Summer 2008
NSCI Undergraduate Research Program

MENTOR INFORMATION

NAME	**Dr. Michael Behrens**
PLU Position	Assistant Professor
Department	Biology
List your published *(in past 2 years)* and pending-publication research papers.	Behrens, M.D. & K.D. Lafferty (2007) Temperature and diet effects on omnivorous fish performance: implications for the latitudinal diversity gradient in herbivorous fishes. Canadian Journal of Fisheries and Aquatic Sciences 64:867-873. Lester, S.L., E.D. Tobin & M.D. Behrens (2007) Disease dynamics in the sea urchin, *Strongylocentrotus purpuratus*. Canadian Journal of Fisheries and Aquatic Sciences 64:314-323. Behrens, M.D. & K.D. Lafferty (In review) Temperature and food availability associations with geographic variation in the diet of opaleye (*Girella nigricans* (Ayres)). Journal of Fish Biology. Gooding, R.A. † & M.D. Behrens. (In review) Using freshwater fishes to assess the mechanisms underlying geographic variation in marine herbivorous fish richness. Journal of Fish Biology. Smith, K.F., M.D. Behrens & L. Max. (In review) U.S. drowning in fish: scope, implications and regulation of freshwater and marine imports. Conservation Letters. Smith, K.F., M.D. Behrens, L. Schloegel & P. Daszak (In review) U.S. live animal trade: 1.6 billion and climbing. Science. † - denotes Pacific Lutheran University undergraduate co-author
List your grant awards	
List your pending grant proposals	Murdock College Research Program for the Life Sciences Grant Title: Temperature effects on diet selection and digestive physiology of herbivorous and omnivorous prickleback fishes Expected Notification: Late March 2008 Research Start Date: June 2, 2008
Using specific examples, list your plans to include Student-Researchers in your *Summer 2008* Research.	1. Field collections of study organisms 2. Husbandry of study organisms in the lab 3. Review literature for diet choice experimental methods 4. Conduct diet choice experiments 5. RNA:DNA analysis 6. Preparation of research report and poster 7. Other field activities: Sea urchin disease surveys, work with Olympic NP
Research Title	**Temperature effects on diet selection and digestive physiology of herbivorous prickleback fish**
Research Abstract	Global climate change will likely have important impacts on biological communities due to changes in species distributions. Herbivorous fishes may show such a shift, because they are most common in the tropics and become rare as one approaches the poles. Recent work suggests this pattern may be driven by temperature's effect on physiology. This proposal aims to study the effect of temperature on diet selection and performance in herbivorous and omnivorous fishes. If temperature is found to impact these processes, this would indicate the generality of the previously described mechanism and hint at possible effects of global climate change.

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Research Background	How climate change affects marine environments continues to be an important area of research. Predictions are that species ranges should shift to higher latitudes during periods of warmer water. Herbivores, species that consume primarily plants and algae, can play an important structuring role in communities. In temperate marine systems, reduced levels of herbivory are required to maintain the algal dominated communities characteristic of temperate reefs. This reduction of herbivore pressure is likely produced by a latitudinal diversity gradient, where herbivorous fishes make up a larger proportion of fish communities near the equator than they do at higher latitudes, has been recognized since at least the 1960's. Proposed mechanisms that could drive this pattern include: [1] insufficient time for evolution and range expansion to temperate waters, [2] seasonably unavailable suitable food in temperate latitudes at time scales greater than can be survived by herbivorous fishes, [3] latitudinal differences in algal toughness, nutritional quality, and chemical defenses making temperate algae unusable by herbivorous fishes, [4] physiological constraints due to temperature where herbivorous fishes cannot meet their energetic demands in temperate waters. Indirect assessments of potential mechanisms using non-experimental approaches have supported the existence of such a physiological constraint. Direct tests of the proposed mechanisms have been limited to a single study (Behrens and Lafferty 2006). This study found that a single species of omnivorous fish experienced increased performance at low temperatures when its algal diet was supplemented with animal material. This finding is further strengthened by the increased reliance on animal material by field populations as water temperature declined (Behrens and Lafferty in review). To date this single experiment is the only direct test of the above proposed mechanism. Therefore, while the findings of these studies are suggestive of the importance of temperature in driving this diversity pattern, they provide no generality of the mechanism for other species of herbivorous fishes. The proposed research will focus on evaluating this physiological constraint due to temperature, by investigating the effect of temperature on diet selection and how temperature and diet interact to determine individual performance.
Research Procedure	**Diet Selection Experiments:** Sub-adult and adult specimens of *X. mucosus* will be collected from rocky intertidal areas on the Olympic Peninsula in western Washington. The fish will be held in temperature-controlled aquaria and acclimated to experimental temperatures while being fed diets typical for these species in western Washington. The experimental temperatures (6° and 16°C) will approximate the minimum and maximum monthly mean temperatures experienced by these species across their geographic range. After proper acclimation, diet choice studies will be performed at the experimental temperatures to directly determine if temperature affects feeding behavior and diet choice in both herbivorous and omnivorous species. Fish will be held in small aquaria and starved for 48 hours prior to a feeding trial to ensure feeding. Fish will be offered dietary items common to their field diet (amphipods, polychaetes, green algae) in equal masses and allowed to feed for five minutes. The mass of each item consumed will be determined for each trial. A minimum of twenty runs will be made with each fish species at each temperature. These experiments will determine if thermal conditions affect diet choice in these species and will aid in the interpretation of the findings related to the next experiment. **Temperature and Diet Experiment:** For the second experiment, *X. mucosus* will be collected and acclimated in a similar manner to the first experiment. This second experiment will test for the simultaneous effects of diet quality and temperature on the performance in the study species. After acclimation, fish will be held in individual aquaria at one of two experimental temperatures (6° and 16°C) and fed one of two diets (herbivorous or omnivorous). The herbivorous diet will consist of unlimited supplies of the

	green algae *Ulva* spp. and the omnivorous diet will consist of unlimited supplies of the green algae *Ulva* spp. supplemented with 1% of the fish's body mass per day of animal material (brine shrimp or squid). Ten fish of each species will be held under each combination of diet and temperature treatment for 28 days. Daily consumption rates of all food items will be determined. After 28 days, fish will be euthanized using MS-222 and frozen at -80°C for further analyses. RNA:DNA analysis, which measures the potential for growth, will be performed to determine individual performance. RNA:DNA ratios will be compared among treatments to determine if the effect of diet on performance is dependent on temperature.
Research Scientific Significance	This research aims to increase the generality of our understanding of the potential for temperature to drive patterns of diversity in herbivorous fishes, while addressing some of the methodological difficulties of past studies (*e.g.* assigning causation from correlative field studies). This research will test for the presence of a physiological constraint due to temperature as driver of the above pattern in cold water species, the group most likely to be impacted by such a constraint. If the presence of this constraint is confirmed, this will open the door to further studies of the effect of temperature on the physiology, ecology, and evolutionary history of herbivorous fishes in marine and freshwater systems. Additionally, this research may allow us to make predictions about indirect effects of climate change on marine systems. If herbivorous fish distributions spread towards the poles as temperatures increase, marine communities presently without guilds of herbivorous fishes may show declines in algal populations and algae-associated species.