Data Report for Fish Tracking Special Study: White Croaker and California Halibut Study - Phase 2

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of variance
avg	average
°C	degrees Celsius
χ^2	Chi-square test
CH	California halibut
CI	confidence interval
cm	centimeters
CPUE	catch per unit effort
CSULB	California State University, Long Beach
d	days
dB	decibels
DDT	dichlorodiphenyltrichloroethane
df	degrees of freedom
diam.	diameter
EDA	Euclidian-distance based analysis
g	gram(s)
GAM	general additive model
GIS	geographic information system
GPS	global positioning system
hr(s)	hour(s)
HSI	habitat selection index
IACUC	Institutional Animal Care and Use Committee
ID	identification
IDW	inverse distance weighted interpolation
kHz	kilohertz
km^2	square kilometers
LA	Los Angeles, California

LA-LB	Los Angeles and Long Beach Harbor complex
LACSD	Los Angeles County Sanitation District
LAIH	LA inner harbor
LAOH	LA outer harbor
LB	Long Beach, California
LBIH	LB inner harbor
LBOH	LB outer harbor
m	meter(s)
m/s	meters per second
m^2	square meters
mg/L	milligrams per liter
min	minute(s)
MKDE	Movement based Kernel Density Estimator
mm	millimeters
ms	milliseconds
MS-222	Tricane Methanosulfate
µm	micrometers
ng/g	nanograms per gram
OEHHA	California's Office of Environmental Health Hazard Assessment
PCBs	polychlorinated biphenyls
PDS II	polydioxanone suture (Ethicon)
POLA	Port of Los Angeles
POLB	Port of Long Beach
PV shelf	Palos Verdes Shelf
PVS EPA	EPA Palos Verdes Shelf
ROM	rate of movement
± SD	standard deviation
sec	seconds
SCB	Southern California Bight

TL	total length
TMDL	total maximum daily load
TOC	total organic carbon
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
VPS	Vemco positioning system
WC	White Croaker
WRAP	Ports Water Resource Action Plan

1.0 INTRODUCTION

The Port of Los Angeles and Port of Long Beach Harbor TMDL (total maximum daily load) has presented the need to predict the most effective means to meet sediment quality objectives and total maximum daily load targets due to the size and feasibility associated with sediment remediation for such a large area. The Port of Los Angeles and Port of Long Beach are adjacent to the Palos Verdes Shelf (PV Shelf), a U.S. Environmental Protection Agency (USEPA) Superfund site, which continues to be one of the largest historical dichlorodiphenyltrichloroethane (DDT) disposal sites worldwide (Schiff et al. 2000; Schiff 2000). Prior to the ban in the 1970s, the former Montrose Chemical Corporation discharged DDT to the Palos Verdes Shelf via the wastewater treatment plant outfall at White Point (Schmidt et al. 1971). Contaminated surface water originating from the Montrose Chemical Corporation Plant also entered storm water drainage ditches, which eventually emptied into the Torrance Lateral that connects to the Dominguez Channel where the contaminants were carried into the Consolidated Slip (also an USEPA Superfund site) in the northern reaches of Los Angeles Harbor (California Regional Water Quality Control Board Los Angeles Region 2011; ITSI-Gilbane 2013). Apart from the historical legacy contaminants, other contaminants (including polychlorinated biphenyls [PCBs]), continue to enter the Los Angeles and Long Beach Harbor complex (LA-LB) through watersheds, storm water runoff, industrial outfalls, and atmospheric deposition from the greater Los Angeles area and from commercial and recreational activities within the Harbor (Port of Los Angeles and Ports of Beach 2009; California Regional Water Quality Control Board Los Angeles Region 2011; Environmental Protection Agency 2012).

1.1 PROJECT RATIONALE

White croaker (*Genyonemus lineatus*) caught in and around Los Angeles and Long Beach Harbor have been found to contain high concentrations of DDT, PCBs, and other contaminants in their tissues. Malins et al. (1987) found concentrations of DDT and related compounds reaching 100,000 ng/g in the livers of white croaker taken from the White Point area on the Palos Verdes Shelf (PV Shelf), a known USEPA Superfund site. A number of fish species (e.g., California halibut, shiner perch, white surfperch) caught within the Los Angeles Harbor also were also found to contain high levels of contamination. White croaker caught in the Cabrillo Beach area have been found to exhibit a high, but highly variable contaminant body burden, ranging up to levels far too high to be explained by concentration of contaminants in the sediment at the Cabrillo Beach area (Anderson et al. 2001). The original source of DDT in the area is known to be the Montrose Chemical Corporation who, between the years of 1947 and 1971, discharged between 1500 and 2500 tons of DDT into LACSD's municipal wastewater treatment plant in Carson, CA. It is estimated that between 870 and 1450 tons of DDT was ultimately released into the ocean through a sewer outfall at White Point (Eganhouse and Pontolillo 2008). In addition, the site had poor or nonexistent containment, allowing stormwater and dry weather runoff to convey contaminants from the site through the Kenwood Ditch/Drain to the Torrance Lateral and into the Dominguez Channel Estuary. The Dominguez Channel Estuary feeds into the Consolidated Slip, a narrow waterway in the Los Angeles inner harbor. The entire stormwater pathway (including Consolidated Slip) is designated as a unit of the Superfund. Other contributory sources of DDT and other contaminants include the Los Angeles River, which drains into eastern portion of San Pedro Bay. Within the Harbor itself, the highest concentrations of contaminants are found in the sediments of the Consolidated Slip and Fish Harbor (Anderson et al. 2001).

One possible explanation for the high variability in contamination load in white croaker is the degree to which the fish move in and out of the harbor or move within the harbor. The direct source of the contamination is likely either the Consolidated Slip/Dominguez Channel Estuary or the Palos Verdes (PV) Shelf, but with no previous attempts to determine home range or movement patterns of the white croaker, it is impossible to say with any certainty where the fish are acquiring these contaminants.

We just completed the USEPA funded study examining the movement patterns of white croaker and barred sand bass on the PV Shelf, off White Point to determine how much time fish spend over the most contaminated sediments on the PV Shelf, and whether fish caught on the PV Shelf enter the Los Angeles and Long Beach Harbors. While we found at least 50% of the fish tagged on the PV Shelf entered the harbors, a very small proportion of those individuals moved towards in the inner harbor (Wolfe 2013; Wolfe and Lowe In press). Unfortunately, none of the previous studies were designed to quantify white croaker movement from the PV Shelf or from within the harbor to public fishing piers in the harbors, the locations where contaminated fish could most likely be acquired by fishers. Therefore, a better understanding of whether fish caught and tagged on the PV Shelf or from Consolidated Slip move to these fishing areas will provide important data needed for improving bioaccumulation models and evaluate remediation options for the Ports and USEPA.

The aim of this part of the study is to characterize the movement patterns and degree of site fidelity of white croaker and California halibut caught and tagged at Cabrillo pier in the Los Angeles Harbor and at Pier J in Long Beach Harbor, and whether these species tagged on the PV Shelf and other regions of the harbor move to these public fishing areas and at what frequency. The acoustic receiver locations and tagging locations are specifically designed to inform fish movement data and better parameterize a new bioaccumulation models for the Ports. Two phases of fish tracking were conducted as part of the special studies for the Port of Los Angeles and Port of Long Beach. Phase I was conducted in 2011-2012 and quantified both the long-term, coarse-scale movement and short-term, fine-scale (active tracking) movements of white croaker within the Harbors. Phase II of the fish tracking study was conducted in 2013-2015 and quantified white croaker and California halibut long-term, coarse-scale movement and fine-scale movements associated with Cabrillo Pier. The results of the short-term, fine-scale movements of white croaker in Phase I are presented in the report "Data Report for Fish Tracking Special Study: White Croaker Phase I" (Lowe et al. 2015). The results of the long-term, coarse-scale white croaker movements from Phase I and the results of the Phase II tracking study for both white croaker and California Halibut are presented in this report.

1.2 PROJECT GOALS AND OVERALL APPROACH

The specific goals of the project were to:

- Characterize the longer-term movements and site fidelity of California halibut and White Croaker in the Los Angeles and Long Beach Harbors over a multi-year period.
- Identify emigration of white croaker from the Harbor and onto the Palos Verdes Shelf.
- Determine the degree of association and site fidelity of California halibut and white croaker to fishing piers within the Harbor.

To accomplish these goals, we used a combination of passive acoustic telemetry techniques to monitor and quantify longer-term, coarse-scale and fine-scale movement patterns for white croaker and California halibut over a multi-year period. Fine-scale movement data from white croaker acquired from active tracking during Phase I were used to develop a dispersal model in order to compare longer-term passive tracking data to better understand how white croaker disperse through the harbor over time.

1.3 PROJECT TEAM

Dr. Chris Lowe of the CSULB Shark Lab was the principle investigator and coordinator for the project. Dr. Lowe along with CSULB graduate student Armand Barilotti were responsible for deployment and maintenance of the acoustic receiver array, fish capture and tagging, data maintenance and analysis. Data and analysis from Phase I of the fish tracking study was conducted by graduate students, Bonnie Ahr and Michael Farris. Additional information from the Phase I Final Report are available in "Data Report for Fish Tracking Special Study: White Croaker Phase I" (Lowe et al. 2015).

