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Transport of Ghost Shrimp as Live Bait: Potential Effects on
Impacted Southern California Populations

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Project Hypothesis

We hypothesize that:

- 1) many individuals of live bait species intended for use in marine waters of California (including ghost shrimp) are imported into the state annually.
- 2) northern ghost shrimp imported into southern California are genetically distinct from ghost shrimp native to southern California.
- 3) some parasites of northern ghost shrimp that are imported into southern California are not native to southern California and may affect local populations.

Project Goals and Objectives

Specific objective 1: Determine how many northern ghost shrimp are imported into California as live bait annually.

Specific objective 2: Determine whether or not northern ghost shrimp imported into southern California as live bait are viable, either as adults or larvae.

Specific objective 3: Determine if there is significant phylogeographic structure among west coast populations of ghost shrimp.

Briefly describe project methodology

Objective 1: We addressed this objective using telephone surveys of California bait shops known to import live marine species for use as bait. We carried out this survey statewide to get a statewide estimate of the magnitude of the live bait trade and the geographic sources of the ghost shrimp sold.

Objective 2: see modifications, below. Because we discovered no genetic differentiation between northern and southern ghost shrimp, this goal became irrelevant—it doesn't matter if northern ghost shrimp can survive in southern California, as "northern" and "southern" shrimp are not distinguishable using the genetic techniques that we used.

Objective 3: We used sequencing of two mitochondrial DNA loci (cytochrome oxidase I and cytochrome b) from shrimp collected from Washington in the north to southern California in the south (we have since been able to add shrimp collected from several sites along the Pacific coast of Baja California). We then applied standard phylogeographic analyses to these data.

Objective 4: We have quantified parasite diversity and numbers carried in bait shop ghost shrimp each quarter for the past two years. In order to clarify the native ranges of parasites, we have carried out regular surveys of parasites in populations of ghost shrimp from southern California in the south to San Juan Island, Washington in the north.

Describe progress and accomplishments toward meeting goals and objectives.

Objective 1: After a preliminary telephone survey of all coastal and many interior baitshops in the state, we compiled a list of 71 shops known to sell marine live bait. A written survey was sent to all of these shops in early Feb 09, and results are now returned. We had a response rate of 30% (which, from other published work, appears to be typical of such surveys) and from these data estimated annual import volumes and economic value of trade in a variety of live bait species. We anticipate producing a publication on these results in the spring or summer of 2011.

Objective 2: see modifications, below.

Objective 3: Phylogeographic analyses of mtDNA sequence data show no obvious geographic differentiation of populations spanning a range from Washington State to southern California, and thus suggest that northern and southern ghost shrimp exchange genes routinely. These results were published in 2008.

Objective 4: We have found three main taxa of parasites—bopyrid isopods, nematodes, and tapeworms. The final hosts for the latter two species are fishes, while the final host for bopyrids are the ghost shrimp. Currently it appears that bopyrid isopods and perhaps one or more species of nematodes are the only metazoan parasites carried in shipments of northern ghost shrimp, and thus the only two types of parasites at risk of being released into southern California. It remains unclear whether or not these two types of parasites are native in southern California.

PROJECT MODIFICATIONS:

A series of modifications were approved (via email) by Dr. Russ Moll in Dec 2007, before funding had officially arrived to begin the project. Below are the original and modified objectives as in that correspondence.

Specific objective 1 (original)—determine how many northern ghost shrimp are imported into California as live bait annually.

Specific objective 1 (modified)—determine how many northern ghost shrimp are imported into California as live bait annually, but

broaden this survey to also include other live bait species sold for use in marine habitats.

Specific objective 2 (original)—determine whether or not northern ghost shrimp are viable as adults or larvae.

Specific objective 2 (modified)—because phylogeographic analysis suggests no obvious differentiation between northern and southern populations, we don't think that this is an important question any longer. Thus we are simply not addressing this original objective.

Specific objective 3 (original)—determine if there is significant phylogeographic structure among west coast populations of ghost shrimp.

Specific objective 3 (modified)—we have accomplished this goal already (with a paper published in *Marine Biology* in 2008).

Specific objective 4 (original)—determine if parasites are imported, and if they are viable.

