

WASHINGTON SEA GRANT PROGRESS REPORT
for the period 2/1/2008 – 1/31/2009

WSG Project Number: **R/ES-66**
Project Title: Integrating Intertidal Habitat into Seattle Waterfront Seawalls

Principal Investigator(s) and Affiliation:
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1. ABSTRACT ELEMENTS

OBJECTIVES (note: this section has been updated)

More than 60% of the human population lives in coastal areas, and further increases are projected. A major component of urbanization affecting biodiversity along urbanized shorelines is the addition of built structures such as seawalls to the natural landscape. The importance and advantages of including ecological criteria in the design and management of such structures has recently been recognized, and one way to make relatively featureless seawalls more environmentally friendly is by adding habitat complexity—complex substrata are known to enhance the diversity and density of intertidal organisms. The ability to test this concept arose when the City of Seattle realized that the failing Seattle seawall needed to be replaced and provided resources to design, build, and deploy habitat enhancement panels along the seawall. The City and Washington Sea Grant provided further funds that allowed for rigorous scientific testing of these panels. Habitat panels incorporating several levels of complexity and surface texture (Figs. 1, 2) were deployed in early 2008 and biological monitoring began in Spring 2008 and will continue through Summer 2009. Also, troughs (livestock watering troughs) extending out from the base of the seawall were deployed. These were intended to add a horizontal sediment treatment to the seawall experiment to mimic shallow water sediment habitats. Each site had three treatments, ranging from sand to large cobbles. The goal of this project is to experimentally assess the ecological benefits of incorporating engineered complex intertidal habitats into vertical seawalls along Seattle's shoreline. Ongoing objectives of the biological evaluation include: (1) assessing sessile invertebrates and algae colonizing the habitat panels; (2) assessing benthic invertebrates colonizing the sediment troughs (3) evaluating juvenile salmon and other fish presence and behavior around the engineered habitat; (4) sampling epifaunal invertebrates known to be prey for juvenile salmon; and (5) providing recommendations to the City and other interested parties as to which designs would be most ecologically beneficial when incorporated into the new seawall and other similar built structures in the aquatic environment.

METHODOLOGY (note: this section has been updated)

Experimental habitat panels and sediment troughs have been installed in three areas of the Seattle waterfront. Three panel designs (flat, stepped, finned) with two surface treatments (smooth and cobble) are being sampled and compared to adjacent sections of seawall that have been power-washed (controls) and left alone (references) (Figs. 1, 2). In addition to the vertical panels, the intertidal troughs have been installed and filled with three types of substrate—sand, gravel, and cobble—that are also being evaluated. We have monitored the treatment and reference panels

and troughs for one full field season (April-August 2008) to document the affect of each treatment on associated algae and invertebrates, and on behavior of juvenile salmon and other fishes. The second field season started in April 2009. Species composition and percent cover of sessile invertebrates and algae are being quantified with a 0.25 m², gridded quadrat (Fig. 3). On habitat panels, mobile macro- and meiofaunal invertebrates such as amphipods and harpacticoid copepods that live on the surface of the substrate are sampled using an epibenthic pump, which vacuums invertebrates inside a cylinder of known volume from the surface layer of substrate (Fig. 4). In troughs, invertebrates are sampled with benthic cores at the end of each sampling season. Overwater observations and underwater video transects are used to assess juvenile salmonid and other fish in the area around the habitat treatments. The overwater observations consist of walking transects along the seawall looking down from the sidewalk level with polarized glasses. Observations will include schools and, if possible, species, adjacent to the seawall and habitat test panels. Video of fish is taken by walking the underwater video camera along the seawall, keeping it approximately 5-6 feet from the seawall, to capture the majority of habitat test panel, reference, and control areas. In 2008 videos were done bi-weekly for three months during peak juvenile salmon rearing and migration. Fish observations include species identification, sizes, position, depth, and behavior.

RATIONALE (note: this section has been updated)

Replacement of the Seattle seawall will begin as early as late 2012, and the reconstruction provides an opportunity to enhance habitat for intertidal invertebrates and fishes. Physical characteristics of the existing shoreline and the relatively deep bottom adjacent to the seawall preclude restoring the natural shorelines that once occurred in this region of Puget Sound. Thus, it is desirable to explore seawall habitat enhancement under existing uses and conditions. This project represents a unique opportunity and has a high probability of success because (1) there has already been a convergence of planners, engineers, and scientists working on and troubleshooting the concept; (2) previous studies have suggested that enhancing habitat through seawall modification is theoretically possible; (3) the presence of abundant juvenile Chinook and other salmon actively using the intertidal areas of the City's shorelines suggests that improving seawall habitat could directly benefit these important species; and (4) preliminary results indicate that the concept is working (see below).

