**Brandt’s Cormorant Population Ecology Lab**

**Instructions**

Please read the article “Changes in forage fish community indicated by the diet of the Brandt’s cormorant in the central California Current’’ by Elliott et. Al. Use the questions to help guide your reading. Those questions you can’t answer, should be clear by the end of the two labs devoted to this project.

**Vocabulary:**

* Benthic: ocean floor- the depth depends on nearshore vs. offshore (deeper)
* Pelagic: open ocean water
* Neritic: part of the ocean associated with the continental shelf and therefore shallower
* Offshore, nearshore: distance from the shoreline and therefore how close to the continental shelf drop off
* Upwelling: because of the direction of the winds, cold, nutrient rich water is pulled up from the bottom. This feeds the phytoplankton, which in turn leads to a lot of zooplankton and fish. Some species of fish rely on this for the base of their food chain more than others.
* Bird pellet: many species regurgitate the indigestible portions of their prey.
* Productivity: also called breeding success, a measure of how many chicks are raised to the fledgling stage, which is typically measured as number of chicks fledged per breeding pair
* Forage species: small pelagic fish or invertebrates which are preyed upon by larger marine organisms; they are typically abundant, occur near the base of the marine food chain, and are plankton feeders.
* YOY= Young of the Year. The young rockfish in their first year of life and live in the water column. They will settle to the bottom when mature.

**Introduction:**

1. This study is attempting to study the fish and birds as part of a larger ecosystem rather than just studying the fish population dynamics or measuring ocean temperature.

* What are the advantages to this type of study?
* How might this be useful when considering fisheries management?
* Impacts of climate change?

1. Which population of Brandt’s Cormorant are nearshore? Offshore?

* Are the two populations eating the same fish species?
* Are the differences due to the population size and availability of the prey?
* Are these differences in Brandt’s Cormorant feeding affecting the population size, growth and/or productivity?

1. What are the 3 questions that are being addressed in this study?

**Materials and Methods**

1. How do they measure the cormorant population size?
2. How do they calculate the cormorant productivity (fledging rate)?
3. How can cormorant pellets be used to estimate the abundance of forage fish species? Population size? Fish size?
4. Why analyze diet information by annual proportions rather than the total number of each prey found?
5. If instead of proportion of prey, they determined biomass (the size of the fish) that were being eaten by the cormorants, what would that tell us that would be different than proportion? *What could each measurement tell us about the fish populations? The cormorant feeding and hunting behavior?*
6. What about frequency of occurrence in the diet samples? What would that tell us about the fish populations? The cormorant feeding and hunting behavior?
7. Why use the Rhinoceros Auklet instead of the cormorant to identify specific forage fish species?

**Results**

1. Describe the trends in the population size, growth and productivity for the VAN and SEFI populations. ( figure 2, 3, 4, 5)
2. Diet: for each population, what were the trends or patterns in the
   1. Anchovy portion of their diet
   2. Rockfish portion of their diet
   3. Flatfish portion of their diet
   4. (figures 6 & 7)

Discussion

1. Which type of fish population do you think would be the best forage species for the Brandt’s Cormorant? ( Hint: how deep can these birds dive? How far do they need to fly to find food? How will that affect the energy left over for reproduction?)
2. What type of fish is a higher portion of the diet during the time that corresponds with the decline in the SEFI cormorant population?
3. Which species of fish are higher calorie? Rockfish or anchovy?
4. Look at Fgure 9. The upper graph (A) shoes an offshore rockfish species, while B & C show nearshore rockfish species. Which population of cormorants would benefit from this trend? SEFI or VAN? Why?
5. Which population of Cormorants is feeding on larger fish? Why might this be the case? (Hint: think about size of fish as they mature and where they settle in the water column, and the potential depth of the water).
6. Explain the drop in productivity in the SEFI colony in terms of the food availability, energy needed to fish and energy for reproduction.
7. What is causing the change in the fish populations?
8. Does El Niño affect the fish population sizes? Can it explain the change in cold water loving anchovy since 2010?
9. Which cormorant population experiences greater intraspecific (within species) competition? Interspecific (between species) competition?
10. What are the broader implication of this study? For Brandt’s Cormorant populations specifically, or more generally for measuring ocean ecosystem health?

Bar graph:

1. Why proportion of diet🡪 gave information about relative abundance of the prey but also feeding behavior of birds: depth of feeding, distance of feeding.

Questions to help them think about what type of fish are way out to shore with the SEFI vs. close to shore with the VAN

This could connect to the graphs 9 from the paper showing decline in offshore rockfish and increase in near shore rockfish

1. Connection to the ENSO data
   1. Upwelling 🡪 cold water and nutrients but also are rougher currents that disrupt fish- smaller fish like anchovies ( larvae) get pushed off shore: in
   2. Also there is a lot of variability in offshore environment 🡪 highly variable, many factors, so offshore is less predictable than nearshore. -🡪 visual about fish/eggs/ larvae and getting pushed offshore
   3. Cormorant breeding march – august: what they ate that year compared to ocean condition the fall before🡪 leading up to breeding season. If conditions are warm and water stratified, the anchovies show up more in the diet. Time of year of the warm water conditions makes the difference *Need periods of stability during the upwelling season- no pauses during the year, then the top layers aren’t still enough for the algae to grab those nutrients and grow. So not all about upwelling, but also need relaxation in that pattern.— and normally get relaxation of upwelling during the fall.*
2. Add diet data from VAN and compare to SEFI
   1. VAN is eating a lot of flatfish- low calorie but they are close and not that deep
   2. SEFI- rockfish and misc 🡪 smaller and historically offshore rockfish populations are declining – see auklet data. And if those are declining, and there is a big chunk of rockfish in their diet🡪 nearshore rockfish . long flight.
3. Productivity:
   1. Offshore rockfish until 2013 when it goes up dramatically and see a corresponding SEFI productivity and their diet shifts away from flatfish ( low calorie) back to their rockfish
4. Where are these cormorants going? Dying? Migrating?