Specific objective 4 (modified)—we have partially accomplished this goal. We are nearly finished with a specific molecular analysis to see if northern and southern *Ione cornuta* (a parasitic isopod) are genetically distinct, which will shed some light on whether or not they are native to southern CA or not. We have completed an assessment of whether or not northern *Ione* are viable in southern CA water temperatures (they are). We anticipate publishing these results in 2011.

New specific objective—use molecular and morphological data to clarify the systematics of ghost shrimp on the west coast of the United States. Our phylogeography clearly demonstrated that there are two common species of *Neotrypaea* in the intertidal zone of southern California—one of them is *N. californiensis*, and the other is *N. gigas*. We have recently accomplished this goal, by publishing a paper in the *Journal of Crustacean Biology* using molecular markers to describe a new, simple morphological marker that allows visual distinction of these two common species in the field. This is a major step forward for work on these important bioturbators.

Since those original modifications, we made one main change, which was to ask for and be granted a one-year extension on the project. Its new end date was 31 Jan 2011.

PROJECT OUTCOMES

Our principle results are that:

a) there is no geographically-structured genetic variation in *Neotrypaea californiensis*, a result which informs the discipline of phylogeography (the result is consistent with the generalization that species with long larval periods show little genetic differentiation over large spatial scales), and is also potentially useful for managers of west coast estuaries. spp. A related thalassinidean (burrowing shrimp), *Upogebia pugettensis*, is apparently in a major decline in northeast Pacific estuaries, and

estuary managers may soon be particularly concerned about maintaining populations of other ecologically important burrowing shrimp, such as *Neotrypaea* spp. In such cases, knowledge of genetic structure (and larval dispersal patterns, more directly) will be helpful in making management decisions.

b) our recent publication that describes an effective morphological marker for distinguishing between the two common *Neotrypaea* spp. in west coast estuaries will be very helpful to ecologists/managers who work in these systems and are interested in quantifying abundances of these two very important species.

c) we have produced estimates of the numbers of individuals of various marine live bait species that are imported into the state of CA each year. These are currently in Bruno Passarelli's master's thesis, but we are working on a manuscript we hope to submit by summer 2011.

IMPACTS OF PROJECT

See above.

BENEFITS, COMMERCIALIZATION, AND APPLICATION OF PROJECT RESULTS

n/a

ECONOMIC BENEFITS

n/a

Issue-based forecast capabilities

Our studies of the native ranges of parasites of ghost shrimp on the west coast of the US are a useful baseline for future studies of climate-change induced range contractions or expansions, and are also useful as a baseline for later identifying introduced species. In addition, we now can quantify the distributions of ghost shrimp at the species level effectively (because of our recently described morphological markers that allow anyone to identify them with accuracy in the field), and this will allow us to look at effects of climate change, etc., on their distributions.

Tools, technologies and information services developed

We have identified nucleic acid (mtDNA) and protein (allozyme) and morphological markers of species identity in the genus *Neotrypaea* in the northeastern Pacific.

Publications**Conference papers, proceedings, symposia:**

Western Society of Naturalists San Diego, CA Nov 2010
The marine live bait trade in California: a pathway for the
introduction of non-indigenous species
Passarelli, B. and B. Pernet

Peer-reviewed journal articles or book chapters

Evaluating risks associated with the transport of the ghost
shrimp *Neotrypaea californiensis* as live bait
Pernet, B., A. Deconinck, A. Llaban, and J. Archie. 2008
Marine Biology 153:1127-1140

Molecular and morphological markers for distinguishing the sympatric
intertidal ghost shrimp *Neotrypaea californiensis* and *N. gigas* in
the eastern Pacific

Pernet, B, A. Deconinck, and L. Haney. 2010
Journal of Crustacean Biology 30(2):323-331

DISSEMINATION OF RESULTS

By publication in peer-reviewed journals (two so far, with another
coming soon we hope), posters (3) and talks (1) at scientific
meetings, talks at local universities (2), and one workshop.

FOR ALL STUDENTS SUPPORTED BY THIS GRANT, PLEASE LIST:

Volunteer Count: 6

Graduate Student Info

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Degree Program: M.S.

Thesis Title: The marine live bait trade in California: a pathway
for the introduction of non-indigenous species?

Supported by Sea Grant: Yes

Start Date: 2/1/2009 End Date: 1/31/2010