Elkhorn Slough Research Project Ideas

The following are some of the many possible questions student researchers are encouraged to attempt to answer at Elkhorn Slough. Some are well-suited to short-term projects, others would require longer efforts, such as thesis research.

We at the Elkhorn Slough National Estuarine Research Reserve particularly encourage projects that examine threats to Slough ecosystems and how best to minimize them. The questions below are organized first by habitat type, then mostly by threats to each. While these questions represent priorities for informing conservation, we’re curious and interested in all aspects of the Slough. Feel free to contact Kerstin Wasson (research@elkhornslough.org) for advice about a project at the Slough. If you would like to conduct research on the Elkhorn Slough Reserve (northeast portion of Slough), you will also need to contact her to apply for a research permit.

1) ESTUARINE HABITATS

➢ TIDAL RESTRICTION
What mechanisms are responsible for differences in assemblages between sites with full and restricted tidal exchange?
We have data suggesting that birds, fish, invertebrates, and marsh plants differ, but manipulative experiments are needed to get at the processes behind these patterns. Mechanisms might include active habitat selection, differential transport, or differential mortality in response to biotic or abiotic conditions.

How do water quality and estuarine assemblages change with distance from tide control structures?
For large sites with water control structures that restrict tidal exchange (e.g., North Marsh or Moro Cojo), do water quality and biotic diversity decline with increasing distance from these structures?

➢ TIDAL EROSION
What are the major causes of salt marsh degradation in undiked areas?
The proximate cause of current rapid decline in salt marsh appears to be subsidence of the marsh plain, which in turn appears likely to have resulted from death of marsh plants (which halted the sediment generation and trapping that marshes provide). But what killed the marsh plants in the first place? And why are patterns of salt marsh loss spatially variable in the Slough? The key driver is likely to be related to longer inundation times resulting from opening of the harbor mouth, but there may also be other key contributing factors, such as increased Ulva mats or decreased sediment inputs. Factorial experiments could attempt to separate the role of individual factors and examine interactions between them.

How have South Marsh assemblages changed in 20 years?
Repeat sampling done in first years after this area was opened to tidal exchange, to assess how assemblages have changed. Constructed islands have shrunk due to bank erosion and channels have deepened, so there are likely to be significant effects of tidal erosion that could be documented here.
How have regulators approached tidal erosion in the past and what regulatory mechanisms could be used in the future to address erosion from dredged channels and harbors?
Some evidence suggests that the dredging of the Moss Landing Harbor may influence tidal erosion in Elkhorn Slough. How have decision makers analyzed this impact elsewhere in the world? What regulatory mechanisms have been used or have potential to be used in our region?

- **HISTORICAL BASELINES**
  What range of environmental conditions were typical at the Slough for the past 5000 years?
  Use modern isotope techniques to re-examine fish otoliths and mollusc shells to determine relative marine vs. terrestrial inputs to Slough systems.

Which Slough wetlands today most resemble conditions before major human alterations?
Compare indicator assemblages (e.g. forams) at sites with varying amounts of tidal and freshwater influence today, and take cores at these same sites to assess past assemblages. Is today’s main channel foram assemblage most similar to that of the main channel 1000 years ago, or most similar to that of a brackish system like Moro Cojo?

How have eelgrass invertebrate assemblages changed since the 1920s?
Repeat MacGinitie’s sampling of eelgrass fauna and look for broad changes (missing species? new invaders?).

How important are historical baselines to successful restoration?
The use of historical baselines is an oft-cited restoration practice. But, does referencing historical conditions in any way aid in restoration of communities or organisms? A review of existing literature and trends could help many restoration professionals better approach their work in many ecosystems.

- **REGIONAL PATTERNS**
  What are patterns of estuarine habitat loss and conversion in California’s estuaries?
  In order to set regional conservation goals, we are sorely missing a synthesis of overall acres of salt marsh, brackish marsh, intertidal mudflat, and subtidal channels today vs. 100-200 years ago (before major human influences). A broadscale GIS analysis would help inform restoration planning.

How do shorebird numbers at Elkhorn compare to those at other wetlands in the region?
Convert shorebird abundance data at Elkhorn into Slough-wide total estimates, and then compare these to numbers from monitoring programs at Morro Bay, San Francisco Bay, Bolinas Lagoon, etc.