2.0 METHODS

2.1 STUDY LOCATION AND HARBOR REGIONS

Both Phase I and Phase II of the fish tracking studies were conducted in the Los Angeles and Long Beach Harbor complex located in southern California, USA (Figure 1, Appendix A). White croaker and California halibut were caught and tagged throughout four regions of the LA and LB Harbors: LA outer harbor (LAOH), the LA inner harbor (LAIH), the LB inner harbor (LBIH), and the LB outer harbor (LBOH) to examine fish movements within and between regions, especially between regions with high sediment contamination and regions with public fishing piers. Phase I study included an additional three regions within the Harbors: Fish Harbor, Cabrillo Pier, and Pier J. The seven regions of the Harbor were designated based on habitat differences and geospatial boundaries in order to compare fish movements across habitat types, and were not intended to represent TMDL waterbodies.

2.2 TRACKING TECHNOLOGY

VR2W omni-directional underwater acoustic receivers (Vemco Ltd.) were deployed throughout the Harbor in shipping channels and were designed to act as "gates," which allow for determination of the direction of fish movement between receivers and harbor regions (Figure 1, Appendix A & B). Receivers recorded time, date, and unique ID code for each fish when within receiver range, which varied by location and environmental conditions (100-400 m). The receivers were positioned approximately 1 m off the seafloor, deployed on subsurface moorings or were suspended from existing dock structures.

2.2.1 *Phase I receiver array configuration (2011-2012)*

In the Phase I study twelve acoustic receivers were deployed at strategic locations throughout the Harbors, particularly choke points where the waterways were narrow enough to be completely encompassed by receiver detection range (Figure 1, Appendix A & B). All receivers were deployed in August 2011 except for Station 13, which was deployed in January 2012. Each receiver also was equipped with a temperature datalogger set to record seafloor temperatures every hour (Onset Computer Corporation, Pocasset, MA). Receivers and temperature dataloggers were deployed for one year, and were downloaded and cleaned every month.

2.2.2 *Phase II receiver array configuration (2013-2015)*

A total of 38 VR2W acoustic receivers were positioned at key locations around the Harbor and surrounding areas, including twelve that were placed in the same locations as in the Phase I study (Figure 1, Appendix A & B). Eight acoustic receivers are positioned inside and outside of the gates (Angel's and Queen's Gates) of the Harbors in order to detect fish moving into or out of the Harbor. Three receivers were placed in a perpendicular line extending out away from the

Los Angles Federal Breakwater, approximately half way between Angel's Gate and Cabrillo Beach to function as a migratory gate between White Point and the Harbor (herein referred to as PV-Cabrillo Beach). Seven receivers were placed in a grid configuration (100-180 m apart) at Cabrillo Pier and four receivers (linear array) at Pier J to ensure any tagged fish that moved near one of the public fishing areas would be detected by at least one receiver. Two receivers were placed in Fish Harbor and two receivers were placed at the southeast corner of Pier J to act as a gate to identify fish leaving to eastside of Long Beach Harbor. All receivers were deployed before July 2013, except for HCHP 11 (Outer Fish Harbor) deployed in August 2013, HCHP 16 (inner Fish Harbor) deployed November 2013, and C4-7 (Cabrillo Pier receivers) deployed December 2013 (Figure 1, Appendix A & G). All receivers were routinely cleaned and downloaded every other month.

To measure fine-scale movements around a fishing pier in Phase II, we used the seven VR2W receivers placed in a grid configuration deployed on 22 December 2013, at Cabrillo Pier to allow for use of the Vemco Positioning System (VPS) (Figure 1, Appendix A & G). VPS arrays have been used in previous studies to obtain fine-scale position estimates of tagged fishes and elasmobranchs, based on trilateration of the transmitter transmission when detected by three or more acoustic receivers (Espinoza et al. 2011; Wolfe and Lowe In press). This form of hyperbolic positioning is based on measuring the difference in time detection of a transmission recorded by neighboring VR2W receivers, and then converting this measurement to distance differences from the receivers using the speed of signal transmission in seawater (Smith 2013). When the distance differences are coupled to known GPS locations of the receivers, the algorithm can then calculate a positional location of the transmission. All VR2W receivers in the VPS-enabled array must have their clocks synchronized in order to derive an accurate position.

VR2W receiver clocks can drift up to 4 sec per day, so each receiver is paired with a synchronization transmitter (V16-5x, 69 kHz, 300 sec pulse interval) to measure the drift from each receiver clock, which can later be corrected. The synchronization transmitters also are used to calibrate the receiver locations and determine the effects of positioning error (Smith 2013).

2.3 FISH COLLECTION AND TAGGING

All white croaker were caught using hook and line. California halibut in Phase II were caught using hook and line or a 3 meter otter trawl. Acoustic tags were surgically implanted into each fish. Prior to surgery fish were anesthetized with Tricaine methanesulfonate (MS222) (75 mg/L of seawater) (Freedman 2014; Wolfe and Lowe In press). Once the fish achieved stage-4 level of anesthesia, fish weight (g), standard length (mm), fork length (mm), and total length (mm) were recorded (Summerfelt et al. 1990). A small incision was made through the abdominal wall and the acoustic transmitter was inserted into the peritoneal cavity of the fish. The incision was closed with 2 sutures of Chromic gut (Brown et al. 2010). When applicable, fish sex was determined by the presence of gonads or reproductive behavior. Once the fish recovered from surgery it was released near its capture location. Fish were only implanted with a transmitter if the fish condition was deemed acceptable and if the fish was large enough so that the transmitter would not negatively impact the fish (white croaker over 145 grams and California halibut over 370 mm TL). All surgical procedures were in compliance with IACUC #283 and #325.

2.4 PHASE I LONG-TERM, COARSE-SCALE WHITE CROAKER MOVEMENT

During Phase I equal numbers of white croaker were tagged within each region (25 per region except LBIH where only 24 fish were tagged). Ninety-nine white croaker were surgically implanted with coded acoustic transmitters (Vemco, V9-1L, 24 mm long x 9 mm diam., 3.6 g in air, 2.2 g in water, pulse interval 30-90 sec, battery life 153 days, power output 145 dB, 69 kHz) during a summer (2011) and winter (2012) tagging event in all four regions of the LA-LB Harbor (Table 1, Appendix B). Due to the battery life of the transmitters, two tagging events were used in order to capture an entire year of fish movement. White croaker capture locations were spatially concentrated at the Consolidated Slip in LAIH and the San Pedro Bait Barge in LAOH, but were more dispersed in LBIH and LBOH (Figure 2).

2.5 PHASE II LONG-TERM, COARSE-SCALE MOVEMENT

To characterize the movements of white croaker and CA halibut throughout the Harbor (including some new regions) and at fishing piers, these fish were passively tracked using acoustic telemetry over a one and half year period. The transmitters used for Phase II had a longer nominal pulse interval of 120-250 sec at 69 kHz and an estimated battery life of 363 days. Forty-two halibut and 198 white croaker were surgically fitted with acoustic transmitters between July 2013 and May 2014 (Table 1, Appendix B).

White croaker and halibut were caught and fitted with transmitters in seven regions within the Harbor and one location outside of the Harbor. At least twenty-five white croaker and two halibut each were tagged within the same four regions of the Harbors as Phase I: Consolidated Slip, Los Angeles Harbor bait barge, SSA Terminal at Pier A, and Long Beach Outer Harbor (Table 1). Additionally, 29 white croaker and 26 halibut were caught and tagged at Cabrillo Pier, and 25 white croaker and 6 halibut were caught and tagged within 250 m of Pier J Fishing Area (Figure 2). Nine white croaker were tagged off White Point, Palos Verdes. An additional 30 white croaker were caught and tagged in Fish Harbor (Table 1, Appendix B).

2.6 DATA MANAGEMENT

The acoustic receiver detection dataset was filtered to remove false detection and data from individuals that were thought to have died. We determined a fish had died from surgery if its transmitter was detected continuously by the receiver closest to the fish's release location for the entire battery life of the transmitter. To determine if a white croaker had been eaten by a predator, we took an estimated detection range of 250 m and measured the time it took a fish to move between two receivers locations, minus 500 m detection range distance. This provides an estimate of how fast a tagged fish may be travelling between receiver detection areas. White croakers have been estimated to have a maximum sustained swimming speed of 0.61 m/s (Dorn et al. 1979). Therefore, any transmitters that were observed to travel faster than 0.61 m/s between receivers were considered predation events and likely being carried by larger organisms such as sharks, sea lions, or dolphins. Maximum sustained swimming speeds of halibut are unknown so we could not perform this test for the halibut detection data. Lastly, if a single transmission was detected by multiple receivers with overlapping detection ranges, we removed any redundant detections after the initial detection if the time difference is less than 30 s (2011-2012) or 120 s (2013-2015), the minimum amount of time between transmitter transmissions. Removing these erroneous detections prevents artificially inflating detections, which will affect result of any movement analysis.

