CALENDAR ITEM
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CONSIDER DELEGATING AUTHORITY TO THE EXECUTIVE OFFICER TO ENTER INTO AN AGREEMENT TO SUPPORT A STUDY EXAMINING THE EFFECTS OF VESSEL HULL HUSBANDRY AND OPERATIONAL PRACTICES ON NONINIDGENOUS SPECIES INTRODUCTION RISK

PARTIES:

California State Lands Commission

Smithsonian Environmental Research Center

BACKGROUND:

Nonindigenous species (NIS) are organisms that are introduced through human activity into areas where they do not naturally or historically occur. NIS can cause a variety of economic, environmental, and human health impacts once established in new areas. Economic costs are estimated at $120 billion in losses and damages annually in the United States (Pimental et al. 2005).

Nonindigenous species can be introduced into new areas through a variety of mechanisms. One of the most prolific mechanisms by which NIS are moved to new coastal and estuarine locations throughout the world is vessel biofouling. Vessel biofouling occurs when organisms attach to, or associate with, a vessel's underwater or wetted surfaces, and it is responsible for up to 60% of California's currently established coastal and estuarine NIS (Ruiz et al. 2011).

The extent and intensity of vessel biofouling is influenced by a vessel's maintenance and operational practices, including:

- Time spent stationary in a port
- Type of preventive anti-fouling or foul-release coating used
- Traveling speed and activity level

The Commission implements a statewide NIS prevention program (i.e., the Marine Invasive Species Program) to develop and enforce regulations governing vessel-borne NIS introductions. Commission staff is currently developing draft regulations governing the management of vessel biofouling.

The Commission's efforts to regulate vessel biofouling will be enhanced through a better understanding of the effect of:

- How different coating types (i.e., biocide-based antifouling and biocide-free foul-release coatings) affect biofouling accumulation
- Vessel stationary time on the rate of development of a biofouling community on different coating types
- Variable stationary periods on the extent and diversity of a biofouling community on different coating types
- Vessel movement (i.e., transit effects) on established biofouling communities of different ages and on different coating types

Per Public Resources Code section 71213, the Commission shall 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 AUTHORIZATION:

Staff proposes contributing funds from the Marine Invasive Species Control Fund to the Smithsonian Environmental Research Center to support a study evaluating the effects of vessel stationary period, antifouling coating type, and hydrodynamic flow on nonindigenous species introduction risk.

The study will involve the placement of square (5.5 inch per side) settlement plates in the water to allow biofouling organisms to colonize and accumulate over time. The settlement plates will be left in the water for a series of six different stationary periods ranging from 3 to 60 days. Each set of plates will include eight replicates that are either coated with a biocide-based coating, a biocide-free foul release coating, or unpainted controls. This portion of the project will result in a detailed relationship between stationary time and biofouling extent for both biocide-based and biocide-free antifouling coatings.

The proposed research will also include an assessment of the effects of vessel movement on the biofouling communities that develop on the settlement plates. Each plate will be examined to determine biofouling extent before and after a flume trial, where the plates will be exposed to controlled water flow at 14 knots (the average traveling speed of vessels arriving at California ports in 2015).

The proposed research will occur in two locations, with either location representing a different phase of the study.

Phase 1: Settling plate and flume trial research will be conducted over several months in San Francisco Bay during the summer of 2017. The Smithsonian Environmental Research Center will prepare and submit an interim report detailing the results of Phase 1. Commission staff will review the interim report and will approve or deny commencement of Phase 2, depending on the results of Phase 1.

Phase 2: Settling plate and flume trial research will be conducted over several months at a mid-Atlantic site during the summer of 2018. At the completion of both Phase 1 and Phase 2, the Smithsonian Environmental Research Center will prepare and submit a manuscript for publication in a peer-reviewed scientific journal.

REFERENCES CITED:

Pimentel, D., Zuniga, R., Morrison, D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273-288.

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STAFF ANALYSIS AND RECOMMENDATION:

Authority:

- Public Resources Code section 71213
- Public Resources Code section 6106 (Delegation to execute written instruments)
- Marine Invasive Species Act of 2003, Chapter 491, Statutes of 2003

- State Administrative Manual Section 1200
- State Contracting Manual (rev 01/14)

Public Trust and the State's Best Interests Analysis:

The subject study will enhance the Commission's scientific knowledge of biofouling, a mechanism that poses a significant threat to marine ecosystems, coastal economies, and human health. As a component of a scientific study of the marine environment, the proposed study evaluating the effects of vessel stationary period, antifouling coating type, and hydrodynamic flow on nonindigenous species introduction risk is consistent with the Public Trust, insofar as it will provide a greater understanding of the effects of variable stationary periods on the development of biofouling communities on vessels bound for California ports and effects of vessel movement on the accumulation and survival of biofouling organisms while a vessel is in transit, which all benefits a greater understanding of how to protect the marine environment.