Are there patterns to the cultures of estuarine management and regulation?
How does tidal wetland management and regulation differ in northern California differ from southern California? Are there trends in management and restoration that suggest information sharing or barriers to knowledge? Where do managers and regulators get their information and what are their information needs?
RESTORATION

Does increasing elevation in degraded marsh areas lead to sustainable salt marsh recovery?
Small scale experiments would begin to shed light on whether salt marsh cover would be stable if the elevation of the marsh plain is increased substantially in subsided areas.

Can small-scale measures decrease bank erosion?
Small scale experiments with structures to reduce velocities (e.g., anchored Christmas trees) could reveal whether bank erosion could be slowed by such mechanisms.

Might native *Spartina foliosa* be a viable alternative or addition to hydrological management strategies to combat tidal erosion?
The Slough has no native (or non-native) *Spartina* marshes. Introducing the native species into intertidal mudflats (degraded former pickleweed marshes and bank edges) might increase sediment deposition and decrease bank loss. Carry out literature review and simple modeling to determine where *Spartina* beds could potentially survive at Slough (maximum and minimum estimates of extent), given what is known about elevation and salinity tolerances of the species from elsewhere. Make predictions about effects on tidal erosion / depositional process at the Slough, under maximum and minimum estimates of distribution, based on sediment trapping studies elsewhere.

What is restoration success and how do we monitor for it?
Amongst the many restoration projects, how has success been defined? Are there success parameters that are better than others in terms of practicality of monitoring and management?

How much does restoration cost?
There have been many tidal wetland restoration projects. What drives the costs of these projects? How much is spent in planning, permitting, construction, maintenance, and monitoring? Are restoration planning, construction, and maintenance costs related to restoration success? Are costs increasing through time or decreasing?

ECOSYSTEM SERVICES AND FUNCTION

What is the habitat value of vegetated vs. unvegetated estuarine habitats?
Compare larval settlement, fish abundance, etc. in paired areas with and without dense pickleweed (intertidal) or eelgrass (subtidal). Or, using isotopes, compare marsh plant vs. algal sources of N and C in key indicator species (such as commercially harvested fish).

What is the relationship between tidal erosion and habitat use by key target species?
Are degraded marshes that have converted to high mudflats useful to migratory shorebirds (relative to other Slough mudflats)? Are eroded subtidal habitats in the channel useful to commercially valuable fish species or sea otters (relative to depositional subtidal areas in other estuaries)?

POLLUTION

Does water quality correlate with adjacent land uses?
Use our 15 year database of water quality around the Slough, and pick specific case history sites to carry out GIS analysis of links between changed land practices and adjacent water quality.
What sort of vegetated buffer strips most effectively reduce polluted run-off from entering estuarine wetlands? 
Not well known for Mediterranean region; some experiments with annual grasses found these were not effective barrier.

Are Elkhorn Slough habitats eutrophic? 
What are the direct (e.g., toxicity) and indirect (e.g., changes in species assemblages due to macroalgal production or hypoxia) effects of high nutrient concentrations documented in the Slough?

Is the distribution of algal mats related to nutrient levels? 
Correlate algal density with nutrient levels measured by monthly volunteer water quality monitoring program.

Has the abundance of *Ulva* mats increased over time? 
Examine aerial photographs; extrapolate from increase in nutrient levels. Algal mats can have big effects on community dynamics, so knowing how historical levels have changed is important.

How do dense algal mats influence the distribution and abundance of infaunal invertebrates? 
Compare invertebrate diversity and abundance in areas with and without dense algal mats (naturally occurring, or manipulate). Map distributions of dense algal mats to identify areas where invertebrates might be influenced most.

How do dense algal mats influence bird distributions? 
Map bird distribution and abundance as a function of algal cover; experimentally change or look at natural variation. Presumably birds cannot access invertebrates through dense blanket of algae.

Are pesticides accumulating in Slough organisms? 
Are pesticide concentrations causing chronic toxicity to organisms low in the food web at Elkhorn Slough, and is this resulting in bioaccumulation in birds and mammals?

