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Title of project: A Comparative Survey of Ichthyoplankton in Humboldt Bay, California.

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Project background description and location: My thesis research characterizes the ichthyoplankton assemblage of Humboldt Bay, then compares that assemblage with an offshore survey of ichthyoplankton and with historical samples from the 1960s and 2010s.

Humboldt Bay, the second largest bay in California, is home to a wide variety of fishes, including two at-risk species of interest: the endangered Northern Tidewater Goby (*Eucyclogobius newberryi)* and the threatened Longfin Smelt (*Spirinchus thaleichthys*).[1,2] Nearly all species of marine bony fishes begin their lives as larvae. However, the percentage of marine teleost larvae that reach metamorphosis is incredibly low on average, with estimates as low as 0.11% survivorship.[3] Studying larval distribution and growth improves understanding of the population dynamics of adults, as the rate of development and size of larvae impact survivability at transformation,[4] and the number of larvae that transform into juveniles directly impacts adult population sizes and the population's reproductive capacity.[5,6] Therefore,

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[1] Frimodig, A.J. & Goldsmith, G.H. (2008). First record of a Cymothoid isopod from a Tidewater Goby and three new Tidewater Goby localities in Humboldt County, California. California Fish and Game, 94(4), 194-199.
[2] Garwood, R.S. (2017). Historic and contemporary distribution of Longfin Smelt (*Spirinchus thaleichthys*) along the California coast. California Fish and Game, 103(3), 96-117.
[3] Houde, E.D. (1994). Differences between marine and freshwater fish larvae: implications for recruitment. *ICES Journal of Marine Science,* 51(1), 91-97. DOI: 10.1080/01965581.1987.10749508.
[4] Pepin, P., & Myers, R.A. (1991). Significance of egg and larval size to recruitment variability of temperate marine fish. *Canadian Journal of Fisheries and Aquatic Sciences,* 48(10), 1820-1828. DOI: 10.1139/f91-215.
[5] Hollowed, A.B., Bailey, K.M., & Wooster, W.S. (1987). Patterns in recruitment of marine fishes in the Northeast Pacific Ocean. Biological Oceanography, 5(2), 99-131. DOI: 10.1080/01965581.1987.10749508.
[6] Jones, G.P. (1990). The importance of recruitment to the dynamics of a coral reef fish population. Ecology, 71(5), 1691-1698. DOI: 10.2307/1937578.

characterizing patterns of larval distribution and development through both time and space can help inform conservation efforts of economically important and at-risk species.

Despite the bay's ichthyological importance, only two previous surveys of fish larvae have been conducted (1969 and 2015). The 1969 survey, completed by Maxwell Eldridge as a master's thesis at Humboldt State University, is available online, but its findings were never peer-reviewed and published in an academic journal. The 2015 survey, conducted by James Ray and Dylan Inskeep with the California Department of Fish and Wildlife, replicated the 1969 survey's methods and sites, but the project was never prepared for publication, so these data are not available to the public. This 2025-26 project replicates the methods and sites (Fig. 1A) from the 2015 survey to maximize comparisons between the three surveys over time. Comparison with historical Humboldt Bay samples will also provide information about shifts in the composition of this ichthyoplankton assemblage over time, which is particularly critical as the Bay experiences climate-related and other anthropogenic change. Additionally, noting size classes of larvae across time (and making those data publicly available) will enable future studies of survivability rates of species of interest.

In collaboration with Dr. Eric Bjorkstedt (California State Polytechnic University, Humboldt (CPH)), this project also compares oceanic samples from the Trinidad Head Line (THL) with samples taken from Humboldt Bay to assess similarity of offshore and Bay species assemblages. The THL has been sampled monthly since 2007, at five sites that have remained consistent throughout all eighteen years of sampling (Fig. 1B). Comparison of the offshore community to the Humboldt Bay (HB) community will start to establish the interconnections of ichthyoplankton communities between Humboldt Bay and the northeast Pacific Ocean along the California and seasonal Davidson Currents.

Project and work procedure description: Sites are surveyed once a month from February 2025 through January 2026. For HB sites, I sample pH with a pH probe and dissolved oxygen, temperature, and salinity with a YSI water quality probe across three depth ranges of the water column (one meter above bottom, mid-water, and one meter below surface). After this, a one meter-wide, 500 µm mesh ring net is towed for approximately three minutes at each of three depth ranges. Samples are sieved through a 250 µm mesh sieve and preserved on-site in 95% ethanol to maximize potential for future DNA analysis, if necessary. In the laboratory, ichthyoplankton are sorted out and preserved in 95% ethanol by month and station, where I identify, measure, and note the developmental stage of each fish to the lowest possible taxonomic rank. Samples are sorted within 48 hours of retrieval to be sieved once again through a 250 µm mesh and preserved again in fresh 95% ethanol to ensure proper preservation. Specimens will ultimately be accessioned into the CPH Fish Collection. Comparative statistical

