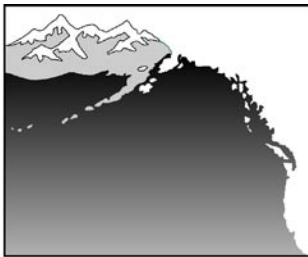


Inventory and Mapping of City of Seattle Docks Along Lake Washington, the Ship Canal, and Shilshole Bay

J TOFT, C SIMENSTAD, K DODD, T MILLER
WETLAND ECOSYSTEM TEAM
UNIVERSITY OF WASHINGTON

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of Design Construction and Land Use



University of Washington
SCHOOL OF AQUATIC
& FISHERY SCIENCES

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Key Words

shoreline modification, docks, shade, overwater structure, shoreline habitats, aerial photographs, Seattle, chinook salmon, GIS, Lake Washington, Ship Canal, Shilshole Bay

Executive Summary

The main objective of this study was to outline and map the above-water docks and piers along City of Seattle shorelines throughout Lake Washington, the Ship Canal, and Shilshole Bay. Juvenile endangered chinook salmon (*Oncorhynchus tshawytscha*) from the Lake Sammamish and Lake Washington watersheds use the littoral zone for rearing and migration to Puget Sound and the ocean. Understanding the degree of shading along the shoreline edge is an important information need in planning salmon recovery, as the function of the littoral zone may be influenced by shoreline modifications such as overwater structures. We conducted field surveys locating and classifying dock types and amount of shading, which were merged with Geographic Information System (GIS) aerial orthophotography analysis.

We documented a total of 1,551 acres of shading by docks along the surveyed shoreline. The majority of the shade was caused by boat marinas (42.6%), followed by industrial marinas (17.45%), houseboat marinas (14.98%), recreational docks (11.21%), overwater structures (9.12%), and overwater platforms (4.65%). Most of the dock area was composed of non-floating structures (77.03%), as compared to floating docks (22.97%).

Future research should attempt to assess the impacts that different dock types and amount of shoreline shading have on the surrounding biological community. This will be a challenging but necessary step in order to quantify possible effects of shoreline modifications. Managing shoreline developments in the urbanized landscape may be an important component for enhancing the recovery of endangered salmonid populations.

Introduction

The goal of this study was to map the positions and dimensions of docks, piers, overhanging platforms, and permanent structures built over the water along the City of Seattle's shorelines from Lake Washington west to and including Shilshole Bay. Artificial shoreline shading could affect surrounding ecological systems, including those of juvenile endangered chinook salmon (*Oncorhynchus tshawytscha*) that use the littoral zone for rearing and migration to Puget Sound and the ocean. This report is in collaboration with the shoreline inventory recently completed by Toft et al. (2003b). See Toft et al. (2003b) for a more complete background on historical and current shoreline modifications, general habitat types, and dock numbers.

In this report, we document how the historical shorelines have been modified by the construction of docks and piers along the following waterways – Shilshole Bay between Meadow Point and West Point, through the Chittendon Locks into the Ship Canal including Salmon Bay, Fremont Cut, Lake Union, Portage Bay, Montlake Cut, continuing through Union Bay and ending at the City of Seattle's boundaries for the Western edge of Lake Washington. Our new surveys were founded on the techniques and analysis approaches developed by Toft et al. (2003b; 2001), Parametrix and NRC (1999), and Hockett (1976).

Main Objectives:

Inventory of Dock Characteristics

- Outline dock dimensions and determine amount of water surface area that is shaded.
- Classify dock shading into the following types: (1) recreational docks, (2) large marina docks, (3) overwater structures, and (4) overwater platforms.

Material and Methods

Initial dock and shoreline mapping techniques described in Toft et al. (2003b) were conducted by boat during October 22-30, 2002. Subsequent surveying and groundtruthing by land was continued through February 2003. This fieldwork also served as a basis for the current report. Further surveying specific to dock shading was conducted during the summer of 2003. Lake level measurements were 20.5 feet at the Ballard Locks during our October fieldwork (USACE Hydraulics and Hydrology Section). Mapping of Shilshole Bay was conducted on a high tide (+ 10.8 feet) so that water levels would be at the shoreline edge. The high-resolution digital orthophotos of the City of Seattle (image source Triathlon, Inc., August 1999) were used for data input, observations, and incorporation into the Geographic Information System (GIS) database.