For all of the reasons above, Commission staff believes authorizing the funding of the subject study is consistent with the common law Public Trust Doctrine and in the best interests of the State.

OTHER PERTINENT INFORMATION:

1. The Commission is authorized under Public Resources Code section 71213 to identify and conduct research determined necessary to carry out the requirements of the Marine Invasive Species Act (Pub. Resources Code, § 71200 *et seq*.)

2. This action is consistent with Strategic Goal 1, Key Action 1.1.3 of the Commission's Strategic Plan. This Key Action calls for staff to implement Ballast Water Discharge Standards and biofouling management strategies that prevent the introduction of nonindigenous species into State marine waters.

3. The staff recommends that the Commission find that this activity is exempt from the requirements of the California Environmental Quality Act (CEQA) as a categorically exempt project. The project is exempt under Class 6, Information Collection; California Code of Regulations, title 14, section 15306.

   Authority: Public Resources Code section 21084 and California Code of Regulations, title 14, section 15300.

EXHIBIT:

A. Vessel biofouling & invasions: evaluating biofouling introduction risks under lay-up conditions in marine systems: Prospectus submitted to California State Lands Commission (October 2016).

RECOMMENDED ACTION:

It is recommended that the Commission:

CEQA FINDING:

Find that the activity is exempt from the requirements of CEQA pursuant to California Code of Regulations, title 14, section 15061 as a categorically exempt project, Class 6, Information Collection; California Code of Regulations, title 14, section 15306.

PUBLIC TRUST AND STATE'S BEST INTERESTS:

Find that the proposed activity will not substantially interfere with the public rights to navigation and fishing nor the Public Trust needs and values at this time or during the term of the study, is consistent with the common law Public Trust Doctrine, and is in the best interests of the State.

AUTHORIZATION:

1. Authorize the Executive Officer or her designee to award and execute an agreement not to exceed $160,178 with the Smithsonian Environmental Research Center in accordance with State policies and procedures to evaluate the effect of vessel hull husbandry and operational practices on nonindigenous species introduction risk.

2. Authorize and direct the Executive Officer or her designee to take whatever action is necessary and appropriate to implement the provisions of the agreement with the Smithsonian Environmental Research Center.

EXHIBIT A

Vessel biofouling & invasions: evaluating biofouling introduction risks under lay-up conditions in marine systems

Project Cost: $160, 178

By: Ian Davidson, George Smith, Greg Ruiz
Smithsonian Environmental Research Center, Edgewater MD & Tiburon CA

To: California State Lands Commission, Marine Invasive Species Program

Background

Biofouling of vessels is coming under increasing scrutiny as a vector of nonindigenous species. It has a long history and widespread potency, often ranked the highest for vector strength in different locations throughout the world (Eldredge & Carlton, 2002; Hewitt & Campbell, 2010; Ruiz et al., 2011). Sampling of ships over the last 15 years confirms that the vector is very active and that gaps exist in the industry's preventive biofouling measures (Coutts & Taylor, 2004; Davidson et al., 2009; Inglis et al., 2010; Davidson et al., 2016). As a result, managers and policymakers are devising strategies to reduce and prevent new biofouling-mediated introductions from shipping fleets (IMO, 2011; Scianni et al., 2013; New Zealand Government, 2014).

One of the priorities for management is to determine factors that can inform policy development, implementation (enforcement or monitoring) and strategic investments based on the riskiest vessels in a population. One such risk factor is lay-up period, whereby vessels remain stationary (or relatively inactive) in a single port or bay. These periods are associated with increased biofouling colonization of vessels because (i) colonization tends to occur during periods of vessel inactivity rather than when a vessel is underway; (ii) hydrodynamic forces that remove biofouling are not occurring; (iii) antifouling and foul-release coatings do not work effectively in the absence of vessel movement and (iv) localized movement within the same bay environment usually leads to higher biofouling. While there is long-standing theoretical support for stationary period as a risk factor, and some evidence from ship studies (e.g. Visscher 1928; Davidson et al., 2008), the multi-factorial nature of ship biofouling and the variation in biofouling among ships obscures potential threshold levels for acceptable (low-risk) lay-up periods (Inglis et al., 2010).

