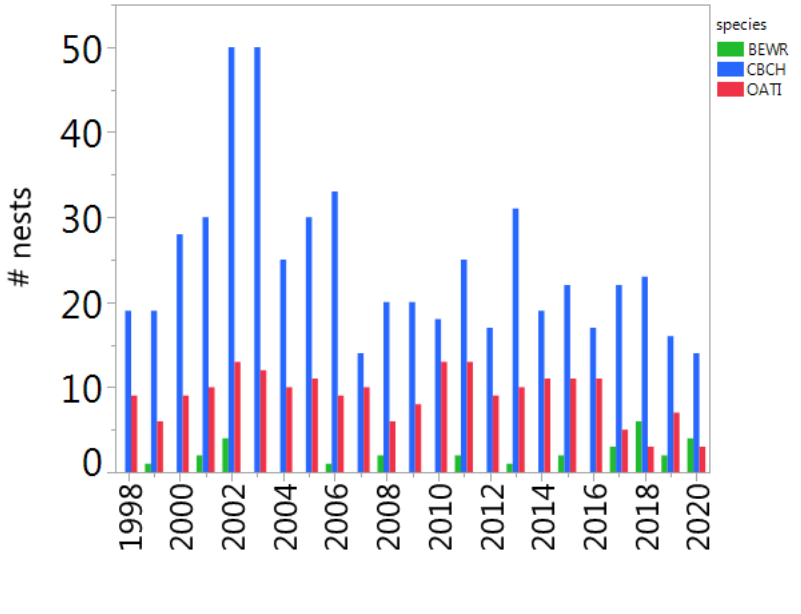
HERONRY NESTING IS VARIABLE OVER TIME

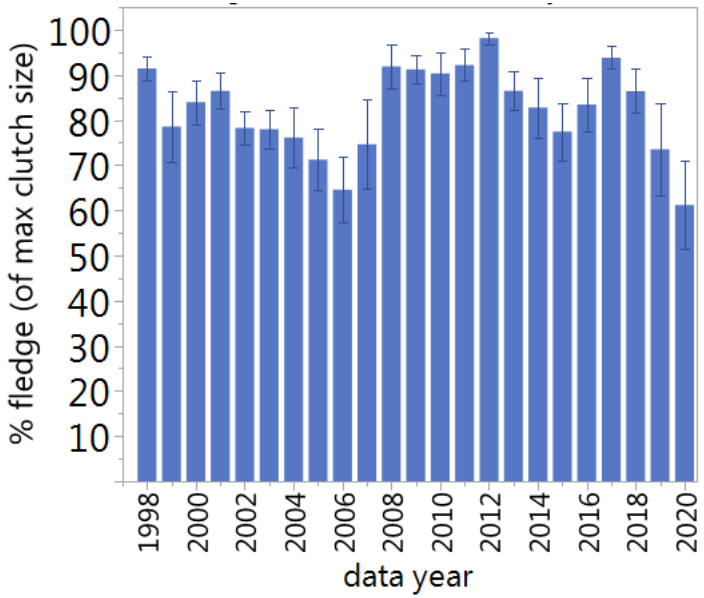
After a strong decline in 2007-2008, Great Egrets, Great Blue Herons, and Double-crested Cormorants moved from their old site near Rookery Pond to the Seal Bend portion of the Elkhorn Slough Reserve. Herons are quite stable over time; egrets and cormorants have variable numbers of nests across years.

[See http://www.elkhornslough.org/research/bird_rookery.htm for more information]