Dock Characteristics

Outlines of docks were digitized primarily from aerial photography, except when necessary to groundtruth by land (e.g., due to shading from bridges). Shading of covered moorages of large marinas in which the actual docks could not be seen with aerial photography were included in the outlines. Floating docks and permanent houseboats were also included. Small boat canopies without walls and structure that were attached to private docks were not included, in which dimensions of the dock were not obstructed and could easily be measured using aerial photographs. Addition or removal of docks since the date of the aerial photograph were recorded during the field surveys. We used the definitions of Hockett (1976) to separate docks into main categories of recreational and large marina docks, and further specified dock types according to the following dock types:

- *Recreational docks*: "...associated with a single-family residence, a single-family residence projecting over the water, small marinas which accommodated a few boats and readily identifiable single piers projecting from public or neighborhood parks (Fig. 1; Hockett 1976)."
- *Large marina docks*: "...large multifamily or commercial structures which projected over the water, the large pier networks, the large marinas, the large

filled areas supporting structures or combinations of the foregoing which formed complexes (Hockett 1976).” We also separated large marina docks into three types of main usage: recreational boats (Fig. 2), houseboats (Fig. 3), and industrial (Fig. 4).

- *Overwater Structures*: Large buildings constructed over the water (Fig. 5).
- *Overwater Platforms*: Platforms shading the water (Fig. 6).

GIS Analysis

All of the above measurements were incorporated into GIS format using ArcView version 3.2a (Projection: Washington State Plane, North Zone NAD83(91); Vertical Datum: NAVD 88). Dock dimensions were entered as a polygon shapefile. From the shapefile, surface area measurements of the various categories were determined.

Results

We documented a total of 1,551 acres of shading by docks along the surveyed shoreline (Fig. 7). The majority of the shaded area was caused by large boat marinas (42.6%), followed by large industrial marinas (17.45%), large houseboat marinas (14.98%), recreational docks (11.21%), overwater structures (9.12%), and overwater platforms (4.65%; Fig. 7). Most of the dock area was composed of non-floating structures (77.03%), as compared to floating docks (22.97%; Fig. 8).

Discussion

Our results indicate that docks, overwater structures, and overwater platforms shade 1,551 acres along the shoreline edge within the City of Seattle’s boundaries of Lake Washington to Shilshole Bay (this study), and 17.3% of the shoreline linear edge (Toft et al. 2003b). It is interesting to note that large boat marinas caused 42.6% of the shading and recreational docks 11.21%, as they accounted for 21.3% and 55.2% of dock numbers, respectively (Toft et al. 2003b).

Now that current shading of the shorelines has been outlined in the Lake Washington, Ship Canal, and Shilshole Bay areas, it is important to incorporate these findings with the results of other related projects. For instance, factors that could affect chinook populations occupying littoral habitats have been identified, including the possible impacts of shading by docks on juvenile chinook behavior, depletion of prey resources, and increased predation (Kahler et al. 2000; Parametrix et al. 2000). Recent studies have tested the relation of shoreline developments to various habitat usages of fish and invertebrates (Koehler 2002, Tabor and Piaskowski 2002), and have started to use snorkel surveys to examine the effects of overwater structures on fish distribution and behavior (Toft et al. 2003a).

Future research should consider expanding studies to the specific attributes of shoreline habitats that potentially impact biological communities. In respect to shoreline shading, there is need for more information on the effects that degrees of shading caused by different types and sizes of recreational and marina docks have on fish and invertebrate habitat use. Such inclusive scientific studies that combine physical and ecological attributes will be the next step in quantifying the impacts of shoreline structures along Seattle urbanized waterways.

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Figure 1. Recreational docks along the shoreline.



Figure 2. Large marina docks with recreational boats.



Figure 3. Large marina docks with houseboats.



