Lily Olmo
GCA Scholarship

Can coastal artificial wetland ponds provide habitat for diverse fish communities?

Background

Wetlands are some of the most productive ecosystems in the world, and human communities depend on them for water quality improvement, flood protection, and erosion control (Barbier et al. 2011). In the past 200 years, land-use changes have reduced wetland coverage by 53% in the U.S. and over 90% in California (Dahl 1990). Wetland loss has diminished vital habitat that fish and wildlife use as spawning, foraging, nursery, and migration grounds (Sheaves et al. 2015). There has been growing interest in the creation of artificial wetlands, which are human-made habitats first constructed to treat raw sewage, stormwater, and agricultural effluents (Shutes 2001). Artificial wetlands have also been shown to mimic a variety of other natural ecological functions, such as reducing flood damage and supporting ecosystem biodiversity, now coined as "multi-functional" habitats (Thiere et al. 2009). Artificial wetlands now comprise over 12% of global wetland coverage (Gardner & Finlayson 2018). However, there is a lack of comprehensive data on how these artificial wetlands function ecologically compared to natural wetlands.

Of particular concern for managers and ecologists is the ability of a habitat to support fish and wildlife. Wetland fish, serving as both predators and prey, can have multidirectional effects within the food web (Cosby & Szkyman Gunther 2021) and can act as indicator species that help us understand the health of wetlands over space and time. Due to the mobile nature of fish, they are some of the first organisms to occupy and utilize restored tidal habitats (Herbold et al. 2014), so they have potential to indicate the relative success of restoration projects. However, fish are often overlooked in post-restoration monitoring surveys. Many studies describe the presence or absence of target species and may calculate simple metrics of abundance and diversity as indicators of success for restoration projects (Chamberlain & Barnhart 1993; Schulz et al. 2020). Current biological monitoring of artificial wetlands is usually conducted in small, newly restored wetlands over short time periods of less than four years (Zedler and Callaway 2000). These studies are lacking in community-level data that describes fish assemblages and the factors which influence them on spatial and temporal scales.

Objectives

Humboldt Bay is the second largest estuarine system in California (Barnhart et al. 1992) and has lost 90% of its original wetland coverage, making it an ideal location to study artificial wetlands. With over 110 species of marine and estuarine fish in the bay (Gotshall et al. 1990), these ponds could serve as potential spawning and nursery sites, but no baseline data is available on which species or life history stages of fish utilize these ponds, nor at what time of year. In Humboldt Bay, there are three unexplored tidally-influenced wetland ponds that allow the movement of fish into and out of the habitat via metal gates and pipes. This study aims to expand our understanding of what species utilize the habitat, when, and why.

This project will describe fish community health by:

1) estimating the abundance, diversity, and richness of fish in the ponds
2) monitoring the seasonal movement of fish into and out of the ponds, and
3) identifying the life history stages of fish that utilize the ponds
4) measuring habitat characteristics that influence fish community composition.

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I hypothesize that community composition will differ:

1) Among seasons due to the varied life history strategies among species, and
2) Among pond sites due to the unique designs of artificial wetlands, with the most important variables being flow, depth, and salinity

Statement of Work

This project will monitor fish communities in three tidally-influenced artificial wetland ponds: Klopp Lake, Brackish Pond, and Long Pond. Sampling will occur monthly from February 2024 to November 2024 to cover known spawning and rearing periods for local species. I will collect fish samples once monthly using a variety of fish trapping techniques including beach seine nets, fyke nets, and light traps (Figure 1).

1. Seine nets: This technique will estimate the abundance, diversity, and richness of fish in each pond (**Objective 1**). A 15mx2m net (1cm mesh) will be deployed for 3-5 minutes to capture juvenile/adult fish. 4 replicate tows will be conducted per pond per sampling day.

2. Fyke nets: This technique will estimate movement into and out of the ponds (**Objective 2**). A stationary fyke net will be placed at the entrance of each pond to capture fish entering/exiting the ponds during each tidal cycle. The fyke net has a 10m wingspan (0.5cm mesh) and will be placed for a total of 4 hours per pond per sampling day.