Are ghost shrimp sensitive to polluted run-off? 
Collect ghost shrimp from beds on the Reserve and grow them in Reserve water vs. water from Tembladero Slough and other polluted areas to test R. Kvitek hypothesis that decline of ghost shrimp near mouth may be due to polluted run-off.

What is the role of groundwater and atmospheric sources of nitrogen relative to freshwater run-off? 
Use isotopes or other tools to determine relative importance of different sources of nutrient loading.

What are the main sources of fecal coliform bacteria in the Slough?
Concentrations are highest in areas receiving the most freshwater input, but it is not clear whether sources are residential septic tanks or agricultural.

How does polluted runoff affect individual organisms, especially economically important fish and shorebirds?
Mixed pollutants may have additive or emergent toxic properties and individual pollutants may not presently be recognized as harmful; decision makers need information about which pollutants have which specific effects on tidal organisms.

INVASIONS BY NON-NATIVE SPECIES
What are the effects of the introduced Japanese mudsnail *Batillaria* on diatom communities and macroalgal mats?
Assess diatom diversity & abundance and/or *Ulva* mats in areas with differing (naturally varying or experimentally manipulated) *Batillaria* densities. Interesting because enormous densities must be changing food webs in Slough, but effect hasn’t been documented.

What factors influence *Batillaria* distribution and abundance?
The mudsnails appear to be densest in low elevation intertidal mudflats, particularly in subsided (formerly diked) areas; they are rare along the Slough’s main channel. Is this due to patterns of spread from initial introduction sites? Or increased population growth in the subsided mudflats? Or lower predation (by crabs, shorebirds?) there than along the main channel?

How does the introduced gem clam (*Gemma gemma*) influence the abundance of other infaunal invertebrates?
Set up enclosures with and without gem clams, with otherwise normal invert community; examine changes in abundance over time. These clams are incredibly abundant, but no one has ever shown what sort of community effect they have.

Which invertebrate invaders are transported to the Slough on boat bottoms?
Examination of boats in Moss Landing Harbor, esp. those which have recently arrived from San Francisco Bay or other places with established populations of invaders; demonstration of local boat traffic as an important mechanism of transport might lead to boat-cleaning regulations.

Do non-native species fare better under human-altered conditions than natives?
Test a particular guild with natives and non-natives, such as fouling community, for survival and reproductive success in different pollution conditions, artificial vs. natural substrates, etc.

What are the competitive dynamics between the native long-jawed mudsucker and the non-native yellowfin goby?
Anecdotally, it appears that the former is becoming rare with the latter is becoming abundant.

RARE ESTUARINE ENDEMICS
What are the microhabitat correlates of the threatened brackish snail *Tryonia imitator* and/or tidewater goby?
Fieldwork to map small-scale and large-scale distribution of these rare species at Slough; correlate to environmental factors (nutrients, pickleweed cover, predators). For the snail (which
is not listed), manipulative mesocosm or laboratory experiments could confirm the role of putative environmental factors.

**What are the current environmental correlates of oyster distribution and mortality?**
Assess turbidity, depth, nitrates, etc. as possible factors affecting the distribution and mortality (ratio of dead/live shells) of native oysters at Elkhorn Slough. Results would inform potential restoration experiments.

**Why have green phoronids become so rare?**
In terms of native estuarine biodiversity, the dramatic declines of the green phoronid (formerly a mudflat dominant near the mouth, now virtually absent) are concerning, especially since there are only about a dozen species in this animal phylum. Carry out multi-estuary study to determine microhabitat requirements and environmental tolerances of green phoronids, assess the distribution of such microhabitats at Elkhorn Slough. Could carry out manipulative experiments at sites where they still are abundant (Bodega) to test role of possible limiting factors at Elkhorn (burial with *Ulva*, etc.).

**How does species diversity of salt pannes differ from adjacent habitats?**
Salt pannes elsewhere have been shown to host various threatened species (e.g., tiger beetles) adapted to the extreme hypersaline conditions; the fauna of Elkhorn Slough salt pannes (e.g., in the North Marsh area) has never been examined; these habitats may be of high value to these rare communities.

- **RECREATIONAL USES**

  **How do kayakers influence marine mammal and bird behavior?**
Observations to determine whether recreational visitors influence behavior of resident animals; results could lead to management recommendations.