CAVITY-NESTING BIRDS IN OAK WOODLANDS VARY IN REPRODUCTION ACROSS YEARS





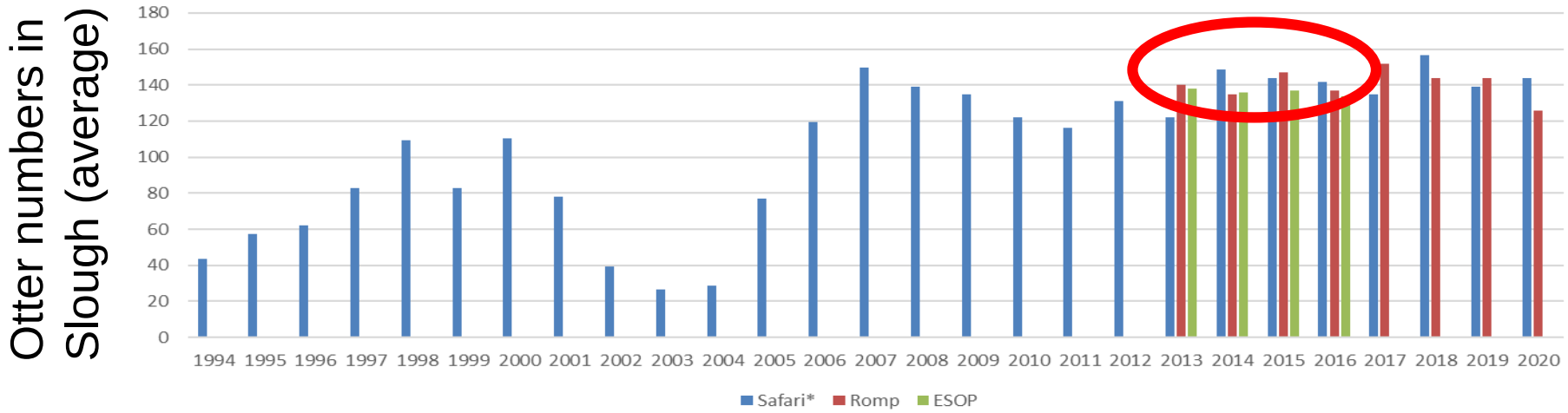
Cavity nesting birds, especially Chestnut-backed Chickadees (CBCH) and Oak Titmice (OATI) use some of the 150 nestboxes on Elkhorn Reserve. Numbers of nesting pairs and fledging success show considerable variation over time, but no long-term trends

[For more information, see http://www.elkhornslough.org/research/bird_nestbox.htm]

SEA OTTER COUNTS IN ELKHORN SLOUGH HAVE BEEN RELATIVELY CONSTANT SINCE 2006

Sea otters re-colonized Elkhorn Slough in the late 1980s. As of 2006, numbers have remained fairly constant. Counts by the Reserve Otter Monitoring Program (ROMP) align well with the Elkhorn Slough Otter Project (ESOP - a temporary grant-funded collaboration between USGS, UCSC, CDFW, MBA and ESNERR) and with counts by passengers on the Elkhorn Slough Safari (provided generously by Captains Yohn Gideon and Joe Mancino and entered by Jeff Wagner). This highlights the value of monitoring by community members.

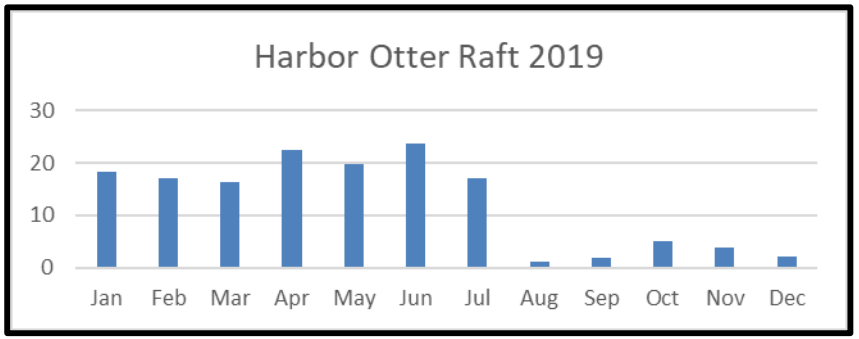
[for more information see https://www.elkhornslough.org/research-program/biological-monitoring/reserve-otter-monitoring-project/]



THE HARBOR OTTER RAFT IS GONE!