3. Light traps: This technique will sample for larval fish that seine and fyke nets do not capture in order to assess the potential of these ponds as nursery habitat (**Objective 3**). Light traps capture larvae attracted to an LED light with a series of funnels and 333µm mesh over a 12-hr period. 4 replicate traps will be placed in each pond per sampling day.

For each trapping technique, I will identify, count, weigh, and measure fish to calculate the abundance, diversity, and richness of species utilizing the habitat. By using a variety of different techniques, I will be able to understand which life history stages of fish (i.e. larval, juvenile, adult, spawning adult) are utilizing this habitat. Juvenile/adult samples will be caught and released, and larval samples will be analyzed in the laboratory via dissecting scopes.

Each of these ponds has a unique design, with varying oceanographic influences and environmental conditions. I will collect information on artificial pond designs including water flow, pipe and tidal gate dimensions, and residence time of water in the ponds (**Objective 4**). I will use a YSI meter, measuring sticks, and local buoy data to collect environmental variables that may be altered due to artificial wetland design, including salinity (ppt) , turbidity (mg/L), water depth (m), and tidal stage. I will temporarily install four HOBO data loggers in each pond, which will collect water temperature readings every 30 minutes for the duration of the study. In an effort to complement other research projects already occurring at the marsh, data will be available for sharing with other researchers. I have already obtained the required permits for sampling from California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, the Institutional Animal Use and Care Committee, and the City of Arcata.

Upon completion of field work, data will be analyzed using multivariate statistical techniques in R Studio, including non-metric dimensional scaling (NMDS), distance-based linear models (DistLM), and permutational analysis of variance (PERMANOVA). These techniques will help explain if fish communities are significantly different between different artificial pond

sites. If significant differences are found, pond designs and habitat characteristics will be analyzed to see which factors are most influential in structuring the fish communities.

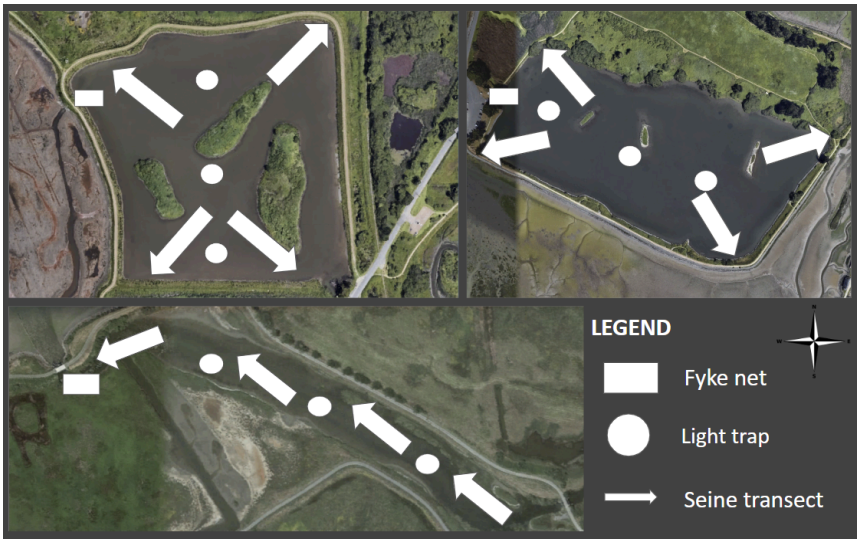

Figure 1. Locations for fish collection methods for Brackish Pond (top left), Klopp Lake (top right), and Long Pond (bottom). Rectangles represent fyke net locations, circles represent light trap locations, and arrows indicate seine net transects. Size not to scale.

Benefitting Coastal Wetlands

Coastal wetlands are declining globally due to anthropogenic impacts such as land-use change, sea level rise, and erosion. Can artificial wetlands help us restore habitat functions for fish communities? By collecting baseline data on fish in artificial wetlands, we will not only understand the health of the fish communities, but also provide data relevant for local wildlife, like river otters and piscivorous birds, which depend on these fish as primary prey sources. This project will serve as an example of how to monitor fish usage of artificial wetlands for continued assessment and ultimately inform the management of fish and wildlife resources in constructed coastal wetlands.