2.7 DATA ANALYSIS

Passive tracking data from VR2W receivers was downloaded and managed using VUE (Vemco). Data analysis was carried out using R 3.0.2 (R Foundation for Statistical Computing). Map images were created using ArcGIS 10.1 (ESRI). Age of white croaker was estimated from size according to von Bertalanffy growth curves derived by Love et al. (1984), which were also compared among regions. Standard length of white croaker tagged for passive tracking was compared among regions for each phase of the project using ANOVA and Tukey's HSD post-hoc test. Standard lengths were also compared between the two phases, for all regions individually and with all regions pooled, using independent two-sample t-tests.

2.7.1 *Long-term, coarse-scale movements*

Acoustic receiver detection data were used to calculate estimates of site fidelity or residency of white croaker and halibut to regions of initial capture and to the Harbor as a whole. To determine the overall degree of site fidelity to the Harbor, we measured the number of cumulative days individuals were present within the entire receiver array. To determine site fidelity for the regions for each species, we measured the number of cumulative days individuals were present among receivers in the areas they were initially caught. For an individual to qualify as being "present" for a day, the individual must have been detected at least twice by a receiver within a 24 hr period.

A non-parametric, randomization test was used to compare the difference in mean site fidelity (number of days detected) of white croaker (overall Harbor, site of initial capture, and by region). This method generates null distributions derived from the data by combining number of days white croaker were detected within the region they were originally tagged from both Phase I and Phase II into one pool. This pool of data is subsequently sampled with replacement to generate two samples of the observed sample size for each project. The difference in mean value from each of the two samples was calculated. This is bootstrapped 10,000 times to create a distribution of expected differences in the means assuming all white croaker belonged to one population. We then compared the actual observed differences between the Phase I sample and the Phase II sample to the null distribution to calculate the probability of observing this outcome if the fish were from the same population.

2.7.2 *Integrative movement model*

In order to determine the relationship between the average daily movements of white croaker within the harbor and their long-term dispersal throughout the harbor, both the short-term and long-term movement data were analyzed in conjunction using a movement model. The goal of this approach was the determine if the long-term movements of white croaker throughout the harbor were the result of individuals shifting their area use patches from day to day resulting in a gradual dispersal from the location of tagging, or if they were the results of discreet, periodic directional emigrations made from one region to another. We also wanted to determine over what time period these inter-regional dispersals occurred. The model itself is a two-dimensional, individual-based, random walk model that was created specifically to simulate the long-term movement and dispersal trends that would arise if the short-term movements observed during active tracking of white croaker were extended over long periods of time (> 20 days). This was achieved by starting the model at pre-selected coordinates and moving it in steps generated by random sampling from lists of step lengths and turning angles recorded during fine-scale active tracking, with each step in the model representing ten minutes of time, corresponding to the ten-minute interval at which actual fish location estimates were recorded during active tracking. The movement model was bounded to operate within a shapefile created to conform to usable habitat within the Los Angeles and Long Beach Harbors using a simple point-in-polygon test at each step, so that any step generated outside the harbor was rejected and replaced with a step inside the harbor. In order to generate an output that could be statistically compared with the long-term dispersal trends observed during passive tracking, one iteration of the model was started in the tagging location of each of the 93 white croaker passively tracked during this study and was allowed to run for 22,176 steps (corresponding to the number of ten-minute intervals in the manufacturer-estimated 154-day battery life of the transmitters used for passive tracking). Passive tracking data from Phase II was also compared to the output of this model. Phase II data were parsed to include only detections recorded by receivers used in the Phase I study, and only for the first 154 days after tagging for each white croaker. This allowed us to make statistical comparisons between sets of data that were collected at the same spatial and temporal scales.

2.7.3 *Movement network analysis*

Long-term, coarse-scale movements of white croaker and halibut in the harbor were analyzed using network-based analysis techniques (Jacoby et al. 2012). This involved creating networks from the data obtained by the static receiver array in which each receiver is represented as a node, and each path between two receivers (including the path from each receiver back to itself) is represented by an edge. Each edge is assigned a "weight" based on the number of times an individual white croaker transits between the nodes at each end of that edge. An individual movement network was generated for each white croaker that was detected by multiple receiver stations during passive tracking. A corresponding randomized network was then generated for each of the real networks by starting a simulated fish track at that station, then allowing it to move for the same number of steps given equal probability of each possible transition. The differences between variance in edge weights for the real networks and the randomized networks were calculated, and a bootstrapping technique was then used to generate a large set from which a non-parametric 95% confidence interval was created. This analysis was run for white croaker tracking in Phase I and Phase II separately. In addition, movement networks were compared between Phase I and Phase II to see if individuals were shifting their movements to different parts of the of the harbor over years. Similar movement network analysis was done for halibut from Phase II data.

2.7.4 *Phase I habitat selection*

Using a similar, but more coarse-scale approach, we estimated habitat use from fish passively tracked during Phase I of the study to compare with results from active tracking (Phase I report). Within each estimated VR2W receiver range area, the average depth (m) (Figure 3), sediment TOC (%) (Figure 4), and grain size (µm) (Figure 5) were calculated based on raster values for each factor in ArcMap. Harbor habitat map surfaces were created in ArcMap in ArcGIS 10.1 and were created using an inverse distance weighted (IDW) interpolation in order to account for the complex shape of the Harbor. The outline of the Harbor complex was used as a boundary for all IDW interpolations, preventing interpolated of values across land masses within the Harbor. All maps were created using natural breaks in the data for 5 categories except for the bathymetry surface which was binned according to the Ports Water Resource Action Plan (WRAP) model. Bathymetry files were provided by Everest Consulting Inc. Sediment TOC and grain size within the LA-LB Harbor included data from the Biological Regional Monitoring Program 2008 (Bight 2008) and Weston Solutions Inc. 2011 (Weston 2011) sampling. Sediment samples in both the Bight 2008 and Weston 2011 sampling were collected using a modified 0.1 m^2 Van Veen grab sampler for the top 5 cm of sediment. All final maps were created using the California V State Plane meters projection. Maps including station locations are provided in Figure 3-5. The number of detections per receiver divided by receiver range (# detections per m^2) was compared to each abiotic factor (depth, sediment grain size, sediment TOC) average using correlations in R. A correlation between white croaker detections and polychaete density was not run due to insufficient polychaete sampling stations within or near receivers. Receiver range was determined from range testing and varied by receiver from 32,350 m^2 (Station 6) to 70,700 m^2 (Station 13) (Appendix A).

2.7.5 *Pier association*

To determine use of public fishing areas within the Harbors we used measures of site fidelity and amount of time spent at public fishing piers. The degree of site fidelity of white croaker and halibut tagged at Cabrillo Pier and Pier J was compared to white croaker and halibut tagged from other regions of the Harbors. Also average amount of time spent in proximity to these piers was compared between individuals caught and released at the piers and the individuals visiting the piers from other areas. Average amount of time spent was determined by multiplying the average time interval between subsequent transmitter emissions (182 s) by the number of detections at the pier. This time was then divided by the number of days detected within the array, which yields average amount of time detected at the piers. To compare site fidelity and amount of time spent at piers between individuals tagged at piers and individuals visiting piers, we used the non-parametric randomization test described in the above section.

To determine if white croaker and halibut that visit Cabrillo Pier area actually associate with the pier we used the VPS-rendered positions of individuals detected within the Cabrillo Pier receiver array to measure their proximity to the Cabrillo Pier. We used Euclidean Distance-based Analysis (EDA) to determine if tagged individuals were selecting for areas based on distance from the Cabrillo Pier. The frequency distribution of distances in 5 m bin increments were compared to an equal number of randomized positions distributed within 300 m of the Cabrillo Pier using a Pearson's Chi-squared test. If the fish exhibited pier association we expected to find a disproportionate amount of their detections within 50 m of the Cabrillo Pier as compared to a random distribution. There is also a low-relief rocky reef that runs perpendicular to the pier on the southeast corner, to determine if tagged individuals use the ecotone provided by both structures (Cabrillo Pier and reef), the same analysis described above was used to determine habitat association to the structure ecotone.

3.0 RESULTS

3.1 SUMMARY OF TAGGING DATA

3.1.1 *Phase I Fish Tagging Summary*

Ninety-nine white croaker were caught and tagged from areas throughout the Harbor and were passively tracked using stationary acoustic receivers (Table 1). Ninety-three were detected by at least one receiver within the static receiver array during the course of the study, and the six individuals not detected were excluded from all further analyses due to potential mortality or transmitter malfunction. Using previously derived von Bertalanffy growth equation for white croaker (Love et al. 1984), we estimated the mean (± SD) age of fish tagged to be 8.6 ± 2.6 years (range: 3.4-16 years). When sex was unknown, age was calculated based on the male equation provided by Love et al. (1984).

The mean number of detections for each individual fish pooled across all receivers was 20,680 ± 30,888. All twelve receivers recorded detections of tagged fish, and mean number of detections for each individual receiver was highly variable (160,107 ± 215,800). The number of fish visiting each receiver ranged from 7 to 46 individuals over the course of the 1-year receiver deployment (Figure 6A). Receivers located in Consolidated Slip (POLA) (18,835 ± 24,723) and the San Pedro Bait Barge (POLA) (34,250 ± 51,947) had the highest average detections per fish (# detections/fish), whereas the receiver in Sea Plane Lagoon (Station 12) (23 ± 48) had the lowest number of detections (# detections/fish) and fish visiting the station (# fish/station) over the course of the study (Figure 7A).