Opportunities to fully restore habitat in urban areas are exceedingly limited and rehabilitation or enhancement—not complete restoration—are the only feasible approaches to increasing ecological function. This project represents an opportunity to put into place recent concepts about how to successfully approach habitat enhancement in urban areas, including (1) working within human-induced system constraints that limit the approaches, patterns, and rates of restoration; (2) exploring innovative and adaptive approaches that can comprise adaptive management experiments; and (3) expanding social and cultural connections and institutional commitments to urban restoration. Such a comprehensive approach will help mitigate damage to nearshore systems, addressing priorities for organizations like the Puget Sound Partnership, which has stated in their Action Agenda that habitat alteration is one of the major threats to ecosystem processes in Puget Sound.

2. ACCOMPLISHMENTS AND OUTCOMES

Initial data from the 2008 sampling indicates that the test panels were not colonized with the full diversity of organisms already residing on the existing seawall. For example, in quadrat

samples, all of the test panels had fewer types of algae and sessile invertebrates (e.g., barnacles, limpets) as compared to the reference seawall (Fig. 5). Also, the panels had more algal cover and less empty space in the first year than reference sections of seawall, possibly due to the lack of grazing invertebrates. The test panels were colonized by pioneering and seasonal species of algae, and invertebrates were limited to newly settled barnacles. Reference panels were characterized by more diverse algal species, and had four limpet species, three barnacle species, and snails. Initial monitoring in 2009 indicates some of the algae and invertebrates characteristic of the mature reference seawall are beginning to colonize the test panels. It also appears that mussels are colonizing the more complex panels in greater numbers and larger sizes than on the reference, control, and flat panels.

Results from epibenthic pump samples taken in year 1 show that two juvenile salmon prey groups, harpacticoid copepods and chironomid midge larvae, were more abundant on the habitat panels than on either the mature seawall or the power-washed controls (Fig. 6). Interestingly, a third salmonid prey group of gammarid amphipods were more abundant on the flat panels and the seawall reference and control. We do not know if these patterns will hold in subsequent samplings, and some of the results may be correlated with the short time that the panels have been deployed, e.g., with some of the ephemeral pioneering algae species.

3. IMPACTS

Currently, the Seattle seawall is deteriorating and is in need of major repairs or replacement, presenting an opportunity to improve the ecological function along an urban shoreline with a redesign that includes increased complexity and surface area. The findings of this study have the potential to be applied across several fields to encourage creative engineering solutions in the future design of intertidal structures, to integrate intertidal habitat enhancement design features in policy regarding new construction, and to support conservation efforts where restoration to natural conditions is not feasible. This research will also advance our basic ecological knowledge of intertidal species and fish use in a significantly altered urban intertidal environment and our broader understanding of intertidal ecological mechanisms, processes, and interactions associated with artificial structures. **Impact:** This study evaluates several environmentally friendly seawall designs, and will provide valuable information about which design types improve the intertidal habitat. It is intended that design criteria suggested by this study will be integrated into reconstruction of the seawall, which will begin as early as 2012. The redesign and habitat enhancement of a permanent intertidal structure could provide long-term benefits by supporting salmon, an economically and culturally important resource.

4. PERFORMANCE MEASURES

Measure 1: Economic and societal benefits derived from the discovery and application of new sustainable coastal, ocean, and Great Lakes products from the sea.

Actual (reporting period covered by this report):

Anticipated (12-month period following this reporting period):

Measure 2: Cumulative number of coastal, marine, and Great Lakes issue-based forecast capabilities developed and used for management.

Actual (reporting period covered by this report):

Anticipated (12-month period following this reporting period):

Measure 3: Percentage/number of tools, technologies, and information services that are used by managers (NOAA and/or its partners and customers) to improve ecosystem-based management.

Actual (reporting period covered by this report):

Anticipated (12-month period following this reporting period):

5. PUBLICATIONS

Please refer to instructions for hardcopy reprint requirements and citation formats.

