CALENDAR ITEM
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REQUEST AUTHORITY TO ENTER INTO AGREEMENT TO CONDUCT INVASIVE SPECIES RESEARCH TO CHARACTERIZE THE EFFECTS OF TRANSIT ON THE CONDITION, REPRODUCTIVE STATUS, VIABILITY, AND ESTABLISHMENT RISK OF VESSEL FOULING COMMUNITIES

PARTIES:

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BACKGROUND:

Vessel hull fouling has been a long-standing mechanism, or "vector" of species transfers throughout the world, and has led to numerous nonindigenous species (NIS) introductions. Fouling organisms attach to submerged hard surfaces, including the underwater portions of commercial ships. As vessels transit from place to place, they can also transport nonindigenous fouling organisms which can be introduced to regions where they do not occur naturally. In Hawaii, vessel fouling is believed to be responsible for more successful marine introductions than any other mechanism (Eldredge and Carlton 2002). For North America, one study estimated that fouling accounts for at least 36% of all shipping-related introductions of invertebrates and algae (Fofonoff et al. 2003).

Though the importance of vessel fouling for species introductions has been well recognized, critical information gaps remain for determining the risk posed by commercial vessel movements and associated assemblages of fouling organisms. In particular, specific data for the U.S. Coastline is limited. A California State Lands Commission report submitted to the State Legislature in 2006 stated, "The limited amount of scientific research on vessel fouling and NIS in California and the West Coast is the most prominent obstacle to a clear evaluation of the overall risk faced by the State" (Takata et al. 2006).

The Commission's Marine Facilities Division entered into an agreement in 2005 with Portland State University (PSU) to initiate a long term study to analyze the extent and composition of fouling among vessels operating along the U.S. Pacific coast. One

component of this research involved characterization of the potential magnitude of species transfers using wetted hull surface area as an initial proxy. The "wetted surface area" (WSA) statistic provides a very rough approximation of vessel surface that has the potential to be colonized by fouling organisms. Over a two year period, the study estimated that approximately 265 million square meters or 102 square miles of WSA arrived to the U.S. West Coast and approximately 64 percent of vessels arrived from outside of the three western states (Davidson et al. 2006). The large WSA suggests that the potential threat for fouling invasions may be significant. Another component of this research involved underwater surveys of the extent and composition of fouling communities on containerships, which account for over 40 percent of all ship arrivals to California. This research provided valuable insight into the effects of ship husbandry practices and voyage characteristics on the accumulation of fouling organisms.

The Commission's Marine Facilities Division entered into another agreement in 2007 with PSU to build upon the first phase of vessel fouling research. One component of this work involves additional underwater surveys of ships arriving to California, this time focusing on barges which typically exhibit characteristics which are believed to present a greater risk of NIS introductions than containerships and most other ship types. This work complements the work previously completed on container ships and enhances the ability of the Commission to better understand the relationships between certain vessel practices and the risk of accumulating fouling organisms. Another component of this second phase of research has involved an extensive literature review and a critical appraisal and re-analysis of data from the hull fouling literature to enable the Commission to determine how findings from modern studies of vessel fouling in different regions of the world can be applied to California.

Public Resources Code 71213 requires the State Lands Commission to:

" . . .. identify and conduct any other research determined necessary to carry out the requirements of this division. The research may relate to the transport and release of nonindigenous species by vessels, the methods of sampling and monitoring of the nonindigenous species transported or released by vessels, the rate or risk of release or establishment of nonindigenous species in the waters of the state and resulting impacts, and the means by which to reduce or eliminate a release or establishment . . .."

PROPOSED ACTIVITY:

To meet this mandate, the Commission's Marine Facilities Division (MFD) has determined that continued research to characterize the transfer of organisms on ships' hulls for vessels arriving at key port systems in the western US is necessary. Additionally, MFD has determined that evaluation of the condition of the fouling organisms attached to vessels arriving in California is necessary to properly evaluate the risk of NIS introduction. Previous work has focused on the abundance and complexity of the fouling communities on ships arriving to California but there is still a need to determine if these organisms are capable of reproducing and establishing upon