3.1.2 *Phase II Fish Tagging Summary*

A total of 417 white croaker were caught at locations throughout the Harbor and the PV Shelf; however, only 198 white croaker were tagged in years 2013-2015 (Figure 2, Table 1 and 2). Attempts to tag 25 white croaker caught on the PV Shelf were not successful, despite considerable effort, only 15 individuals were tagged from PV Shelf. Overall, the PV Shelf had several order of magnitude lower catch per unit effort (CPUE) than all other locations in the Harbor (Table 2), with the Los Angeles bait barge (LAOH) having the highest CPUE (Table 2). A total of 42 California halibut were caught and tagged at locations throughout the Harbor (Figure 2, Table 1). Using previously derived von Bertalanffy growth equation for white croaker (Love et al. 1984), the mean age of white croaker for Phase II was determined to be 6.51 ± 1.27 years. Age was not estimated for halibut, since sex could not be determined for any halibut we tagged and the von Bertalanffy growth curves differ significantly between sexes.

We did not detect 27 white croaker tagged throughout the Harbor, these individuals were excluded from all analyses. The mean number of detections for each individual white croaker pooled across all receivers was 6,202 ± 8,073. All 38 receivers recorded detections of tagged fish, and mean number of detections for each individual receiver was highly variable (26,605 ± 46,441). The number of fish visiting each receiver ranged from 2 to 54 individuals over the course of the 2-year receiver deployment (Figure 6B). Receivers located in Consolidated Slip (POLA) (7,430 ± 7,882) and the San Pedro Bait Barge (POLA) (2,829 ± 6,302) had the highest average detections per fish (# detections/fish), whereas the receiver in Sea Plane Lagoon (69 ±

122) had the lowest number of detections (# detections/fish) and fish visiting the station (# fish/station) over the course of the study (Figure 7B).

The mean number of detections for each halibut pooled across all receivers was 13,618 ± 18,611. All 38 receivers recorded detections of tagged fish, and mean number of detections for each individual receiver was highly variable (14,708 ± 31,869). The number of fish visiting each receiver ranged from 1 to 27 individuals over the course of the 2-year receiver deployment (Figure 6B). Receivers located in Consolidated Slip (POLA) (41,019 ± 678) and the San Pedro Cabrillo pier (5,992 ± 14,900) had the highest average detections per fish (# detections/fish), whereas the receiver at Commodore Heim bridge (2.5 ± 2.1) had the lowest number of detections (# detections/fish) over the course of the study (Figure 7B).

3.1.3 *Fish size and comparisons*

White croaker caught and tagged for passive tracking during 2011-2012 (n = 99) averaged 251.96 ± 21.19 mm total length (± SD), and all individuals tagged were larger than size at 100% maturity (190mm TL) (Love et al. 1984) (Figure 8A). Variation in average length of fish among regions for 2011-2012 was significantly different, with the largest fish caught in the inner harbor. Fish caught in LAIH and LBIH regions were 264 ± 19 mm and 261 ± 20 mm, respectively; fish caught in the LAOH and LBOH regions averaged 252 ± 16 mm and 232 ± 13 mm, respectively ($F_3 = 16.53$, $p < 0.001$) (Figure 8A). All pairwise comparisons between regions for 2011-2012 (Tukey's HSD) were significant ($p < 0.05$) with the exception of LAIH-LBIH ($p = 0.94$) and LAOH-LBIH ($p = 0.28$).

White croaker tagged during 2013-2015 within the Harbors (n = 189) averaged 233.48 ± 16.30 mm total length, and all individuals tagged were larger than size at 100% maturity (190 mm TL)

(Love et al, 1984) (Figure 8B). Variation in average length of fish among regions for 2013-2015 was significantly different, with the largest fish caught in the inner harbor. Fish caught in the LAIH and LBIH regions were 252 ± 18 mm and 237 ± 10 mm, respectively; fish caught in the LAOH and LBOH regions averaged 230 ± 16 mm and 228 ± 11 mm, respectively ($F_3 = 18.31$, $p < 0.001$) (Figure 8B). All pairwise comparisons were significant ($p < 0.05$) with the exception of LAOH-LBIH ($p = 0.14$) and LAOH-LBOH ($p = 0.79$). This pattern across region was similar to fish caught in 2011-2012.

The average total length of white croaker tagged in 2011-2012 was significantly larger than for individuals caught in 2013-2015 ($t = 7.58$, $df = 160.12$, $p < 0.001$) (Figure 8C). When divided into separate regions, fish tagged in 2011-2012 were significantly larger (t-test, $p < 0.05$) in all regions except the LBOH region ($t = 1.36$, $df = 40.97$, $p = 0.18$) (Figure 8C).

California halibut tagged in 2013-2015 averaged 400 ± 86 mm standard length. Size comparisons among regions were not made due to low sample size. Age was not estimated for California halibut because sex of individuals could not be determined and von Bertalanffy growth curves differ greatly between sexes for this species.

3.2 COMPARISONS OF FISH SITE FIDELITY

3.2.1 *Weekly Presence throughout Harbor*

Weekly presence of white croaker was highly variable among years. During passive tracking in 2011-2012, an average of 52.1 ± 15.4% of tagged white croaker were detected by the receiver array each week. During 2013-2015, an average of 19.1 ± 21.7% of tagged white croaker were detected by the receiver array each week (Figure 9). A sharp decline in presence of white croaker was observed shortly after August 2013, and by January 2014 only 12 of 182 tagged individuals (6.6%) continued to be detected by the receiver array. California halibut had higher weekly site fidelity compared to white croaker during 2013-2015, with an average of 40.4 ± 16.8% of tagged halibut being detected by the receiver array each week (Figure 10).

3.2.2 *Harbor Site Fidelity*

Site fidelity to the Harbor as a whole varied greatly among individuals passively tracked during all years, but in general, white croaker passively tracked during 2011-2012 exhibited higher site fidelity (# of days detected) than white croaker passively tracked during 2013-2015. Despite the higher numbers of white croaker tagged throughout the Harbor in Phase II, proportionally fewer individuals were detected by Harbor receivers over the course of the study than was observed in Phase I. Since transmitters used in Phase II had a longer battery life than those used in Phase I, for comparison between the studies, we only used the first 154 days of data for white croaker tagged in Phase II (Figure 11A & B). White croaker tracked during 2011-2012 were detected in the Harbor for an average of 56.8 ± 51.3 days (Figure 11A), which was significantly longer than fish passively tracked in 2013-2015 (45.1 ± 51.3 days) (Figure 11B) when compared at the same temporal scale and using the same receiver array ($p = 0.025$). White croaker from 2013-2015 were present within the harbor on average 47.6 ± 51.3 day when including all receivers within the Harbor (Figure 11C). California halibut exhibited far greater site fidelity in the Harbor, being detected for an average of 103.1 ± 99.4 days (Figure 11D).

Overall the pattern of site fidelity to location of tagging was similar to that of the whole Harbor (Figure 11 & 12). Site fidelity to the initial site of capture also varied greatly among individuals passively tracked in all years, but white croaker from 2011-2012 exhibited higher proportional residency to site of initial capture than white croaker from 2013-2015 (Figure 12A & B). For comparison we only used the first 154 days of data for white croaker tagged in Phase II and only for fish released within detection range of a receiver. White croaker tracked from years 2011-2012 were detected at the site of capture an average of 53.9 d ± 52.4 days (Figure 12A), which was statistically greater than ($p < 0.001$) white croaker tracked from years 2013-2015 (36.7 ± 37.6 days) (Figure 12B) when compared at equal temporal and spatial scales. Site fidelity to site of initial capture for the entire study of white croaker from 2013-2015 was 39.3 ± 44.9 days. California halibut tagged within the Harbor had an average residency time of 86.3 ± 95.1 days to their initial capture location (Figure 12D). There was no relationship between size of fish and residency time to initial capture location for white croaker from Phase I ($F_{1,63} = 0.09$, $p = 0.76$), white croaker from Phase II ($F_{1,156} = 0.20$, $p = 0.66$), nor for CA halibut ($F_{1,35} = 0.82$, $p = 0.37$).

Site fidelity of white croaker to each region of the harbor was compared between years. Site fidelity for LBOH was not compared due to the high proportion of white croaker tagged outside of receiver coverage in that region. Regional site fidelity followed the same patterns across all years, and no significant difference was found between years for LAOH ($p = 0.36$), LAIH ($p = 0.07$), or LBIH ($p = 0.60$) (Figure 13). More tagged individuals in Phase I (2011-2013) were detected in LAIH after 100 days than in the Phase II study; however, the patterns of site fidelity were the same in LAOH and LBIH over time between both study periods (Figure 13).