A. Journal articles:

B. Theses and dissertations:

C. Book chapters:

D. Book or Monograph:

E. Paper in Proceedings

F. Proceedings or Symposia:

G. Technical reports:

H. Advisory publications (e.g. handbooks, manuals, guides):

I. Magazine articles:

J. Media Placements:

K. Other publications (e.g., videos, DVDs, software, websites):

6. PRESENTATIONS - inc. Conference (Poster or Oral), Seminar & Public

Conference poster presentation: Goff M. (2008) Can Habitat Enhancement Improve the Intertidal Environment for Salmon?: Experimental Designs along the Seattle Seawall. Poster presentation at 2008 Pacific Estuarine Research Society annual meeting, Newport, OR, February 15, 2008

Workshop presentation: Goff M. (2008) Intertidal Habitat “Enhancement” along Seattle’s Seawall. Center for Ocean Sciences Education Excellence, Communicating Ocean and Marine Science workshop, Seattle, WA, November 22

7. PATENTS AND COPYRIGHTS

8. NEW BUSINESSES OR JOBS CREATED

9. LIST ALL STUDENTS SUPPORTED BY OR AFFILIATED WITH THIS PROJECT

_____ no students involved (check here if no students were involved in the project)

Student Name: Maureen Goff

Department: School of Aquatic and Fisheries Sciences

Major/Degree field: School of Aquatic and Fisheries Sciences

Major Professor: Charles Simenstad

Student Type: M.S.

Dissertation/Thesis title: Effect of Intertidal Habitat Enhancement on Seattle’s Seawall

Date of graduation (actual or anticipated): March 2010

Total support or affiliation period (e.g., Jan – June 2005):

Type of support (RA, research costs, conferences – list all that apply): RA, research supplies, tuition, conferences.

Current employment if applicable:

Student Name: Paul Son

Department: School of Aquatic and Fisheries Sciences

Major/Degree field: School of Aquatic and Fisheries Sciences

Major Professor: Charles Simenstad

Student Type (Ph.D., M.S., M.A., B.S., B.A. J.D., etc): B.S.

Dissertation/Thesis title: Fish Distribution and Behavior at Intertidal Habitat Enhancement Test Sites along Seattle’s Seawall (Capstone Project)

Date of graduation (actual or anticipated): June 2009

Total support or affiliation period (e.g., Jan – June 2005): June 2008 – June 2009

Type of support (RA, research costs, conferences – list all that apply):

Current employment if applicable:

10. INTERACTIONS

Two other University of Washington research efforts are complementary to the seawall habitat enhancement project. First, a recently completed project quantified the abundance and behavior of juvenile salmon and other fishes along various modified and undeveloped habitat types along Seattle's marine shoreline. Second, part of the Seattle Art Museum's Olympic Sculpture Park includes constructed intertidal habitat along an urbanized portion of marine shoreline. In order to provide benefits for juvenile salmon and other biota, newly constructed habitat within the park has removed or modified seawall and riprap armoring to provide riparian and intertidal biological functions. In order to provide pre- and post-construction evaluations of the habitat, biological monitoring has been conducted at the Sculpture Park site since 2005. The seawall habitat enhancement project in combination with this previous research provides insights on how built structures on shorelines can be reconfigured to enhance their ecological functions.

The location of the project along Seattle's downtown waterfront has generated interest from the general public and considerable interaction with passersby occurs during sampling and monitoring. The study sites were also included on a tour associated with the recent Puget Sound-Georgia Basin research conference. Volunteers from the City of Seattle and the Seattle Aquarium have been involved in sampling efforts.