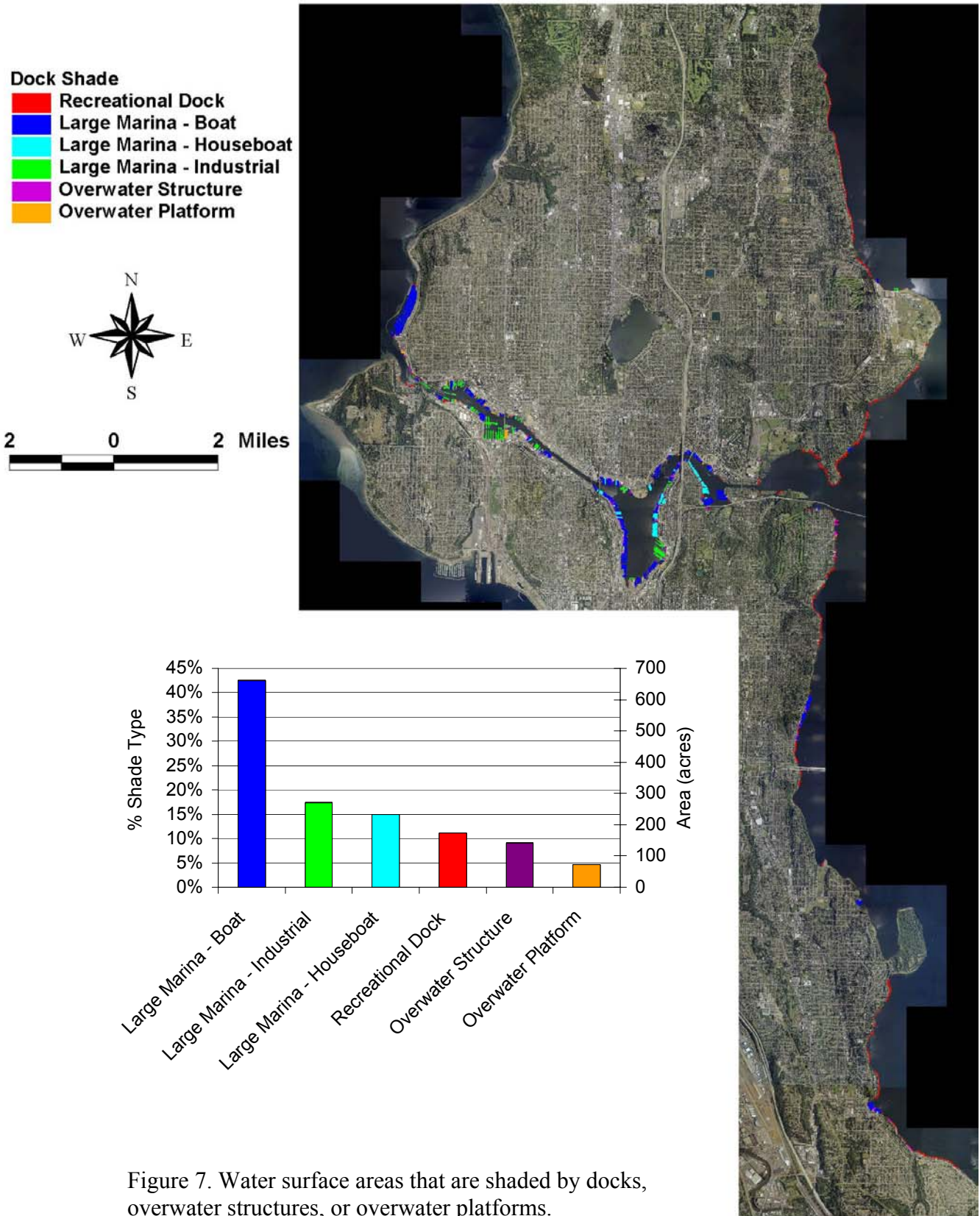
Figure 4. Large marina docks used primarily for industry.



Figure 5. Overwater structure shading the shoreline.



Figure 6. Overwater platform shading the shoreline.