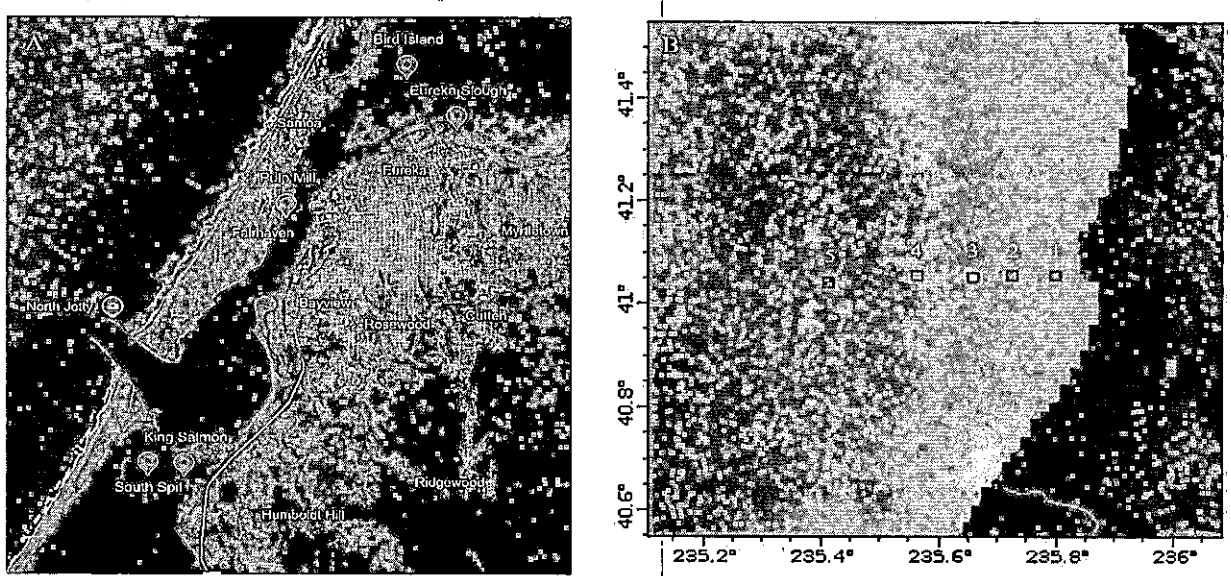

Figure 1. Maps of Humboldt Bay and Trinidad Head Line (THL) sites. (A) The Humboldt Bay sites, as taken directly from the 2015 survey, names included. (B) The THL sites, numbered according to the transect line.

tests will be performed to assess similarity between assemblages, including paired T-tests, ordination and PERMANOVA through R Studio.

Trinidad Head Line (THL) sampling is funded and conducted separately through Dr. Bjorkstedt's lab; however, protocols are included here for context: pH, temperature, salinity, chlorophyll, and alkalinity are measured with CTD water samples. Plankton samples are collected with a vertical ring-net tow and an oblique bongo net tow, then preserved in 10% neutral buffered formalin and 95% ethanol. Samples are sorted for krill, ichthyoplankton, cephalopods, and other groups of interest in the lab, where I identify the larval fish to the lowest possible taxonomic level.

Project objective(s): (1) A descriptive survey of the ichthyoplankton assemblages of HB; (2) comparison of 2025-26 HB samples with unpublished surveys from 1969-70 and 2015-16; (3) comparison of 2025-25 HB samples with 2025-26 THL samples; and (4) analysis of community composition changes over time and space and potential correlations with site-by-site abiotic data for the 2025-26 HB assemblages.

Work schedule: Sampling for this project began in February 2025 and will end in January 2026, with sampling occurring once per month. After the completion of field collections, data analysis and manuscript preparation should be completed by the April 2026 CPH thesis defense deadline.

Proposer's qualification: I earned a B.S. in marine biology from the University of Oregon in December 2023, where I was a research assistant in four different plankton research labs across two years. I spent a total of four-weeks at sea with Dr. Kelly Sutherland, studying gelatinous zooplankton, where I also helped Dr. Bob Cowen at Oregon State University (OSU) with ichthyoplankton collections and identifications. I studied under Dr. Peter Konstantinidis at OSU's Fish Collection in learning ichthyoplankton identifications and worked as a teaching

assistant as an undergraduate for his graduate-level larval fish summer course. I am now a master's student at CPH studying under Dr. Allison Bronson and working with Dr. Eric Bjorkstedt to complete this project.

Amount requested: I am requesting a total of $2,500.00 for this project. See the attached table for the budget breakdown and other funding sources.

Item	Use	Cost per Unit	Unit #	Cost
Vessel rental	Field sampling	$90/hour x 6 hour trips = $540/trip	8	$4,320
Ethanol	Preservation	$75	2	$150
Jars + lids	Sample storage	$0.76/jar + $0.24/lid, $58.37 shipping	48 each	$106.37
500µm sieve	Sample processing	$53.96/sieve, $12.49 shipping	1	$66.05
		Total Cost		$4,642.42
		Hillenburg Marine Science Research Award, CPH		-$1,200
		Raney Fund Award, American Society of Ichthyology and Herpetology		-$960
		Current Cost		$2,482.42
		Amount Requested		**$2,500**

Volunteer participation: Dana Johnstun, a master's student at CPH, has volunteered to help with field collections monthly since February 2025. Allegra Recknor, Sage Roy, Alexis Fierro, and Bri Johnston, all undergraduates at CPH, have volunteered to help sort samples during the spring and fall semesters of 2025.