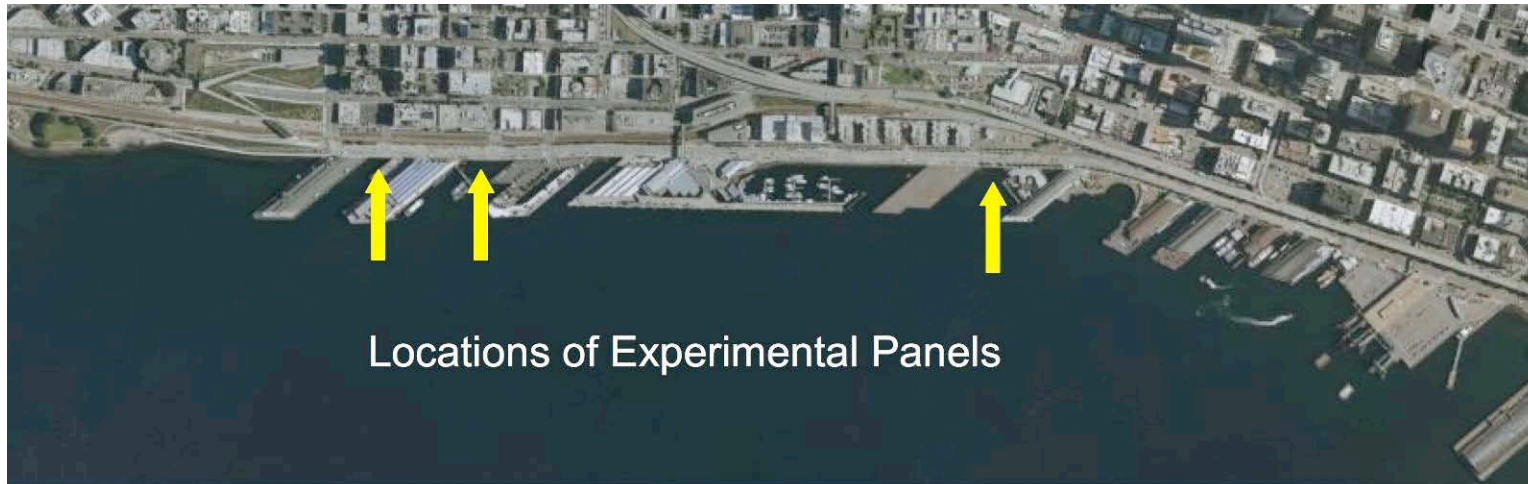
11. OUTREACH AND INFORMATION/TECHNOLOGY TRANSFER

A website is being developed for the project describing its origin, background, and development, and to ensure that results are available to the broadest audience possible.

12. FUTURE ACTIVITIES

Field sampling and data collection will continue through the following reporting period and will include monitoring of algae and invertebrates (April through August 2009) and fish (May through July 2009). Data analysis and reporting will occur (September 2009 through early 2010). Preliminary results will be reported at Coastal and Estuarine Research Federation Conference in November 2009. A final report of the study findings will be submitted to the City of Seattle in early 2010 to inform the design phase of seawall repair and reconstruction.

Several adjustments in sampling protocols have been made for the 2009 sampling season. Quadrat sampling will include size classifications for some mobile and sessile invertebrates such as limpets and mussels. We found little useful data in the underwater fish videos taken in 2008, apparently because of fish avoidance of the moving camera, and the short amount of time spent at any one point. Fish observations in 2009 will be done using overwater transects only and additional locations will be added to compare fish distribution at sites with and without habitat enhancement test panels. During autumn and winter storms most of the sediment was washed out of the experimental troughs, and several of the troughs were damaged by log strikes. Thus, we may de-emphasize trough sampling in 2009. If enough sediment remains in the troughs, benthic core samples will be taken in each trough at the end of the year-one field season.



Locations of Experimental Panels

At each site, six panels, one control, one reference placed randomly:

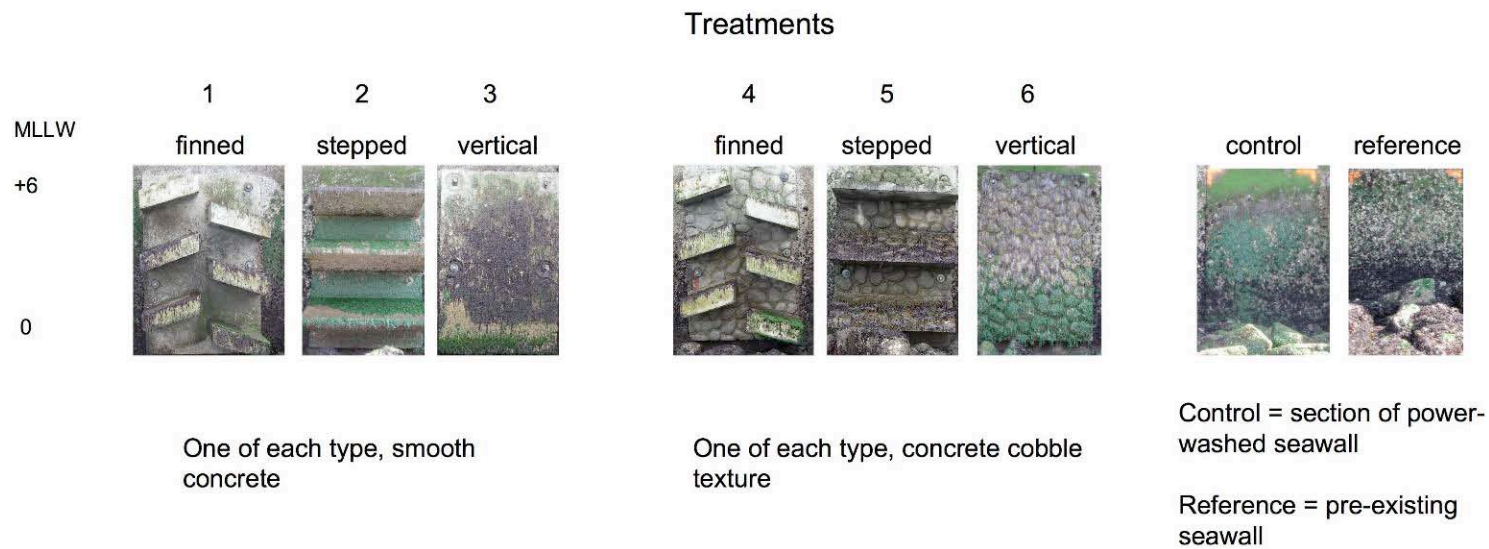


Figure 1. Experimental habitat panel designs and deployment sites on the Seattle waterfront.



Figure 2. Random placement of experimental habitat panels along Seattle seawall. Light colored objects are troughs containing sediment of three different grain sizes.



Figure 3. Quadrat sampling algae and sessile invertebrates on seawall test panel.



Figure 4. Left, epibenthic pump used for sampling invertebrates on habitat panels. Right, prominent salmon prey taxa associated with habitat panels: harpacticoid copepods (top), gammarid amphipod (bottom) (not to scale).

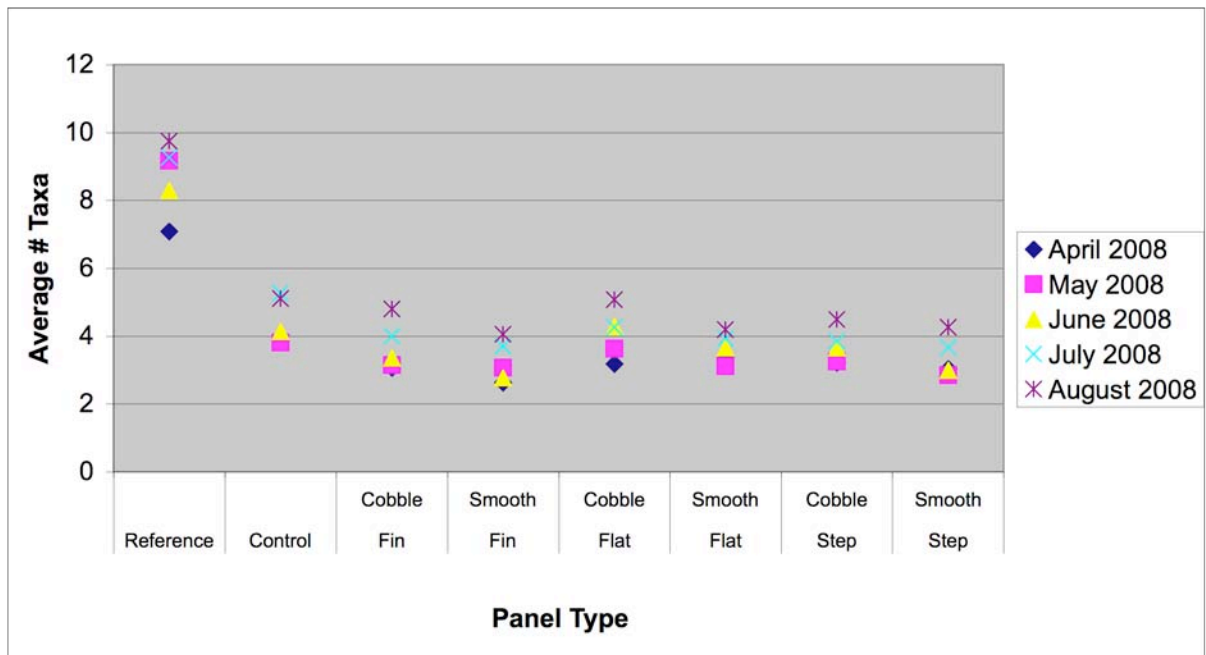


Figure 5. Taxa richness of algae and sessile invertebrates on experimental habitat test panels during year 1 sampling. See methods section for panel descriptions.