3.3 ESTIMATED FATE OF TAGGED FISH OVER TIME

In Phase I, 6% (6) of the white croaker tagged in the Harbor went completely undetected by any receiver after release, while in Phase II 13.6% (27) white croaker were undetected after release. Many of these fish were not necessarily released in the vicinity of a receiver; however, 24 individuals were released inside the Harbor and should have had a greater likelihood of detection before exiting the Harbor if they were emigrating out. While approximately 50% of white croaker tagged during 2011-2012 were detected at least intermittently over the battery life of their transmitters (~5 months), the majority of white croaker tagged in 2013-2015 (> 90%) were detected for a much shorter duration (< 6 months) (Figure 9A & B). The proportion of individuals identified as having died as the result of capture, handling, and surgery (tagging mortality) was 1% for Phase I white croaker and 3.5% for Phase II fish. These characterizations could only be measured for fish that died within detection range of a receiver at the location of release. Approximately 7% (7) white croaker were estimated to have been eaten by a larger, faster predator, based on rate of movement between receivers (> 0.61 m/s), whereas predation rate was estimated at 11.5% (23) for white croaker in Phase II study. Two white croaker tagged in Phase II (in Fish Harbor and LBIH) that were characterized as being eaten, were found to move from the Harbor to Santa Monica Bay in < 30 hrs.

Because there was a substantive decrease in the number of white croaker detected in the Phase II study over the first few months as compared to the Phase I study, we more closely examined detections in order to determine the most probable fate of white croaker not detected during the estimated battery life, in particular the location where a fish was last detected relative to where they were originally tagged and released (Figure 14). All but 27 of these white croaker (16.56%) were last detected in the outer harbor regions, including the harbor gates, indicating that relatively high proportion of individuals likely emigrated from the Harbor and did not return during the monitoring period. Twenty-seven white croaker tagged in the inner Harbor were last detected by a receiver in the inner Harbor, and while it is possible these fish could pass several receivers in the Harbor channels, it is unlikely they could make it all the way through the Harbor without being detected by any other receivers (Figure 14).

3.4 INTEGRATIVE DISPERSAL MOVEMENT MODEL

The average time for white croaker tagged in one region and move to another region was modelled based on rates and directions of fine-scale movements determined from short-term active tracks of fish by region during Phase I. Based on model results, the average time estimated for fish to move from one region of the Harbor to another was significantly longer (10.4 ± 5.5 weeks) than what was observed during passive tracking in both Phase I (4.7 ± 4.1 weeks) ($t = 6.45$, $p < 0.001$) and Phase II (5.1 ± 4.7) ($t = 4.98$, $p < 0.001$) **(**Figure 15A). Times to dispersal for Phase I and Phase II were not significantly different ($t = -0.3699$, $df = 58.48$, $p = 0.71$).

There was no difference in dispersal rate for fish estimated to move from one region of the Harbor to another based on model results from fish actively tracked in each region (Figure 15B). Although the dispersal movement rates observed for white croaker passively tracked in the Phase II study varied widely among regions, there was no significant difference in the observed time to disperse from one region to the next (Figure 15D). White croaker tagged in Phase I in LAIH were observed to move between regions more quickly than fish tagged in LAOH and LAIH regions (Figure 15C).

3.5 REGIONAL CONNECTIVITY AND NETWORK ANALYSIS

White croaker tagged in the Phase I study showed a higher rate of dispersal between LAOH and LAIH, LBIH and LBOH, and LAIH and LBIH; however, there was lower rates of movement between LAIH and LBOH, and LBIH and LAOH (Table 3, Appendix D). For white croaker tagged in Phase II there was less movement between LAIH and LAOH; however, much more movement between LBIH and LBOH (Table 4, Appendix E). White croaker tagged in Fish Harbor were most commonly observed moving to LAOH and Angel's Gate. Individuals tagged at Cabrillo pier were most commonly detected at LAOH, and fish tagged at Pier J were most commonly detected at the Harbor gates (Queen's and Angel's) (Table 4, Appendix F).

California halibut tagged in Phase II showed higher rates of dispersal between Cabrillo Pier and LAOH, Cabrillo Pier and Angel's Gate, Cabrillo Pier and PV-Cabrillo Beach. There was no observed dispersal between LAIH and LBIH, and inner Harbor regions (LAIH and LBIH) and Cabrillo Pier or Pier J (Table 5, Apprendix G).

Movement transition networks of white croaker during both Phase I and Phase II showed very similar patterns of connectivity, with high degrees of residency at Consolidated Slip during both years (Figure 16A & B, Appendix D, E, F**.** The variance of edge weights of randomly generated networks was significantly lower than variance of edge weights for networks generated from observed fish movements for fish in both Phase I (95% CI = 1265.057, 2414.996) and Phase II (95% CI = 1854.728, 3544.16) based on the Phase I receiver array (Figure 16A & B). This indicates that transition between certain pairs of receivers was significantly more likely than other pairs of receivers in both studies and that coarse-scale white croaker movements throughout the Harbor are not random. White croaker movements for fish tagged in Phase II showed similar node patterns when networks were generated based on movement between Phase 1 receiver array (Figure 16B, Appendix D) and Phase 2 receiver array (Figure 16C, Appendix E, F). In the Phase II study, fish showed relatively high site fidelity to Cabrillo pier, Pier J, Fish Harbor and Consolidated Slip, with a the highest edge weights for transitions between LBIH and

LBOH and between Cabrillo pier and LA bait barge (Figure 16C). Angel's and Queen's Gates show a high degree of connectedness to other parts of the harbor, but this is likely due to this being entrance and exit choke points for the Harbor.

California halibut showed a very different network structure, with large nodes at Cabrillo Pier and Consolidated Slip (Figure 16D). California halibut exhibited less Harbor connectivity compared to that observed from white croaker; however, there was a strong edge weight observed between Cabrillo Pier and LA bait barge (Figure 16D). The variance of edge weights of randomly generated networks was significantly lower than variance of edge weights for networks generated from observed halibut movements in Phase II (95% CI = 4275.301, 11811.13) based on the Phase II receiver array (Figure 16D). This indicates that transition between certain pairs of receivers was significantly more likely than other pairs of receivers, and that coarse-scale halibut movements throughout the Harbor are not random.

3.6 PHASE I MIGRATIONS FROM HARBOR AND CONNECTIVITY TO PALOS VERDES SHELF

Nineteen white croaker (20.4%) were detected by receivers at Angel's Gate and 10 white croaker (10.8%) were detected by receivers at Queen's Gate. White croaker that were detected at Angel's Gate and Queen's Gate had very few subsequent detections, indicating the fish did not remain in the vicinity of the gates for extended periods of time, and were not detected again during the monitoring period.

Migrations to the Palos Verdes Shelf were relatively rare, with only two white croaker (2.1%) being detected by the USEPA study receiver array on the PV Shelf (Wolfe and Lowe In press). One white croaker left through Angel's Gate on 26 August 2011 and spent approximately 36 hrs on the PV Shelf before returning to the Harbor through Angel's Gate on 27 August 2011. Another white croaker left the Harbor undetected by receivers at either gate, spent almost three months on the PV Shelf between April and July 2012, and was never detected again.

3.7 PHASE II MIGRATIONS FROM HARBOR AND CONNECTIVITY TO PALOS VERDES SHELF

None of the nine white croaker tagged on the PV Shelf during 2013-2015 were detected by the receiver array within the Harbor. Thirteen of the white croaker tagged within the Harbor (5%) were detected by the three PV-Cabrillo Beach receivers. Of these 13 individuals, nine were detected returning to the Harbor, one was detected at Queen's Gate, and three were never detected again by any receiver (Figure 16C).

Twelve halibut (26%) were detected by the three PV-Cabrillo Beach Shelf receivers. Ten halibut were last detected on the PV-Cabrillo Beach. An additional, two individuals left the Harbor, but eventually returned to the Harbor after periods of 5-6.5 months. One of the two fish that had left and returned to the Harbor was initially tagged at Cabrillo Pier, left the harbor for 5 months and then returned to Cabrillo Pier. The other individual, original tagged at Cabrillo pier, left for 6.5 months and returned to Sea Plane Lagoon. Four California halibut that were tagged in the Harbor were detected on CSULB Shark Lab acoustic receivers along Santa Monica Bay. Time from last detection at the Harbor to detection in Santa Monica Bay were 6.5 days, 1.2 months, 2.1 months, and 3.4 months, with one fish being detected as far north as Zuma Beach.