**What is the intensity of mudflat harvesting, and what are the effects?**
Intensity could easily be assessed by visiting common clamming sites in lower Slough; effects would require controlled expert with fenced take and no-take zones.

**What explains visitor use patterns in the Elkhorn Slough region?**
Visitors in natural areas seek particular features and activities. What are the expectations of visitors to the Elkhorn Slough Reserve and are these expectations met? Do visitors to our region lack certain experiences that they desire? The answers to these questions can help shape development of future recreational improvements such as trails, parking lots, roads, and boat landings.

**2) FRESHWATER AND RIPARIAN HABITATS**

- **THREATENED AMPHIBIANS AND REPTILES**

  **How do various mosquito control practices compare in terms of efficacy and ecological impacts?**
Mosquito and other disease vectors are becoming increasingly of concern, spurring control measures with unknown consequences to the Slough’s salt and freshwater ecology. Research into the efficacy of these measures weighed against the ecological impacts could help inform
better practices. Compare Bt, mosquitofish and native predators such as three-spine stickleback or dragonfly larvae as control mechanisms in 18 Reserve water tanks (guzzlers) or in regional ponds.

**Does restoration of aquatic habitat lead to increased use by breeding amphibians?**
Various restoration measures have been proposed or implemented in aquatic habitats on the reserve and in the surrounding watershed. Understanding how these measures influence water quality and potentially the density or distribution of larval amphibians would help in weighing the costs and benefits of management alternatives.

**What are the patterns of habitat use by southwestern pond turtles in the Elkhorn watershed?**
Explore aquatic habitats and adjacent areas on the Reserve to locate nesting/breeding sites, count numbers of adults, and track their movements.

**What lizard and salamander species are found on the Reserve and what are their relative abundances?**
A combination of visual encounter surveys of lizards on the trails and capturing for identification would allow the Reserve to establish a baseline inventory of what species are present and in what abundances. This would be important for future comparisons to establish how populations are faring. A similar survey for salamander species including the placement of coverboards and checking for presence under natural debris would also have importance for future comparisons.

**What is the distribution and abundance of amphibian roadkill along Elkhorn Rd. during the rainy season?**
Even low levels of traffic are known to have large impacts on amphibian populations near roads. Nighttime or early morning surveys along Elkhorn Rd. during rain events for the duration of the rainy season would allow for quantification of these impacts to local populations, as well as highlight areas where an underpass or culvert could boost rates of connectivity between reserve populations and those off the reserve. This may become important as more of the freshwater habitat that was formerly tidal reverts to higher salinity with rising sea levels. Long-term conservation of reserve amphibian populations will almost certainly require developing and improving connectivity with other freshwater sites.

- **VEGETATION, HYDROLOGY AND RESTORATION**
  **What are the current conditions of aquatic vegetation in the watershed’s freshwater wetlands?**
  Map distribution and types of freshwater habitats in the watershed currently, including aquatic plants and communities as well as hydrological characterization.

  **What strategies can improve water quality in Reserve freshwater wetlands?**
  Bioretention pits or heavy mulch to improve quality of freshwater inputs coming from adjacent agricultural fields? Annual dry down and removal of sediments? Bubbling stations to increase dissolved oxygen?

- **GROUNDWATER DYNAMICS**
What are the links between groundwater and surface water?
Have past changes to the Slough’s tidal prism (e.g., return of tidal exchange to Parsons complex) affected local groundwater (saltwater intrusion)? How would future changes to the tidal prism of different wetlands (moderate decreases at Parsons, slight increases at South Azevedo, etc.) affect adjacent groundwater? Does surface impoundment of freshwater (e.g. in Moro Cojo area wetlands) help to restore groundwater and decrease saltwater intrusion?

POLLUTION
How does polluted runoff affect individual organisms, especially endangered species?
Mixed pollutants may have additive or emergent toxic properties and individual pollutants may not presently be recognized as harmful; decision makers need information about which pollutants have which specific effects on freshwater organisms.

3) COASTAL PRAIRIE

GRAZING AND OTHER RESTORATION TECHNIQUES
What tools are effective for increasing native biodiversity in a very degraded grassland?
Compare various techniques (variants of grazing, mowing, planting, etc.) on the highly invaded Reserve grasslands, and determine effects on key targets (native grasses, annual forbs, perennial forbs). Pair such treatments with large-scale monitoring of similar grasslands in the region where such practices have taken place.