arrival to California. Utilizing funds from the Marine Invasive Species Control Fund budgeted for conducting necessary research, Staff proposes entering into an agreement with Portland State University (PSU) for $175,000 to complement and continue the work begun during the first two phases of research. Specifically, this proposed work will build upon previously completed work and would incorporate investigations of the condition, viability, reproductive status, and parasite loading of the fouling organisms associated with commercial ships arriving to California. The first component of this proposed research will consist of additional sampling of the fouling communities associated with the submerged areas of ships arriving to California. This work will not only focus on abundance and diversity of the fouling communities but also on the condition of the organisms to provide more detailed insight on the risks associated with this vector. The second component will consist of an evaluation of the reproductive status of the fouling organisms collected during the first component. The third component will involve an evaluation of the parasite loading of organisms collected during the vessel sampling (first component) to determine the risk of spreading nonindigenous parasites into California through the vessel fouling vector. Per the California State Contracts Manual, Section 3.06, contracts with a state college or university, from California or any other state, are exempt from competitive bid requirements (PCC 10340). Staff believes that Portland State University is best suited to conduct these studies because of its extensive experience with respect to the evaluation of fouling organisms on commercial and recreational vessels.

STATUTORY AND OTHER REGULATIONS:

A. Public Resources Code Section 6106 (Delegation to execute written instruments)
B. Marine Invasive Species Act of 2003, Chapter 491, Statutes of 2003
C. State Administrative Manual Section 1200
D. State Contracting Manual (rev 10/05)

OTHER PERTINENT INFORMATION:

1. Pursuant to the Commission's delegation of authority and the State CEQA Guidelines [Title 14, California Code of Regulations, section 15060(c)(3)], the staff has determined that this activity is not subject to the provisions of the CEQA because it is not a "project" as defined by the CEQA and the State CEQA Guidelines.

Authority: Public Resources Code section 21065 and Title 14, California Code of Regulations, sections 15060 (c)(3) and 15378.

EXHIBIT:

A. Transit effects on ship fouling communities: condition, reproductive status, viability and establishment risk: Prospectus submitted to California State Lands Commission (May 2009)

IT IS RECOMMENDED THAT THE COMMISSION:

1. FIND THAT THESE ACTIVITIES ARE EXEMPT FROM THE REQUIREMENTS OF CEQA PURSUANT TO 14 CAL CODE REGS. 15060(c)(3) BECAUSE THESE ACTIVITIES ARE NOT PROJECTS AS DEFINED BY PUBLIC RESOURCES CODE SECTION 21065 AND 14 CALIFORNIA CODE OF REGULATIONS, SECTION 15378.

2. AUTHORIZE THE EXECUTIVE OFFICER OR HIS DESIGNEE TO AWARD AND EXECUTE CONTRACT WITH PORTLAND STATE UNIVERSITY IN ACCORDANCE WITH STATE POLICIES AND PROCEDURES FOR INVASIVE SPECIES RESEARCH TO CHARACTERIZE THE EFFECTS OF TRANSIT ON THE CONDITION, REPRODUCTIVE STATUS, VIABILITY, AND ESTABLISHMENT RISK OF VESSEL FOULING COMMUNITIES IN AN AMOUNT NOT TO EXCEED $175,000.

Transit effects on ship fouling communities: condition, reproductive status, viability and establishment risk

Prospectus Submitted to

California State Lands Commission

(May 2009)

Submitted by

Ian Davidson & Greg Ruiz

Aquatic Bioinvasion Research & Policy Institute (ABRPI)

Portland State University & Smithsonian Environmental Research Center

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Project Description

Background

In the past decade, there has been a substantial increase in analysis of biological invasions associated with the fouling communities of commercial and recreational vessels. This research effort has focused primarily on characterizing species richness and (to a lesser degree) the extent of fouling on ships' submerged surfaces (Coutts, 1999; Gollasch 2002; Godwin 2003; Mineur et al., 2007; Davidson et al., in review). There has also been a parallel indirect approach, assessing the extent to which existing invasions may have resulted from ship-mediated transfers, based upon information about habitat utilization and life-history characteristics of nonindigenous species (NIS) (Cohen & Carlton, 1995; Cranfield et al., 1998; Ruiz et al., 2000; Hewitt et al., 2004; Gollasch, 2006). Together, these analyses have provided insight into: 1) the taxonomic patterns of organisms found on vessel hulls; 2) the characteristics of vessel behavior that contribute to fouling accumulation on ships; 3) the prevalence of NIS on hulls; and 4) the relative contribution of the fouling vector to the initial establishment of NIS.