3.8 PHASE 1 COARSE-SCALE HABITAT ANALYSIS

Seafloor depth within each receiver range varied from 5.9 m ± 2.5 (at Station 12) to 20.0 m ± 4.0 (at Station 11), with the standard deviation within each receiver range varying from 0.54 m (at Station 13) to 4.3 m (at Station 2). Grain size within each receiver range varied from 9.06 µm ± 0.53 (at Station 6) to 114.0 µm ± 14.2 (at Station 2), with the standard deviation varying from 0.39 µm (Station 9) to 25.6 µm (Station 1). Temperature within each receiver range varied from 14.07℃ ± 1.30 (at Station 11) to 17.36℃ ± 1.15 (at Station 5), with the standard deviation ranging from 1.15℃ (at Station 5) to 6.61℃ (at Station 12). Sediment TOC within each receiver range varied from 0.84% ± 0.03 (at Station 12) to 7.32% ± 0.20 (at Station 6), with the standard deviation varying from 0.006% (at Station 9) to 0.47% (at Station 5). The number of detections per receiver range (m^2) was not significantly correlated with average water depth or sediment grain size, or average water temperature per receiver (Depth: $p = 0.15$, $r = -0.43$; Grain size: $p = 0.5$, $r = -0.21$; Temperature: $p = 0.23$, $r = 0.37$); however, the number of fish detections per receiver range (m^2) was positively correlated with sediment TOC ($p < 0.001$, $r = 0.95$ (Figure 17). Station 6 receiver was identified as a possible outlier, with the average sediment TOC being 2.4 times higher at this station than the station with the next highest sediment TOC value. To ensure the positive correlation observed for sediment TOC and number of fish detections per receiver range was not driven by this single value, Station 6 receiver was removed and the correlation rerun. Even with the removal of this possible outlier, a positive correlation between sediment TOC and fish detections per receiver range was observed ($p = 0.0008$, $r = 0.85$).

3.9 PIER ASSOCIATION

Receivers in the Cabrillo Pier VPS array detected a total of 57 individual white croaker, of which 27 individuals were tagged in the vicinity of Cabrillo Pier and 30 individuals were tagged in other regions of the harbor (Figure 2). White croaker tagged in the vicinity of Cabrillo Pier spent an average of 31. 9 ± 25.7 total days within the array, which was significantly greater than the total number of days spent in the array by fish tagged in other regions (4.6 ± 10.8 days) ($p < 0.001$) (Figure 18B & D). The duration of each individual visit into the Cabrillo Pier array was also significantly longer for fish tagged in the vicinity (11.9 ± 5.2 hours) than for fish tagged in other regions of the harbor (0.5 ± 1.7 hours) ($p < 0.001$) (Figure 18C & E).

Receivers at Pier J detected a total of 28 individual white croaker, 25 of which were tagged in the vicinity of Pier J, and only three of which were tagged in other regions of the harbor (Table 4). White croaker tagged in the vicinity of Pier J spent an average of 40.1 ± 32.2 total days in the area, which was significantly greater than the total number of days spent in the area by fish tagged in other regions of the harbor (1 ± 0 days) ($p = 0.0198$) (Figure 19B & D). The duration of each individual visit into the Pier J area was also significantly longer for fish tagged in the vicinity of Pier J (6.6 ± 5.3 hours) than for fish tagged in other regions of the harbor (0.2 ± 0.1 hours) ($p < 0.001$) (Figure 19C & E).

The Cabrillo Pier VPS array detected a total of 27 halibut, 26 of which were tagged in the vicinity. These 26 halibut spent an average of 95.9 ± 104.8 total days in the area (Figure 20B), with individual visits to the area averaging 6.6 ± 5.3 hours (Figure 20C). Receivers in the Pier J area detected a total of 7 halibut, 6 of which were tagged in the area. These 6 halibut spent an average of 67.5 ± 100.4 days in the area (Figure 21B), with individual visits into the area averaging 3.1 ± 2.1 hours (Figure 21C). Statistical comparisons of pier association with individuals tagged in other regions of the harbor were not made for halibut due to low sample size.

A total of 563 fine-scale position points were rendered for white croaker within the Cabrillo Pier VPS array (Figure 22A). The distances of these points from Cabrillo Pier was significantly different from random distribution ($\chi^2 = 429.085$, df = 71, $p < 0.001$) (Figure 22B). Frequency distribution of white croaker VPS-rendered positions exhibited one peak between 40 to 120 m from Cabrillo Pier and other at approximately 275 m from the pier. To determine if white croaker were selecting for ecotone habitat associated with the Cabrillo pier (e.g., neighboring low-relief reef), we combined the pier and reef habitats and compared the distance of fish positions from the combined ecotone habitat to that of a random distribution ($\chi^2 = 189.3179$, df = 64, $p < 0.001$) (Figure 23).

A total of 46,615 fine-scale position points were rendered for California halibut within the Cabrillo Pier VPS array (Figure 24). The distribution of distances of these points from Cabrillo Pier was significantly different from random distribution ($\chi^2 = 170146.1$, df = 71, $p < 0.001$) (Figure 25). Comparisons of the pier distributions suggest that California halibut mostly select for habitats approximately 20-140 m from Cabrillo Pier when within 300 m of the pier (Figure 25). To determine if halibut were selecting for ecotone habitat associated with the Cabrillo pier (e.g., neighboring low-relief reef), we combined the pier and reef habitats and compared the distance of fish positions from the combined ecotone habitat to that of a random distribution ($\chi^2 = 35947.78$, df = 64, $p < 0.001$). Comparisons of the ecotone distributions suggest that California halibut select for areas within 0-70 m from ecotone, with the peak in distribution occurring < 25 m from ecotone (Figure 24B).

4.0 DISCUSSION

4.1 DISCUSSION OF RESULTS OF SPECIFIC GOALS

4.1.1 Goal 1: Characterize the longer-term movements and site fidelity of California Halibut and White Croaker in the Los Angeles and Long Beach Harbor over a multi-year period.

4.1.1.1 White croaker site fidelity to the Harbor

Short-term, fine-scale active tracking of tagged white croaker in the Harbor indicated that fish used discrete amounts of space (94,720 ± 78,720 m^2) on a daily basis and that the sizes of these daily spaces varied widely among individuals and among the regions of the Harbor where fish were tracked. These movements were only characterized for periods of up to several weeks. None of the actively tracked individuals were observed to leave the Harbor during any tracking event, and only one individual was found to move from one region of the Harbor to another during a track (Lowe et al. 2015). These daily movements would suggest that white croaker are relatively site specific. However, longer-term, coarse spatial-scale passive tracking of white croaker in the Harbor over a multiple year period have shown that a majority of individuals do not remain resident in all areas of the Harbor for long periods of time (weeks to months) and that fish site fidelity to different areas of the Harbor vary widely among regions and across years.

Overall, white croaker passively tracked (n = 93 out of 99) during the Phase I study (2011-2012) were observed to have a moderate level of site fidelity to the Harbor over the ~ 5 month battery life of the transmitters. Up to 50% of the individuals tagged were detected by receivers (12 Harbor, 6 Harbor Gates) in the Harbor for periods of up to 1-2 months (Figure 9), although there was clear evidence of movement throughout the Harbor (Table 3, Figure 16A). Another portion of the population showed high initial rates of emigration following tagging (Figure 11A). Fish tagged in the inner Harbor regions tended to remain in those areas for longer periods of time, particularly fish tagged in Consolidated Slip (Table 3, Figure 12A, Figure 16A). Fish caught and tagged in Consolidated Slip area were larger than fish caught in the outer Harbor regions (Figure 8A). While it is likely that white croaker are using Consolidated Slip more and for longer periods of time because of the higher TOC and resulting higher prey density (Lowe et al. 2015; Ahr et al. In press), larger individuals may be selectively using that area more so than smaller individuals. This may have something to do with the abundance of larger prey items that may be less accessible to smaller individuals, or the possibility that increased availability of prey may allow fish to reach larger sizes. Even white croaker tagged in the outer Harbor were occasionally observed moving into the Consolidated Slip area (Figure 6A & 7A), which further indicates the relative importance of this habitat.

Another white croaker "hotspot" in the Harbor was the LA bait barge. This area showed highest CPUE for white croaker for any location in the Harbor and on the PV Shelf. White croaker tagged at the LA bait barge were also observed to show relatively high site fidelity to this area (Figure 16A-C). Although fewer fish tagged in other regions visited this area, those that did spent more time at this location than was observed for white croaker at other locations in the outer Harbor. Again, it is likely these individuals show greater fidelity to the LA bait barge area due to the higher nutrient load contributed from wastes and dying bait fish, likely resulting in a higher benthic infauna associated under the bait barge.

White croaker were found to select for areas of high sediment total organic carbon (4.8-8.1%), high polychaete density (406-700 polychaetes/0.1 m^2), small sediment grain size (< 23.5 µm), and at depths between 7-11 m and 13-15 m, based on the active tracking study (see Lowe et al. 2015 - Phase 1 Report). However, passively tracked white croaker detections were only correlated with sediment TOC when compared to seafloor depth, sediment TOC, grain size, and temperature. Since sediment TOC was a driving factor for white croaker selection it follows that there would be a positive correlation with sediment TOC and white croaker detections for the passive tracking. As stated in Phase 1 report, it is likely that white croaker select for areas with high sediment TOC as it often correlates to an increase in benthic infauna (Pearson and Rosenberg 1978). A correlation between white croaker detections and polychaete density was not run due to insufficient polychaete sampling locations near or within receiver ranges. White croaker did not appear to select for temperature based on a general additive model and mixed effects model (see Phase 1 report), thus it was not expected that there would be a significant correlation between temperature and white croaker detections. Fine-scale habitat selection of white croaker did indicate that the fish select for certain depths and grain sizes within the harbor. One possible explanation why this pattern was not seen in the passive data analysis may be due to the range of depths and grain size within each receiver range. Grain size, temperature, and depth had the largest differences (in descending order) in standard deviation within each receiver range. Obviously, the coarse-scale habitat selection data are not as specific as those obtained from individual's actively tracked; however, they do provide a broad categorization of habitat selection where benthic parameters are not too diverse.