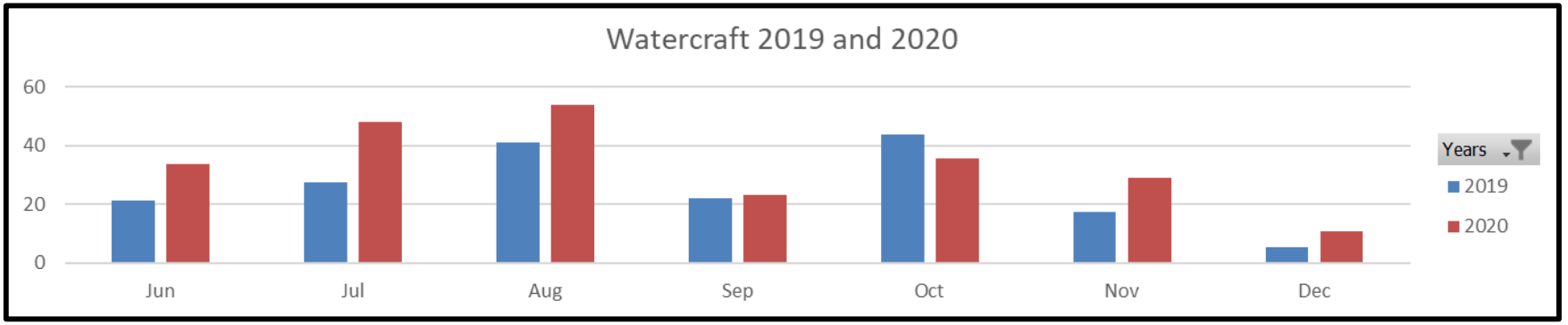
The Harbor raft left in September 2019. The raft dispersed prior to the Harbor dredging and no other factors, such as water quality, watercraft or disturbances appear to be the cause. The culprit appears to be a male otter that claimed the previous rafting area as his territory.

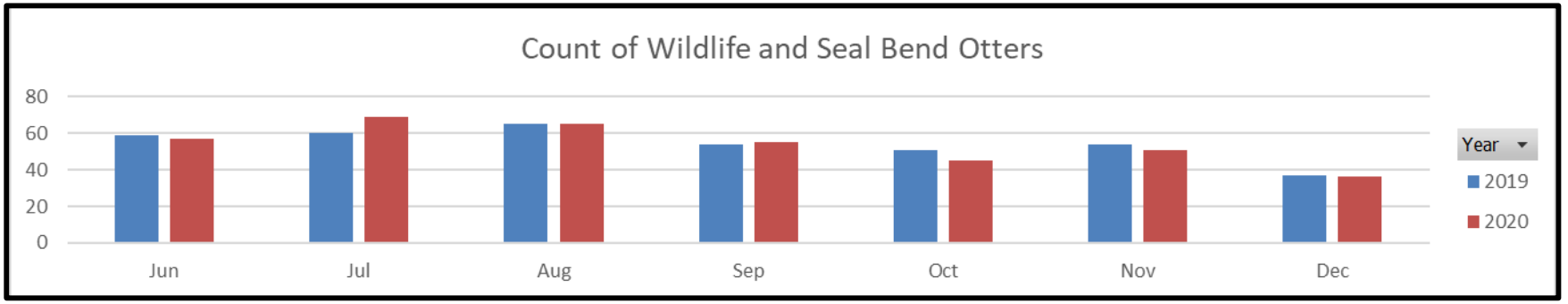
The Harbor raft peaked in 2008 when this photo of 89 otters hauled on Moss Landing State beach was taken.



HIGH WATERCRAFT NUMBERS DURING COVID PANDEMIC DID NOT REDUCE OTTER NUMBERS

One of the impacts of Covid-19 was a significant (nearly 40 percent) increase in watercraft in the slough when comparing June to December of 2019 to the same months in 2020. Despite this increase in watercraft, the number of otters detected by Reserve volunteers in the prime watercraft areas of Wildlife and Seal Bend was nearly the same in 2020 as 2019.





SEAL NUMBERS REMAIN HIGH IN SLOUGH

Passengers on the Elkhorn Slough Safari count harbor seals and these data (generously provided by Captains Gideon and Mancino) provide a long-term time series. The Reserve Otter Monitoring Program has also begun to quantify seal numbers at sites around the estuary starting in 2019, and detects higher numbers than the Safari, which only counts seals along the lower main channel.