Today, it is clear that vessel fouling is a potent vector, delivering a taxonomically diverse community of NIS to California and throughout the world (Hewitt et al., 2009; Ruiz et al., in prep), but significant gaps exist in our understanding of the associated invasion risks. Most of the recent research effort has been directed toward measures of propagule identity and quantity, which are both important components of risk, but analysis of propagule quality has been largely absent. In particular, the condition, viability, and reproductive status of biofouling organisms that arrive on ships' hulls have received little attention. Yet, these organisms are subjected to the stresses and disturbances of voyages, and many may be severely compromised with little chance of reproduction or survival upon arrival to a subsequent port of call.

The condition of fouling organisms associated with vessels and their capacity to colonize is largely unexplored. This should vary greatly among vessels, based upon movement history (route, residence times in port, duration at sea, etc.). In particular, changes in ambient conditions (e.g. salinity and temperature) likely have a large effect of condition and invasion risk but this has not been widely explored for fouling communities. Additionally, changes in environmental conditions have been reported to induce spawning and other reproductive activity (Minchin & Gollasch, 2003).

Clearly, all fouling organisms that reach a destination port are not equal in terms of invasion risk. Arrival to a new location is necessary but not sufficient for an invasion to occur, and the condition of organisms is a critical factor in shaping establishment outcomes. An organism must both survive and reproduce over various time periods. While mobile organisms (e.g., amphipods and isopods) can leave a vessel upon arrival, many of the sessile organisms (e.g., barnacles, bryozoans, mussels) cannot. For the latter group, opportunities for successful colonization are likely to be especially restrictive, requiring that (a) the organisms are in reproductive condition **and** (b) reproduction occurs during short residence times in port.

In this project, we propose to characterize the condition of organisms associated with commercial vessels to better assess the risk of invasion from biofouling. This will be done by use of field-based sampling of vessels, serving simultaneously to expand our on-going assessment of species richness and abundance of biofouling communities on commercial vessels. Specifically, we propose a multi-year investigation that will examine: (a) the condition and viability of fouling organisms from vessel hull sampling, (b) the reproductive status of selected taxa and (c) the

parasites status for selected taxa, including a pilot study using histological methods to assess microscopic parasitism of fouling organisms.

Objectives & Approach

Our overall goal is to characterize the invasion risk associated with biofouling communities of commercial vessels, focusing especially on those that arrive to California. The specific goals of this project are to assess the condition and performance of biofouling organisms associated with vessels, as a key component of invasion risk that has received little attention.

By using a combination of field and laboratory measures, this project will generate significant datasets from field sampling of ships (species richness, abundance, condition) that builds on previous work to assess diversity and extent of biofouling. Below, we outline specific components for this integrative project.

1) Condition of organisms within ship fouling communities

We will sample vessels (n>10) in-water and on dry-docks, with dockside testing, to determine the short-term condition status of organisms. The aim is to characterize the condition of organisms after transit because it is likely to be more complex than the existing presence-absence or live-dead comparisons that have been reported for a majority of studies.

The methodology for this component requires non-destructive sampling of organisms to evaluate their condition. Therefore, non-encrusting organisms, such as mobile species and mussels, are more likely to act as case-study specimens than barnacles and bryozoans. In-water sampling may allow for encrusting species to be evaluated in a time-limited manner (using in situ determinations and video).

On each vessel surveyed, we will characterize species richness and percent cover of biofouling organisms, following methods that we developed and are presently using in current hull fouling analyses. In addition, we will select a subset of organisms based on abundance and feasibility (as above) for detailed analysis of condition. As available, we will select n>20 individuals of target taxa selected for analyses, and assess condition using a standardized index. For example, allometry and condition indices have been in use for decades in studies of bivalves (Crosby & Gale, 1990).

Vessels will be sampled on an opportunistic basis, using contacts we have in place (e.g. for dry dock and in-water access) and new contacts we hope to develop (e.g. we will investigate if we can partner with hull cleaning companies for sample collection). We will focus particular attention on organism quality (condition), as below, for all vessels that we can sample in California and elsewhere on the Pacific Coast.

For vessels with sufficient fouling and the possibility of repeat in-water sampling, we will mark locations where fouling has been observed and videoed and re-sample the location to determine voyage effects on biota (using detailed logs of vessel activity during the interim period between sampling).

2) Reproductive status

Organisms collected during ship sampling (above) will be analyzed in the laboratory under dissecting microscopes to evaluate reproductive status. A broad range of marine organisms have conspicuous gametes or even brood their young. This provides the ability to assess reproductive condition, using either binary classification (presence/absence) or reproductive index for stage of gonadal development. We propose to characterize reproductive condition based upon these types of standard measures that have been developed in past studies. We will focus particular attention on barnacles and mussels, as good model systems for which much past work has been done. In addition, we will also examine a wide range of taxa as available in collections from arriving vessels, sampled above.