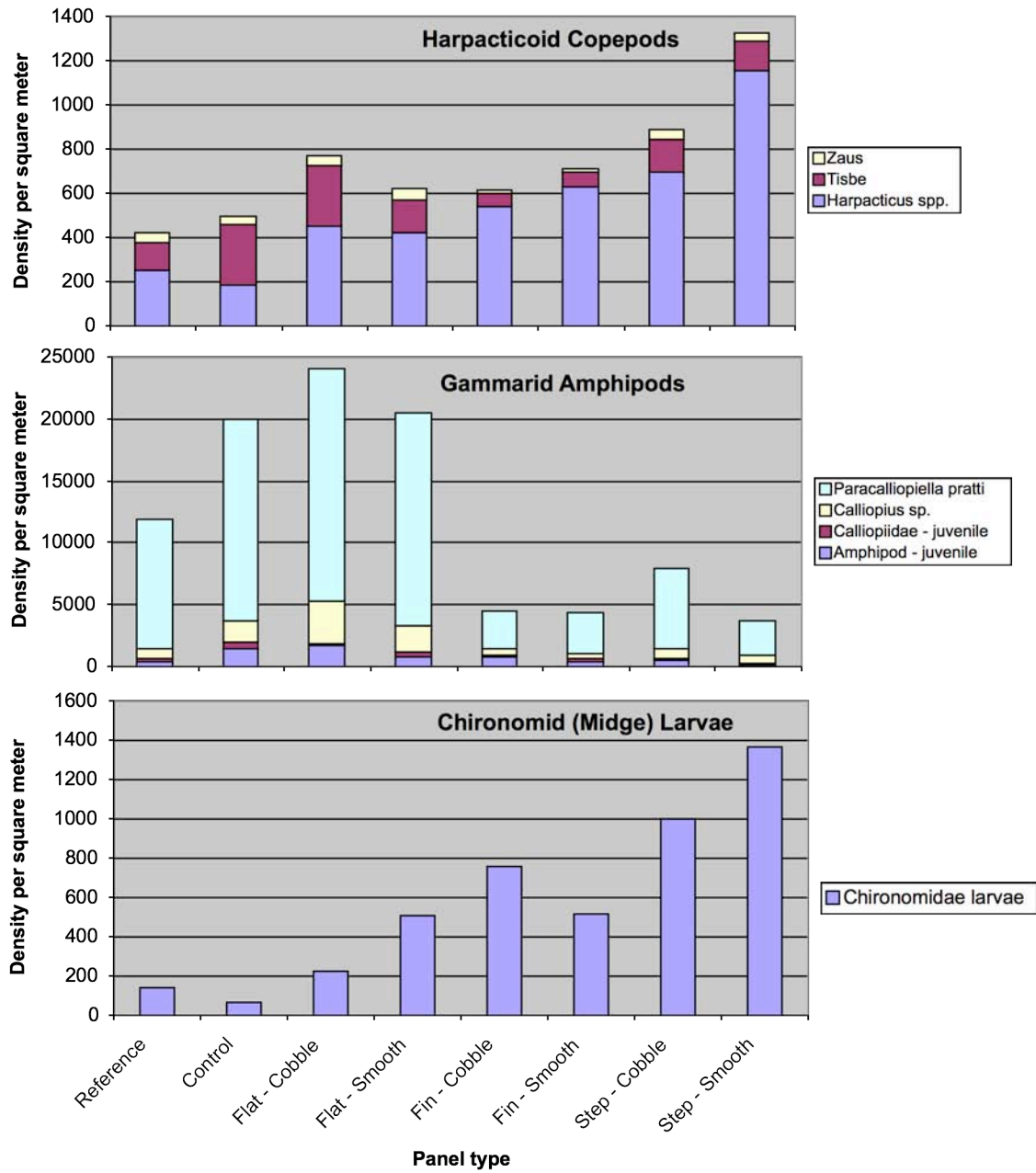


Figure 6. Mean densities (four sampling periods combined) of three groups of juvenile