Broader Impacts

This project was designed with collaboration from stakeholders, including the City of Arcata, the U.S. Fish and Wildlife Service, and Cal Poly Humboldt researchers. My plan for dissemination of results to the community is a priority in my research:

1) I have decided to include community stakeholders on my graduate thesis committee to ensure that research is planned, conducted, and shared with community needs in mind. I have representatives from the Wiyot Tribe, the Humboldt Bay National Wildlife Refuge, the U.S. Fish and Wildlife Service, and the Arcata Marsh and Wildlife Sanctuary who have agreed to collaborate with this project. Community representatives will attend sampling days to be trained in fish capture techniques so that monitoring of communities can continue long-term. Community partners will attend quarterly meetings to receive project updates and provide input.

2) In April 2024, I will present my preliminary results at the *Humboldt Bay Symposium*, a community event where I can share my research locally and receive feedback. In April 2025, I will present additional results at the *American Fisheries Society Conference* to share with other fisheries professionals and stakeholders that work on similar projects across the country.

3) To reach wider audiences, I have planned "Fish Focus" talks with the non-profit *Friends of the Arcata Marsh* in Spring 2025, where I will talk about how fish relate to the health of wetlands. I will also create interpretive panels about fish to be placed on marsh walkways.

4) My thesis research will be published in the Cal Poly Humboldt Digital Commons, an open access repository for university research. All data will be publicly available through this avenue. I plan to prepare a manuscript for journal publication at the conclusion of my degree.

Project Timeline (✔ = portions already completed)

Fall 2023	● Write research proposal and finalize experimental design ✔ ● Solidify community partners and committee members ✔ ● Apply for required collection permits ✔ ● Preliminary field trials to revise methods ✔ ● Hire three undergraduate research assistants ✔
Spring 2024	● Obtain funding necessary (applications in progress), purchase gear ● Train and mentor three undergraduate research assistants ● Begin field sampling and lab analysis of larval fish in February ● Present preliminary results at Humboldt Bay Symposium in April
Summer 2024	● Continue field sampling, laboratory work, and data entry ● Preliminary data exploration and analysis
Fall 2024	● Continue field sampling and data collection through November ● Begin statistical data analysis and visualization of results
Spring 2025	● Collaborate with partners to identify management strategies/actionable steps ● Utilize results to create educational outreach for partner organizations ● Present results at American Fisheries Society conference in April ● Deliver oral thesis defense at Cal Poly Humboldt in May ● Write final manuscript for thesis submission and scientific publication

Budget and justification

Item	**Description**	**Cost**
Transportation to field sites	50 miles per field day @ .65 cents per mile (federal rate) x 45 field days	$1462.50
Parking permits	Year-long parking permit required to pick up/return gear	$420
Equipment to construct four light traps	LED lights, battery packs, drill set, electric jigsaw, durable carboys, 10cm funnels, 333µm mesh, metal wire, zip ties, glue gun, specialty glue sticks, acrylic tubes, sample jars, nylon rope, floats/weights	$3117.50

I currently work 20 hours per week as a Teaching Assistant to cover living expenses in Arcata where cost of living exceeds national averages. I am requesting $1462.50 to cover gas expenses for travel to field sites in my personal vehicle, as well as $420 to cover a parking pass required for me to load and unload gear on campus on field days.

Most equipment for my project can be borrowed from existing projects at Cal Poly Humboldt, but I do not have funding to purchase additional equipment. One of the unique aspects of my project is that it will analyze all life history stages of fish, including larvae. I currently have fyke and seine nets which will capture juveniles/adults but not larvae. I request the remaining $3117.50 to cover equipment for the construction of four durable light traps.