Which native grasses should be planted on what parts of the Reserve?
Fieldwork to permit GIS mapping of soil types and microclimates; match to different plant optima; native grass should be better at resisting invasion if planted in ideal physical conditions.

What is the effect of species diversity on invasibility?
Do grassland restoration with multiple species, singly and in combinations, to look at whether species mixes are more effective than single species at preventing invasion by non-native species.

What is the effect of patch size on restoration success?
Plant natives in degraded grasslands in patches of varying sizes to determine whether bigger areas resist invasion better than do smaller ones.

SPATIAL PATTERNS OF PRAIRIE DISTRIBUTION
Where are remaining stands of intact coastal prairie, and what do they correlate with?
Fieldwork to find remaining native grasses stands, and GIS work to determine whether land use history, current management, slope, surrounding vegetation type, proximity to wetlands, etc. explain distribution of species in the watershed.

RARE PRAIRIE ENDEMICS
What is the foraging efficiency of the many sensitive raptor populations in various types of grasslands in the watershed?
Anecdotal information suggests that thatch accumulation increases vole abundance, and yet raptors forage more frequently in grazed areas with little thatch accumulation. Are these
observations born out by more scientific methods? What characteristics do grasslands exhibit that support raptor foraging?

What is the distribution and habitat use of the listed Salinas Harvest Mouse and Salt Marsh Ornate Shrew?
These species are endemic to a small area around Elkhorn Slough, and haven’t been studied since the 1950s; their taxonomy and ecology should be revisited so that their small populations can be wisely managed.

Does seed number limit introduction of Santa Cruz tarplant and other species?
This species is endemic to coastal prairie and one of the few remaining populations is in the Elkhorn Slough watershed at the Porter Ranch. Research to date has suggested that the number of seeds in any particular population’s soil seedbank may be key to long term survival of the species. This may be because of the species’ ability to withstand year-to-year stochasticity or it may have more to do with low-level chemical compounds deterring herbivory. Experiments with this and related species may help determine the influence of seed number to the survivorship of experimental coastal prairie wildflower introductions.

- **HABITAT USE OF PRAIRIES**
  How does poison hemlock influence community composition?
Examine diversity and abundance of some native plants or animals (e.g., songbirds; grasshoppers in areas with hemlock and areas where hemlock has been removed.

Which large predators occur in Elkhorn grasslands and surrounding landscape?
Which large predators are present? Are their populations viable? What movement pathways are they using, and how large is their range?

4) **MARITIME CHAPARRAL**
- **HABITAT LOSS AND CONSERVATION**
Explore the value of conservation easements and model effectiveness of conservation banking strategies.
Map current conservation easements, document their past and present condition, and evaluate their ecological value. Help design baseline characterization and monitoring programs for chaparral easements. Or, evaluate the benefits of a maritime chaparral conservation banking program in the watershed.

5) **COAST LIVE OAK**
- **HABITAT VALUE RELATIVE TO EUCALYPTUS**
How do ecosystem processes differ in oak woodlands vs. eucalyptus groves?
For instance, how does water usage differ between the two tree species? How does nutrient cycling differ?

What is the value of oak vs. eucalyptus groves for native bird species?
Preliminary work has shown similar bird species composition in oak vs. eucalyptus groves. It would be interesting to track fitness parameters (nesting success, survival, etc.) to see whether the two woodland types are different or equivalent for particular bird species.
OAK RESTORATION
How can native oak understory be enhanced?
Experiments with various methods to initially remove and then to discourage re-establishment of non-natives. Include comparison of areas with varying canopy cover and proximity to edge to determine where long-term success is most likely.

WOODLAND CAVITY NESTERS
What are the effects of providing nestboxes to cavity nesters?
We have 150 nestboxes used mostly by chestnut-backed chickadees (CBCH). Does providing nestboxes increase CBCH densities? (can compare woodlots with and without nestboxes). Does providing nestboxes increase CBCH reproductive success (have to find natural nests in cavities to make this comparison). Does neotropical migrant density correlate with CBCH density (it has been suggested that neotropical migrants are attracted to CBCH and preferentially flock with them).