For the past six years, ships arriving to California have submitted an annual Hull Husbandry Reporting Form (HHRF), in which they report the durations and locations of lay-up times. The sum of vessel arrivals with a reported lay-up of ten-day or greater duration number in the thousands over a six-year period. These include 1581 arrivals with 10-20 day lay-ups, 1092 with 20-30 day lay-ups, 471 with 30-45 day lay-ups, and 158 with 45+ day stationary periods. These vessels have been stationary in temperate and tropical locations across the six populated continents of the world, with notable hotspots in East Asia, the West Coast of North America, Europe, and the Gulf & East Coast of the US.

It is not clear what these lay-up times mean in terms of introduction risk to California, although it is reasonable to infer that vessels with longer and more frequent lay-ups present a higher risk than vessels without such lay-ups. Quantitative information on the effect of lay-up is not well advanced, however, and could underpin a better understanding of the difference between port durations (hours/days) versus lay-ups (weeks/months), as well as identifying useful thresholds for policy. The goal of this proposed project is to experimentally evaluate the duration-abundance (cover) relationship for biofouling to determine some general characteristics of transfer risk after lay-ups.

Scope of Work

Objectives & Approach

Our aim is to determine the relationship between immersion time (analogous to lay-up duration) and biofouling colonization of surfaces across two sites for three levels of a 'coating' factor (antifouling, foul-release, and unpainted control). This will be achieved using settlement plates to determine colonization at two different sites on the Pacific and Atlantic Coasts; San Francisco Bay and a mid-Atlantic site. The two-site approach will provide a strong contrast in source pools of organisms during the tests. Metal plates will be used unless our partners from the coatings industry determine a more suitable substratum for the trials (e.g. Piola & Johnston 2008; Canning-Clode et al 2011; International Paints-Houston, pers. comm.). The experimental design will include replicate fouling plates immersed in water for six different levels of immersion time, ranging from three to 60 days. These data will generate comparative duration-colonization relationships across sites for a comprehensive range of timelines that incorporates ships' port visits to long lay-ups.

The orthogonal and balanced factorial experimental design is outlined in Table 1. Replicate settlement plates (approximately 14cm square) will be immersed at the two sites and a deployment at one site will involve 144 fouling plates. This will require some planning and inquiry regarding site selection and permissions in advance. The replicate plates with antifouling coating, foul release coating, and no coating will be deployed face-down from floating docks or custom-built arrays. The orientation mimics the downward faces of ships' submerged surfaces, which represents a majority of vessels' wetted surface area. For each replicate across each combination of site, coating, and immersion time, the response variable will be the percent cover of biofouling on each plate (using photographs), with additional resolution to functional or taxonomic groups (i.e. broad categories such as biofilm, algae, barnacles, bivalve etc).

Table 1. Factorial design of the experiment to examine the relationship between lay-ups and biofouling percent cover.

Factor	Number of Levels	Levels
Bay	2	SF Bay, Atlantic Site
Coating	3	Antifouling, Foul Release, None
Immersion Duration	6	3, 6, 10, 28, 45, 60 (days)
Replication	8	Standard 8 for balance across all levels

After each block of immersion time, fouling plates will be subjected to a flume trial to examine the effect of hydrodynamic forces on the accumulated biofouling. A simple, portable flume will be designed and constructed to provide laminar water flow over replicate plates (Fig. 1). Trials will occur at field sites near plate deployment sites and occur over a standard duration and standard water flow. Pilot testing will determine the flume exposure durations. The flume design is intended to reach approximately 14knots (20kph) to provide a realistic effect of flow over biofouling assemblages that formed in static conditions. Repeat measures (using photos) will be taken of each replicate to measure biofouling cover after plates are subjected to water flow.

The flume will provide greater control and precision for the application of flow/forces to hull surfaces and biofouling organisms than analogous experimental approaches using boats. The higher cost and comparative lack of control on boat-based flow trials (e.g. Coutts et al., 2010a, 2010b) mean the flume is most appropriate for this investigation. While the flume will be portable, the larger components (especially the pump, weighing 340 lbs) will require over-ground shipping and we intend to conduct sites sequentially rather than during the same time period (Phase 1 = SF Bay, Phase 2 = mid-Atlantic site).