References

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CAREER GOALS: Pursue Ph.D. in Ecology, contribute to community-based ecological research as supervisory biologist

EDUCATION

2023 – pres. **M.S. Natural Resources**, concentration Fisheries Biology, 4.0 GPA
California State Polytechnic University Humboldt, Arcata, CA. USA
Thesis: *Using fish and wildlife to study the trophic food chain of artificial wetlands*
Advisor: Dr. Jose R. Marin Jarrin

2016 – 2020 **B.S. Environmental Science,** concentration Ecology & Natural Resources. 3.85 GPA
University of North Carolina at Chapel Hill, Chapel Hill, NC, USA
Minors: Marine Science and Geography
Honors Project: *Exploring trophic flows among nekton at the marsh-estuary boundary*
Advisors: Dr. Karl Castillo, Dr. Joel Fodrie, Dr. Shelby Ziegler, Dr. Jeffrey Seminoff

RESEARCH EXPERIENCE

2023 – pres. **Graduate Research Assistant**, California State Polytechnic University Humboldt, CA
Conducting field and laboratory research on the value of artificial wetland habitats for fish and wildlife within Humboldt Bay, CA. Training and mentoring three undergraduate student technicians

2023 – pres. **Research Affiliate**, Texas A&M University: Harte Research Institute for Gulf of Mexico Studies
Developing a multinational survey tool with partners in the U.S., Cuba, and Mexico to gather information on the socioeconomic value of recreational fisheries in the Gulf of Mexico.

Summer 2022 ***Fisheries Technician II,*** Alaska Department of Fish & Game, Kodiak, AK
Independently sampled age, weight, length, otoliths, and fin rays from groundfish species at port. Conducted in-person interviews on harvesting practices with recreational anglers and charter boat operators.

2021 – 2022 ***AmeriCorps VISTA Environmental Technician,*** Kodiak Area Native Association, AK
Collaborated with tribal leaders to lead two sampling programs involving the collection, identification and analysis of shellfish and phytoplankton species. Created biweekly data reports, K-12 ocean resources curriculum, and other reader-friendly documents to describe tribal scientific sampling programs

2020 – 2021 ***Biological Science Technician,*** U.S. Fish and Wildlife Service, Red Bluff, CA
Responsible for daily sampling of rotary screw traps and telemetry studies for endangered salmon and sturgeon populations. Completed daily data entry, quality control and biweekly statewide reporting.

2018 – 2020 ***Hollings Scholar & Research Intern,*** NOAA Southwest Fisheries Science Center, La Jolla, CA
Assisted with nightly small boat surveys to capture Green sea turtles with large gill nets to assess population structure. Collected samples of blood, tissue, and bone for genetic analysis and age classification. Conducted face-to-face interviews with local stakeholders to analyze the economic value of wildlife ecotourism.

Fall 2019 ***Research Practicum Student***, Dr. Mariana Mayer Pinto, University of New South Wales, Australia
Sorted and identified marine invertebrates through optical microscopy. Analyzed data and used R programming to graphically represent biological data patterns, including factors which influences the distribution and abundance of invertebrates across a latitudinal gradient in eastern Australian estuaries.

2017 – 2019 ***Honors Student & Field Technician,*** UNC Institute of Marine Sciences, Morehead City, NC
Planned and completed two years of self-developed fisheries research. Utilized trapping techniques to monitor predator-prey relationships and changes in abundance of estuarine fish in salt marsh habitats. Experience with dissection, gut content analysis, and otolith aging.

2016 – 2017 ***Undergraduate Researcher***, Dr. Karl Castillo, UNC Department of Marine Sciences
Constructed database of growth patterns for multiple coral species from the Bocas del Toro Archipelago, Panama. Used CT scanner to obtain coral skeleton images, Horos to delineate coral growth bands, and R coding to analyze annual coral growth rates at both remote and urbanized sites.

TEACHING EXPERIENCE

2023 – pres. **Graduate Assistant**, California State Polytechnic University Humboldt, CA
Assisting upper-division fisheries biology courses, Ichthyology (FISH 310) and Marine Fish Ecology (FISH 435), through organizing and leading laboratory and field activities

Summer 2020 **Marine Educator,** Sea Turtle Camp, Wilmington, NC
Led groups of campers age 12-18 through experiential education activities in marine science, including Sea Turtle Biology, Sandy Beach Ecology, and Scientific Diving Research.