White croaker tagged and passively tracked (n = 168) in the Phase II study did not show similar patterns of residency, even though the transmitters used in this study had twice the battery life as those used in Phase I. In general, most fish were no longer detected on the acoustic array after several days to a month (Figure 9B), despite the greater receiver coverage for Phase II. Regardless of this overall difference in site fidelity to the Harbor as a whole, fish tagged and tracked in different regions of the Harbor show similar site fidelity trends to those tracked in the Phase I study (Figure 13, Figure 16B & C). White croaker tagged in Consolidated Slip tended to remain there for the longest periods of time and individuals tagged in Fish Harbor remain there for approximately 5-6 days before emigrating away, whereas fish tagged in outer Harbor regions were much more likely to leave the Harbor or move into the inner Harbor.

It is possible that more white croaker tagged during the Phase II study emigrated from the Harbor faster after tagging than fish tagged in the Phase I study because of differences in environmental conditions between 2013-2014 and 2011-2012. While there was no available seafloor temperature data for 2013-2015, sea surface water temperatures in the outer Harbor were not significantly different among those years. However, this may not be a good proxy for the seafloor habitats that white croaker are using. It is also possible that differences in the transmitter pulse rates could have accounted for some of the difference in overall detections by receivers (i.e., estimate degree of site fidelity), since transmitters used in the Phase II study were programmed to pulse between 120-250 sec intervals, whereas the transmitters used in Phase I were programmed to pulse at 30-90 sec intervals. This difference was a tradeoff between having longer battery life versus the ability to obtain more detections. However, longer transmitter pulse intervals increase the likelihood that a quickly swimming white croaker could swim past a receiver and not be detected. In addition, twice the number of fish were tagged in Phase II, which could potentially increase transmitter competition for detections if tagged fish were moving together throughout the Harbor. It is unlikely that the longer transmitter pulse rate accounts for the higher observed loss of detection rate in the Phase II study, since it is very unlikely that fish tagged in the inner Harbor regions could pass 4-6 receivers without being detected by at least one receiver. Twenty-seven white croaker tagged in the inner Harbor were last detected at inner Harbor receivers, at periods long before the batteries were programmed to expire. It is possible that these fish subsequently died outside the detection range of a receiver, or that the transmitters fail; however it is most likely these and potentially other individuals in the outer Harbor were caught by subsistence anglers or in otter trawls. Due to an increased biological sampling in the Harbor in 2013-2014, it is possible that many of the tagged fish were incidentally caught in sampling trawls and discarded dead outside a receiver detection area. These fish would have been hard to identify as previously tagged since they were not fitted with external tags and surgical scars may have been well healed. We believe this may account for much of the difference in detection rates and estimates of site fidelity between the Phase I and Phase II studies. Interestingly, analyses between detection data for both studies indicated a difference in potential tagging mortality and predation rates on white croaker in the Harbor. While tagging mortality was considerably low considering the sensitivity of white croaker to capture and handling, tagging mortality assessed for fish tagged in Phase II was 3.5%, but 3 times higher than in Phase I. This is already a very low mortality rate, but is likely due the larger sample size of fish tagged in Phase II. Predation rates were also twice as high in the Phase II study and we think this may be due to growing abundance of fish predators in the Harbor, in particular sea lions, dolphins, and sharks. This was evident in movements of two white croaker that were exhibiting normal type movements within the Harbor, but then suddenly changed, moving much faster than 1 m/s between receivers, then those transmitters were detected in Santa Monica Bay the next day. The rates at which these transmitters were observed to move were significantly faster than white croaker are known to swim and the movement pattern was very similar to those observed in bottlenose dolphin and juvenile white sharks studied in the area (C. Lowe, Unpubl. data).

Overall, white croaker passively tracked in the Harbor (across all years) showed similar patterns of site fidelity to the Harbor as was observed from white croaker tagged and tracked on the PV Shelf (Lowe 2013; Wolfe and Lowe In press). Wolfe and Lowe (In press) found that only a portion of the population of individuals (~30%) caught and tagged on the PV Shelf remained in the area where they were tagged for periods of time (weeks to months), whereas a majority were found to move extensively and rarely return to the area where they were tagged. They concluded based on this behavior that a majority of individuals may exhibit more nomadic type movements.

In general, white croaker tagged and passively tracked in the Harbor showed similar site fidelity behaviors; however, individuals at Consolidated Slip and LA bait barge showed a relatively high degree of site fidelity to those areas compared to fish tagged in other regions of the harbor.

4.1.1.2 White croaker movements throughout the Harbor

Areas of high prey and predator density may greatly influence residency and movements of white croaker throughout the Harbor. Observations of discrete daily area use during active tracks of white croaker tagged in the Harbor (Ahr 2014; Lowe et al. 2015; Ahr et al. In press) have shown periods intense localized area use indicative of patch foraging. Depletion and behavioral modifications of benthic infauna due to intensive patch foraging will cause benthic foragers to periodically move to new patches in order to exploit resources at higher densities. In addition, foraging patches and their richness are often closely associated with habitat characteristics, which may be discontinuous and scattered 100s m to km apart. While active tracking of white croaker in the Harbor found that individuals only shifted their daily use area 100s m to a km from their starting position over the course of several days to weeks, passive tracking data from both Phase I and Phase II show that in most regions of the Harbor individuals often made much greater movements over the course of several weeks to several months. Many individuals made at least one transition from one region of the Harbor to another, often covering distances of several kilometers in a single day and ultimately resulting in much more broad dispersal than what was observed during active tracking. All receivers detected the presence of tagged fish, including receivers in areas where no fish were tagged. However, no receiver detected all tagged fish and no individual fish was detected by every receiver, indicating that, at least at the scale of the battery life of the transmitters (150-370 d), the possible home range of individual white croaker within the Harbor is not broad enough to encompass the entire Harbor.

In addition, dispersal of white croaker throughout the Harbor is not random. The time-scale at which white croaker were seen to disperse from one region of the Harbor to another in both Phase I and Phase II was 2 times faster than what was predicted by the random walk model generated from active tracking movements, indicating that transitions between adjacent regions are likely made using periodic relatively direct, linear movements. This suggests that white croaker may exploit certain areas of the Harbor for purposes such as foraging or refuging for periods of weeks to months, while utilizing other areas primarily as movement corridors to travel between known areas of more favorable habitat. These less used areas may simply be movement corridors, such as the LA Harbor main shipping channel, which contains larger sediment grain size and lower TOC and are likely unsuitable foraging and refuging habitats for white croaker (Ahr 2014; Ahr et al. In press). These areas likely span the distance between potential foraging patches and require highly directed movements to transit between areas of preferable habitat. This hypothesis is consistent with patterns in the variation of rate of movement exhibited during active tracking in Phase I, as some of the highest average rates of movement were recorded in the outer Harbor in or near the shipping channels.

Based on the results of the network analysis, it would also seem that utilization of the available corridors is non-random. The highest numbers of observed inter-regional transitions occurred along the main shipping channels, between the inner and outer regions of the LA and LB Harbors. Higher edge weights for networks between the LAIH, LBIH and LBOH for fish passively tracked in Phase II may indicate that fish more commonly transit between foraging/refuging areas in the inner and out Harbors through the Long Beach shipping channel than the Los Angeles main shipping channel (Figure 16B & C). This may also explain why fish tagged in the LBIH and LBOH showed some of the fastest inter-regional transit times (Figure

15C). It is possible that white croaker move more quickly through channel habitat areas due to increased sediment grain size or other effects of dredging activity (Ahr 2014; Ahr et al. In press), as fish could be expected to use movements characterized by longer step lengths and lower turning angles when moving through less profitable habitat (Zollner and Lima 1999). The low number of transitions between the LAOH and LBOH regions is likely due to the very long distance between the nearest receivers and the large land mass that fish must circumnavigate in order to make the transition. The number of observed transitions between the LAIH and LBIH regions was lower than expected. This could be a result of increased anthropogenic noise caused by two relatively low lift bridges in the area. Another possible explanation is that white croaker simply do not move as quickly through this corridor, since the habitat in this area is more preferable than what is found in the main shipping channels (Ahr et al. In press). It is even possible that this area is used more for foraging and less for transit, although the relatively low CPUE in this area during the fishing and tagging phase of the project would not necessarily support this assertion.

