Science Foundation Chapter 3
Appendix 3.1 – Case Study
Northern Anchovy (*Engraulis mordax*)

Author: Wim Kimmerer[1]

[1] *Romberg Tiburon Center, San Francisco State University, 3150 Paradise Drive, Tiburon, California, 94920.*

DESCRIPTION OF THE SPECIES

Northern anchovy (*Engraulis mordax*) is the most abundant fish in San Francisco Bay. It is a relatively small, planktivorous schooling fish with large populations along the Pacific coast.

CRITERIA FOR SELECTION OF THE SPECIES

Northern anchovy is the most abundant fish in the estuary, especially in the more saline reaches of the estuary, principally San Pablo to South Bay. Coastal ocean populations vary in response to regional ocean climate, so long-term shifts are likely. Because they are so abundant, anchovies are found in all regions of the estuary west of the Delta, including marsh channels, where they may be major consumers of plankton.

OTHER INFORMATION ABOUT THE SPECIES

Anchovy abundance has been monitored throughout the estuary since 1980 by the CA Department of Fish and Wildlife's San Francisco Bay study. This program provides an annual index based on monthly samples taken at about 50 stations throughout the estuary.

Anchovies are highly abundant in the coastal ocean and provide an important food source for larger fish as well as birds and marine mammals. Abundance fluctuates with ocean climate, with higher levels during years of strong upwelling compared to El Niño years (Chavez et al. 2003). There are several subpopulations along the Pacific coast, including a northern (Oregon to central California) and central (central to southern California) subpopulation (Parrish et al. 1985). These subpopulations are divided at about the latitude of San Francisco Bay, but the Bay population is linked genetically to the central California subpopulation (Vrooman et al. 1981).

The California Cooperative Fisheries Investigations (CalCOFI) organization has conducted an egg survey for anchovy in the southern subpopulation. Data for anchovies in the ocean near San Francisco Bay are indirect, including landings in the fishery and bycatch from a rockfish survey (Kimmerer 2006). The Bay population index does not fluctuate as much as, and is uncorrelated with, indices of the biomass of the coastal population (Kimmerer 2006). Thus, the Bay population may be separate from, or subject to other factors than the coastal population. There may nevertheless be a quantitative connection between these populations, but we are unable to detect it since there has not been a monitoring program adequate to characterize anchovy abundance in coastal waters near the Bay.

Anchovies are abundant year-round in the estuary. The Bay population appears to have been stable over the last three decades, but the fraction of the population in low-salinity waters declined abruptly in summer

1987 when plankton populations dropped following the spread of the introduced clam *Potamocorbula amurensis* (Kimmerer 2006). This was probably due to movement by the fish rather than mortality.

Anchovies feed mainly as visual predators on zooplankton but may switch to filter-feeding and consume both zooplankton and large phytoplankton such as diatoms. Thus, fluctuations in anchovy abundance, seasonality, or distribution are likely to have substantial effects on estuarine foodwebs. Specifically, rising or falling populations in the coastal ocean off the Bay mouth could affect Bay populations and thereby lower trophic levels in the Bay.

REVIEW OF LONG-TERM EFFECTS

Coastal populations fluctuate in response to ENSO and other regional climate cycles, with higher abundance during the cool phases. The likely response to climate change is difficult to predict since changes in ENSO, PDO, and NPGO and associated changes in wind, ocean temperature, and upwelling are poorly constrained by current climate models. Any trend toward reduced upwelling would likely result in a decrease in anchovy abundance; however, such a decrease may be difficult to detect in the coastal ocean because of high variability and a lack of monitoring. However, changes in the Bay population would be readily detectable by the existing monitoring program.

Any effect on food supply (plankton) would probably affect anchovy strongly, as would major changes in the abundance of predators. See the phytoplankton case study for long-term influences at the base of the planktonic foodweb. Striped bass, a major predator on anchovy, may be influenced by climate through their tendency to migrate to sea when the coastal ocean is warm. This may have caused the mid-1970s decline in striped bass population size in the Bay, which previously had been attributed to export pumping (Kimmerer et al. 2001). A decline in striped bass might allow for an increase in anchovy, although it is only one of many predators and the others are likely to respond differently.

OTHER STRESSORS

Availability of food is important to any fish, and the evidence cited above indicates that anchovies are sensitive to food supply. Contaminants probably have little effect on these fish since they feed low on the food chain and would not be likely to concentrate contaminants as do striped bass and other high-level predators.

FACTORS THAT MAY AFFECT SPECIES RESILIENCE

Unknown

LIKELY CLIMATE CHANGE IMPACTS AND RISKS

The most likely climate effects would occur through changes in the food supply. There are no significant risks to the long-term maintenance of anchovy but, as key elements in the estuarine foodweb, changes in their abundance would have substantial effects on both predators and prey in the open waters of the estuary and in marshes

MANAGEMENT ACTIONS TO BE CONSIDERED

Ensure continuity of the Bay Study monitoring program. Support some monitoring effort in the coastal ocean.

UNCERTAINTY AND KNOWLEDGE GAPS

- Trajectory of the ocean population and the strength of its link to the Bay population. The former uncertainty is caused by both environmental variability and lack of monitoring data; the latter uncertainty could be reduced if monitoring in the ocean were initiated, or through a research program.
- Responses to changes in foodweb productivity are more predictable at the level of anchovies themselves, but not at the level of the foodweb.

LITERATURE CITED AND RESOURCES

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