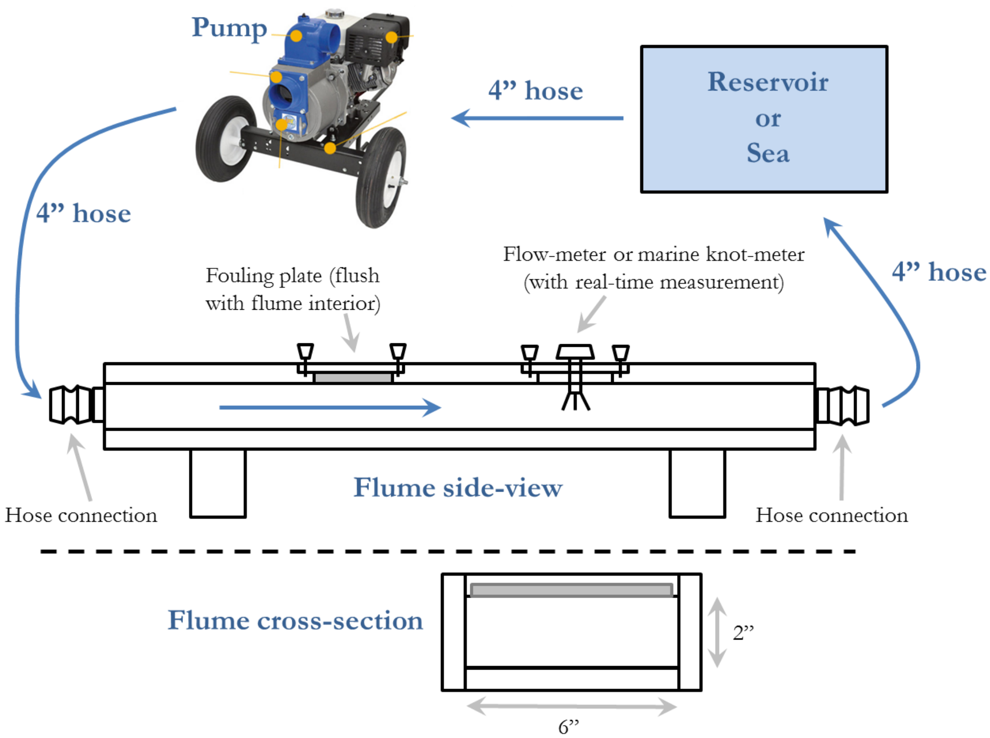

Figure 1. Diagrammatic representation of the flume design. Water will be taken from a reservoir tank or the sea by a 37,800GPH pump. Four-inch hoses will connect the water source to the pump and flume. The flume will be 6" wide and 2" high (cross-section), so biofouling larger than 2" high will only be groomed if it causes complete blockage of the flow space. The flume will allow plates to be installed flush with the interior walls and a flow/knot meter will provide real-time flow data. The exact configuration of the flume (e.g. positioning of plates and meters) is subject to change during additional design and construction.

The outcome of the project will be an experimental test of the predicted effects of lay-up time on the percent cover of biofouling (Fig. 2) and how this varies across coating type and with hydrodynamic flow on the fouled surfaces. This will provide insight on the rates of biofouling accumulation over time, the efficacy of coatings for reducing biofouling accumulation, and the role of vessel movement (water flow) for removing biofouling. It will also provide a system for broader spatial comparisons and additional factors in the future.

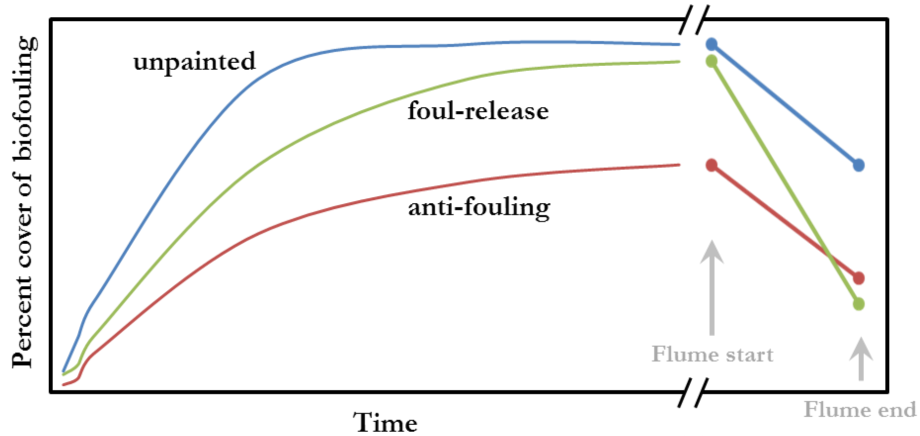

Figure 2. Predicted biofouling cover over time for surfaces subjected to three coating levels. The goal of the project is to test this prediction and parameterize the curves to provide a better understanding of the effect of lay-up of biofouling transfers.