3) Parasite prevalence and histology

Concurrent with work on reproductive condition (gonadal indices), we will also examine organisms for the presence of selected parasites, many of which are well described and can be prevalent in many invertebrate hosts (especially mussels and other molluscs). Importantly, parasites represent a potential risk of invasion (and impact) to California waters, and several non-native parasites are known to be established here. Despite the potential risk, very little information is available on the potential transport of non-native parasites as part of the biofouling assemblage. As an exception, we have reported the occurrence of a parasite (the decapod castrator *Loxothylacus panopaei*) on several crabs in a ship fouling community (Davidson et al., 2008), while ovigerous females are also readily identified.

For parasites, we will screen invertebrate hosts for the presence of trematode and crustacean parasites, focusing especially on mussels as a model system. In addition, we will survey a broad range of other taxa, as available, to estimate the prevalence of parasitism for helminthes, preserving material for later identification. Finally, as a pilot study, we will send additional specimens for analysis of protistan parasites by a pathology lab, specializing in this detection and identification of this group.

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Scope of Work

Scope of Work Tasks

For the this component of a broader research prospectus we propose to conduct vessel sampling, laboratory analysis, and initiate the histological work as a pilot project and proof of concept.

For this funding cycle, ABRPI will:

1) Conduct vessel sampling to evaluate condition of associated organisms across sites in California and elsewhere on the Pacific Coast. This will also contribute to the growing dataset on species richness and abundance (percent cover) as a function of vessel type,

husbandry practices, and voyage route. Vessels will be surveyed upon arrival to assess biofouling assemblage characteristics, including components #2 and #3 below.

2) Conduct laboratory analysis of reproductive status and parasite load of fouling organisms collected from vessels (in #1).
3) Conduct histological analyses using target species to determine protistan parasite extent and identity

Timetable

These tasks will be completed by June 2011 and proceed along the following timetable:

- Summer 2009: Project initiation - logistical planning, including access to vessels and industry personnel for sampling; protocol and analysis development
- September 2009 – June 2010: Vessel sampling with ship-side condition analyses; laboratory processing of fouling samples for parasitism and reproductive status
- July 2010: Interim progress report to CSLC
- August 2010 – June 2011: Continued vessel sampling and laboratory processing; histology pilot project; analysis and report preparation
- June 2011: Final multi-part report to CSLC, with three data chapters outlining results of organisms viability, reproductive statues and parasite status analyses .

Deliverables

We will produce an interim progress report by July 2010 and a final report in June 2011. Both of these reports will be subdivided into the work components outlined above.

The interim report will outline the progress that has been made on the numbers of vessels and samples processed and present preliminary findings from evaluations of organism condition, parasitism and reproductive status.

The final report will present results, analysis and discussion for all three tasks. The purpose of reporting in this way (in a chapter format) is to facilitate the timely development of manuscripts for publication in peer-reviewed journals.

Budget

The total cost of this project is $174,915. This is a labor-intensive project combining logistically challenging field- and laboratory- based components and involving travel for ship sampling (in-water and on dry –dock). Therefore, these funds primarily cover costs associated with staff time (for sampling, laboratory work, analyses and report writing) and travel --- as shown below.

Primary contract to PSU			
Researcher	12 months	1FTE	$50,664
Fringe benefits		OPE:53%	$26,852
PSU personnel cost			$77,516
Travel (including collaborators)			$6,000
Sampling (dry dock, dive gear rental)			$1,500
PSU total direct cost (tdc)			$85,016
PSU Indirect cost		26%	$22,104
PSU total (tdc + indirect)			$107,120
Subcontract to SERC			
SERC PI	SI salary (no cost to SLC)		$0
Researcher	12 months	0.45FTE	$25,582
Fringe benefits		OPE:27.5%	$7,035
SERC personnel cost			$32,617
Travel			$6,000
Shipping (samples)			$1,300
Contract: Pathology / Parasite Analysis			$3,000
Contract: Laboratory Space Lease at Tiburon			$5,000
Contract: Ship Sampling / Taxonomic Analysis			$5,300
SERC total direct cost (tdc)			$53,217
SERC Indirect cost	a	20% of personnel	$6,523
	b	10.0% of TDC	$5,322
	c	4.2%(tdc + a + b)	$2,733
SERC indirect costs (total)			$14,578
SERC total (direct + indirect)			$67,795
Project total			$174,915