2017 **Course Assistant**, Duke University Marine Laboratory, Morehead City, NC
Led weekly environmental education course on microplastics with interactive beach clean-up activities on Shackleford Beach for local 4th and 5th grade students

2017 **Course Instructor**, Splash UNC, Chapel Hill, NC
Developed and taught Coral Reef Ecology 101 curriculum and interactive laboratory experiment to visiting high school students from underserved communities.

HONORS AND AWARDS

2023 Selected Attendee for the 2023 Student Workshop in International Coastal and Marine Management
2020 Graduated with Highest Distinction and Honors
2019 Phi Beta Kappa National Honor Society inductee
2019 Chancellor's Science Scholars Distinguished Scholar Award ($10,000)
2018 NOAA Ernest F. Hollings Scholarship (National Oceanic and Atmospheric Administration, $20,000)
2018 UNC Department of Marine Sciences Internship Award ($2000)
2017 UNC Summer Undergraduate Research Fellowship (SURF) ($3000)
2017 UNC Office of Undergraduate Research Travel Grant ($500)
2016 Hispanic Scholarship Fund (HSF) Scholar ($2500)
2016 Recipient of the President's Volunteer Service Award (2000 service hours)

OUTREACH AND VOLUNTEER ACTIVITIES

2023 - pres. **Professional Mentor for the American Fisheries Society**
Serve as pen pal for high school students in the Hutton Junior Fisheries Biology Program

2016 – 2020 **Buckley Public Service Scholar**
Completed over 500 hours of community service with on-campus organizations during B.S. degree

2018 **Guest Writer for "UNdertheC" Marine Science Blog**
Wrote family-friendly guest article to share the importance of marine zooplankton

2017 **Volunteer research assistant for the N.C. Aquarium at Pine Knoll Shores**
Conducted literature review on sharks and elasmobranchs to reveal local research needs

2017 **Volunteer Diver for PADI Dive Against Debris**
Collected marine debris weekly through underwater dive clean-ups in Beaufort, NC

CONFERENCE PRESENTATIONS

2023 **Olmo, L.**, Henry, H., Besonen, M. *Characterizing Gulf and Caribbean marine recreational fisheries: Current management and future challenges*. Organized symposia at the Latin American and Caribbean Fisheries Congress, Cancun, Mexico (May 2023)

2021 **Olmo, L.**, Ellwanger, G., Wall, A. *An ocean acidification brief for Alaskan tribal communities*. Oral presentation at the 2021 Annual Kodiak Water Quality Conference, Kodiak, AK (March 2021).

2020 **Olmo, L**. Seminoff J. *Sea the value: economics of wildlife tourism in La Jolla Cove*. Oral presentation at the NOAA Science and Education Symposium, Silver Spring, MD (August 2019); The Western Section of the Wildlife Society, Redding, CA (February 2020); and The Ocean Sciences Meeting, San Diego, CA (February 2020).

2017 **Olmo, L.**, Ziegler, S., Fodrie, F.J. B*locking marsh access for nekton to explore trophic flows at the marsh-estuary boundary.* Oral presentation at the Morehead City Field Site Symposium, Morehead City, NC (November 2017)

2017 **Olmo, L.**, Henderson, A., Piehler, M. *Shore thing? An environmental assessment of living shorelines*. Oral presentation at the Morehead City Field Site Symposium, Morehead City, NC (November 2017).

2017 **Olmo, L.**, Fisher, K., Rippe, J., Castillo, K. *Multi-decadal growth histories of Siderastrea siderea and Pseudodiploria strigosa throughout the Bocas del Toro Archipelago, Panama*. Poster presentation at The 46th Annual Benthic Ecology Meeting, Myrtle Beach, SC (April 2017) and The UNC Celebration of Undergraduate Research, Chapel Hill, NC (April 2017).

REFERENCES

1. **Dr. Jose Marin Jarrin**, Cal Poly Humboldt Fisheries Department, jose.marinjarrin@humboldt.edu, 360-280-6352
2. **Dr. Jeffrey Black**, Cal Poly Humboldt Wildlife Department, jeff.black@humboldt.edu, 707-826-3439
3. **Dr. Jeffrey Seminoff,** National Oceanic and Atmospheric Administration, jeffrey.seminoff@noaa.gov, 619-846-5592