Logistics

Plate deployments for all six immersion durations will be carried out such that each site would require 144 plates, 4 field trips, and 4 periods of flume use (Table 2). Plates will be deployed according to a timeline that maximizes the efficiency of field personnel and flume use. All six sets of plates (n=24 per set), based on immersion duration, will be deployed initially during the first field trip (field day 1). Then sets of plates will be removed on that first trip until the 10-day plates are processed (post-immersion and post-flume). Subsequent trips will complete the experiment for the 28-, 45- and 60- day plates.

Table 2. <u>Example</u> timeline for the deployment, retrieval, and flume trials for one site. The Pacific and Atlantic sites will require six sets of plates (n=24 per set), whereby a set is defined as the immersion duration factor (six levels).

Field Day	Example timeline	Action	Set identity	Number of plates
1	10-Jul	deploy 6 sets of plates	All	144
	11-Jul			
	12-Jul			
2	13-Jul	flume 1 set	3 day	24
	14-Jul			
	15-Jul			
3	16-Jul	flume 1 set	6 day	24
	17-Jul			
	18-Jul			
4	19-Jul	flume 1 set	10 day	24
28 days - 5	7-Aug	flume 1 set	28 day	24
45 days - 6	24-Aug	flume 1 set	45 day	24
60 days - 7	8-Sep	flume 1 set	60 day	24

Project Timeline

The project duration will be 26 months, with one site of plates being completed in successive summers. Ideally, the timeline would begin in Fall/Winter 2016/17 so that planning, purchasing, and construction could occur prior to a summer deployment at one site (Pacific). This would also permit planning time for interactions with coating industry experts that will be involved in the project. This timeline would be repeated the following year at the other site (Atlantic). An interim report will be submitted after the first set of field trials is complete (4 months after completion of field work) – review of this report and subsequent written authorization from SLC's project manager would act as a trigger to complete the second phase of the project or end the project after phase 1. A manuscript will be prepared and submitted by December 2018 (according to this example timeline of Nov 2016 to Dec 2018).

Deliverables

There will be several milestones throughout the project revolving around the construction of equipment and completion of field trips. There will also be an interim report to SLC after the first phase (SF Bay) when the first site is completed. Phase 2 of this project may be triggered after review of the interim report and with written authorization from the SLC MISP Project Manager. The final deliverable will be a manuscript submitted to a peer-review journal and using the journal's open-access format (i.e. paying for copyright so that the study is freely available to the public). SLC and SERC have a preference for peer-reviewed publications, so the manuscript submission will double as the final report to SLC. The paper will present the results of the experiment within the context of the HHRF data that SLC collects. The paper submission will happen by the end date and the PI will continue to pursue the review and editing process with the journal after this date until it is published.

Budget

The project cost is $111,332 for Phase 1 and $48,846 for phase 2. ($160,178 if both phases are completed). The amount authorized for work to be performed upon execution of an agreement shall not exceed $111,332, unless phase 2 is triggered by the SLC Project Manager. The details are outlined in Table 2:

Table 2. Budget

Personnel	$66,343
Stipend	$6,000
Materials	$8,500
Shipping	$9,500
Travel	$23,900
Publishing	$2,500
Total Direct Costs	$116,743
Total Indirect Costs	$43,435
Total Project costs	**$160,178**
Total Project Phase 1	$111,332
Total Project Phase 2	$48,846

EXHIBIT A

The costs are distributed among staff time, travel, supplies, shipping, and indirect costs. For each category:

- Staff time includes planning & preparation (& permitting), construction of field equipment, initial testing of purpose-built equipment, eight field trips, data collection and quality control, analyses, report & manuscript preparation, and publication. This is dispersed among two key personnel (senior scientist and senior technician) and two additional support staff. The totals include $52,528 in salary and $13,815 in benefits (applying SERC's benefit rate). A research assistant (intern) is also included at a cost of $6000.
- Materials include the pump ($3200), flume components, knot meter and software, 300 metal plates, and deployment materials.
- Shipping of materials is significant but the added value of industry-application of coatings is a major cost savings. Shipping materials includes sending settlement plates to-and-from International Paint and cross-country shipping of the flume and pump (weighing > 350lbs).
- Travel includes fieldwork at an off-site (non-SERC) location in SF Bay and in the mid-Atlantic. There are no flights associated with mid-Atlantic fieldwork, but vehicle use, lodging, and per diem for staff-intensive field work is budgeted for a cumulative 54 days of field work in MD distributed among several people and 4 field trips. The cost is similar in CA, including six flights but cost-savings from using staff in the Bay area. Field work at the Atlantic and Pacific sites are budgeted at $10,200 and $13,700, respectively.
- We also include some publishing costs to provide the option of publication in open-source format or journals
- The direct costs are $116,743 and the indirect costs are derived from the Smithsonian's budget policies.

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EXHIBIT A

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