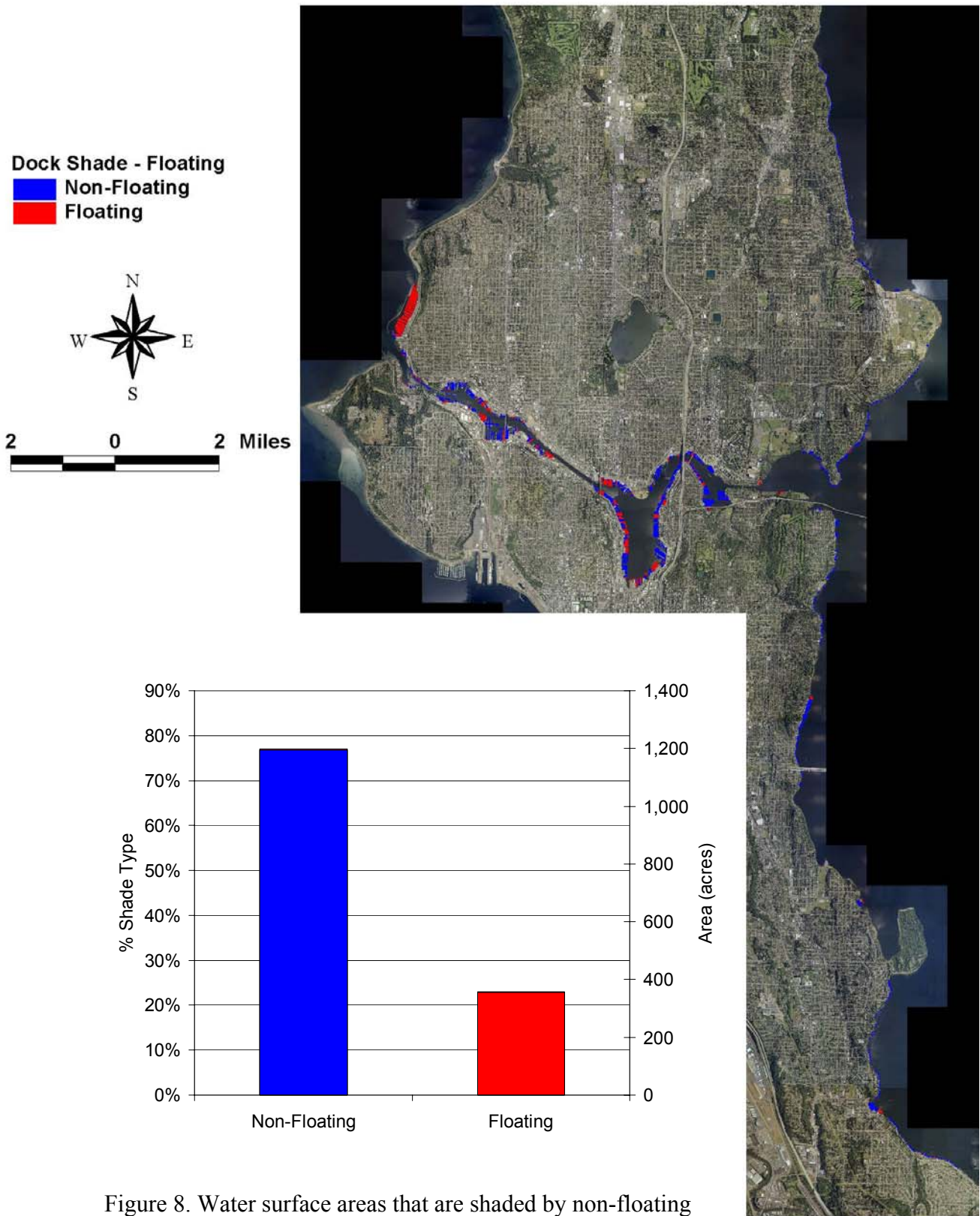


Figure 8. Water surface areas that are shaded by non-floating and floating docks.

Appendices

A. Raw Data

Dock Type	Sum Area (m²)	Sum Area (acres)	Percentages
Large Marina - Boat	2,673,691.87	660.68	42.60%
Large Marina - Industrial	1,095,177.29	270.62	17.45%
Large Marina - Houseboat	940,023.58	232.28	14.98%
Recreational Dock	703,510.45	173.84	11.21%
Overwater Structure	572,223.11	141.40	9.12%
Overwater Platform	291,631.25	72.06	4.65%
<i>Total Shade</i>	6,276,257.55	1,550.88	100%

Floating	Sum Area (m²)	Sum Area (acres)	Percentages
Non-Floating	4,834,593.55	1,194.64	77.03%
Floating	1,441,664.00	356.24	22.97%

B. Metadata of GIS layers

Projection: Washington State Plane, North Zone NAD83(91); Vertical Datum: NAVD 88

Orthophotos: Digital orthophotos provided by the City of Seattle (image source

Triathlon, Inc.; August 1999; 1-foot resolution; Cortho_s.sid and Cortho_n.sid).

All other shapefiles prepared by:

Jason Toft
 Wetland Ecosystem Team
 School of Aquatic and Fishery Sciences
 Box 355020
 University of Washington
 Seattle, WA 98195-5020
 (206) 221-5460
tofty@u.washington.edu

Shapefile codes: dockarea.shp (polygon)

Column		
Dock_type	Type	Color Code
1	Recreational Dock	Red
2	Large Marina - Boat	Navy Blue
3	Large Marina - Houseboat	Light Blue
4	Large Marina - Industrial	Green
5	Overwater Structure	Purple
6	Overwater Platform	Orange

Floating	Type	Color Code
0	Non-Floating Dock	Navy Blue
1	Floating Dock	Red

New	Type	Color Code
0	Existing Dock	Green
1	New Dock (since 1999 aerial photograph)	Red