4.1.1.3 <u>California halibut site fidelity to the Harbor</u>

California halibut showed varying degrees of site fidelity to capture locations through the Harbor, as number of days detected ranged from just a couple days to the extent of the transmitter's battery life. Previous acoustic telemetry studies of halibut in coastal estuaries found similar results that halibut had range in site fidelity from 3 to 437 days (Espasandin 2012; Freedman et al. 2015). California halibut are ambush predators, which bury themselves in sediment and remaining still for long periods of time, waiting for their prey to come to them before striking (Haaker 1975). Higher degrees of site fidelity observed are most likely attributed to these areas provide ample feeding opportunities. It was unexpected to see such high degrees of site fidelity for inner Harbor halibut since this area tends to lack high tidal flow and schools of baitfish (A. Barilotti, Pers. Observ). However, while fishing for white croaker we caught greater numbers of California lizardfish (*Synodus lucioceps*) than white croaker. Lizardfish are known prey item of California halibut and these high abundances of lizardfish could be sustaining the halibut population within the Harbors, thus resulting in a higher site fidelity to the inner Harbor regions. Halibut that were present within inner Harbor regions for long periods of time may also be using these areas to avoid larger predators. Coastal bottlenose dolphins and sea lions were much less prevalent within inner Harbor areas than outer Harbor areas. We also detected four juvenile white sharks (*Carcharodon carcharias*) passing through the outer Harbor areas, but none were detected moving into either of the inner Harbor regions (Lowe et. al. Unpub. data). California halibut have not been actively tracked within the Harbors, so it is unclear what types of microhabitat they may select. Based on coarse-scale movements from this study, halibut appear to be selecting for similar habitat features of white croaker (high TOC, fine grain size, and higher polychaetes abundances) (Ahr et al. In press).

4.1.1.4 California Halibut Movements throughout the Harbor

Compared to white croaker, California halibut tagged within the Harbor showed much more restricted movements; however, when they moved they showed a strong tendency to leave the Harbor or move to areas unmonitored (Table 5, Figure 16D). This difference in behavior is primarily attributed to differences in their foraging ecology, with California halibut being an ambush predator, known to feed on epibenthic prey (Haaker 1975). In addition, they are known to utilize habitats with tidally-induced flow, which increase delivery of pelagic prey and associate with ecotone habitats where higher epibenthic prey densities may occur (Espasandin 2012; Freedman 2014). This explains why halibut were seldom detected by receivers in the main shipping channels. Most of the areas they transited between in the Harbor were to sites known for having high sediment TOC and relatively fine sediment grain size (Figure 4, 5, 7C). Halibut may be selecting areas with high sediment TOC because they attract other prey.

The general trend of movement was for individuals to move from the inner Harbor areas towards the outer Harbor areas, or completely out of the Harbor. No individuals tagged in the outer Harbor were observed to move to the inner Harbor. It is possible that the inner Harbor is acting as a nursery for smaller halibut, which eventually move out to coastal habitat and the individuals we tagged and tracked were at those transition states. In the San Diego area 58% of juvenile halibut were deemed to have originated from embayment areas even though these areas only accounted for 15% of the potential nursery habitat (Fodrie and Levin 2008). Adult halibut are known to enter and utilize estuary and bay habitats, but do not remain for prolonged periods of time like juveniles. Therefore, it might be expected that larger adult halibut used the entire Harbor, but primarily the outer Harbor for shorter periods of time before immigrating back to coastal habitat.

4.1.2 Goal 2: Identify emigration of white croaker and California halibut from the Harbor and onto the Palos Verdes Shelf.

4.1.2.1 Emigration and movements of white croaker from the Harbor

Another important aim of this project was to characterize the degree to which white croaker from the Harbor migrate to the Palos Verdes Shelf (Superfund Site). The extremely low proportion of tagged individuals that were detected making transitions to the PV Shelf, approximately 2% in Phase I and approximately 5% in Phase II, indicates that such migrations are relatively rare. This pattern of emigration differs considerably from that observed by (Wolfe and Lowe In press), who found that more than half of the individuals tagged on the PV Shelf traveled to the Harbor gates, and 41% actually entered the outer Harbor regions. However, this may be at least partially explained by the relative sizes of the individual fish. White croaker tagged within the Harbor were significantly larger on average than white croaker tagged on the PV Shelf. White croaker are known to exhibit an ontogenetic shift in foraging strategy at approximately 100 mm SL (Bond et al. 1999), and it is not unreasonable to suggest that this shift in foraging strategy may be accompanied by a shift in foraging grounds. Polychaete density in the Harbor is known to be inversely correlated with depth (Ahr et al. In press). If this trend is also true on the PV Shelf then white croaker may move toward foraging grounds containing higher polychaete densities within the Harbor as they grow larger. This theory is also consistent with trends we observed in relative size of white croaker within the Harbor where fish caught in the inner Harbor were significantly larger than fish caught in the outer Harbor.

This differential pattern of migration between Harbor and PV Shelf caught fish may also represent two populations of individuals that use each habitat differently. It is possible that there is a PV Shelf population of white croaker that move about coastal habitats and occasionally enter the outer Harbor and a population of Harbor fish that primarily use Harbor habitat. Lower prey densities and more dispersed foraging locations on the Shelf may result in smaller, slower growing white croaker that utilize coastal habitat. Fish on the PV Shelf that are accustomed to lower quality foraging and refuging habitat would also be more likely to have developed a more nomadic strategy in order to meet their energetic requirements and reduce their predation risk. Harbor fish may be less likely to leave Harbor habitat because they have a behavioral advantage in finding and extracting prey in the Harbor, but may lose that advantage on the Shelf due to the vastly differing conditions (e.g., clearer water, lower sediment TOC). It is also possible that Harbor white croaker have simply developed a more resident behavioral strategy in order to take advantage of the more preferable habitat available within the Harbor.

4.1.2.1 Emigration and movements of California halibut from the Harbor

Over half of the halibut tagged within the Harbor were detected at the Harbor gates or PV-Cabrillo Beach receivers at some point during the Phase II study, and those last detected at the gates and were assumed to have emigrated from the Harbor. It is unclear why these halibut left the Harbor as we found no correlations between size of halibut and site fidelity or time of year that could explain these emigration events. Larger, adult halibut could have left to spawn offshore, left due to loss of baitfish schools, or the water temperature may have gotten too warm due to El Niño Southern Oscillation event, all which may be plausible explanations for these emigration events. California halibut are capable of spawning year round so they may be leaving the Harbor to participate in spawning events outside of the Harbor. Male halibut are mature by reaching a size of 32 cm TL and 100% of females are mature when reaching a size of 59 cm TL (Love 2011). Most of our halibut were < 59 cm TL and we were unable to determine sex for any halibut tagged. These differences in sexual maturity between sexes could potentially explain patterns of emigration. Halibut have also been documented following schools of baitfish. California grunion (*Leuresthes tenuis*) spawn in large aggregations from February through September off the beaches of southern California and are known prey of halibut (Love 2011). Halibut could be leaving the Harbor during these times of year in search of these spawning aggregations of grunion. Lastly, water temperatures were above normal for the summer of 2014 due to a mild El Niño. Larger (>237 mm TL) sub-adult California halibut have been found to have reduced growth rates at temperature over 20° C (Madon 2002), thus halibut could be emigrating from the Harbor to find cooler areas.

We detected four halibut on the CSULB Shark Lab receivers deployed to monitor juvenile white shark movements within Santa Monica Bay. In addition, California halibut in previous markand-recapture studies were also observed to make long distance movements, including a few greater than 70 km (Tupen 1990; Domeier and Chun 1995; Posner and Lavenberg 1999). We did not detect any halibut moving south to Anaheim Bay or Huntington Beach where other CSULB Shark lab receivers are moored, both areas are known to be productive for halibut fishing (Haaker 1975). These findings give anecdotal support to the hypothesis that CA halibut in southern California make periodic longer distance movements to the north than south (Posner and Lavenberg 1999). Halibut left the Harbor during all seasons, however, the four halibut detected in Santa Monica Bay all left in late spring to early summer.

4.1.3 Goal 3: Determine the degree of association and site fidelity of California halibut and white croaker to fishing piers within the Harbor.

4.1.3.1 Site fidelity of white croaker and California halibut to Cabrillo Pier and Pier J

White croaker tagged in the Phase II study at Cabrillo Pier (n = 29) and Pier J (n = 25) showed similar degrees of site fidelity. White croaker at Pier J did have slight higher average number of days detected but most white croaker at both locations had left after 2 months. White croaker tagged a Cabrillo Pier did spend a longer average amount of time per visit than white croaker tagged at Pier J; however, this difference is likely due to the greater number and higher density of acoustic receivers at Cabrillo Pier. White croaker from both pier locations that left the piers were mainly detected in outer regions of the Harbor or Harbor gates, with only three white croaker from Cabrillo Pier detected in Fish Harbor and one white croaker from Pier J detected in LAIH. While it is unclear where white croaker in the eastern part of Harbor spend their time, there is appears to be very little connectivity between the eastern part of the Harbor and the rest of the Harbor. It is possible that fish tagged at Pier J spend more time foraging at locations around Belmont Shores or move onto the Huntington Flats (all areas lacking acoustic receivers coverage). Previous otter trawl sampling off Pier J and Belmont Shores have yielded high CPUE of white croaker, albeit mostly smaller juvenile individuals (C. Lowe, Unpubl. data). It is also possible that the Los Angeles River mouth provides good white croaker habitat and that some individuals spend more time utilizing the eastern portion of the Harbor, where there may be fewer large predators.

A total of 30 different white croaker tagged in other regions of the Harbor were detected at Cabrillo Pier and three at Pier J; however, these individuals did not remain for a long period of time (< 0.5 hr) within detection range of either pier receivers. The relatively high site fidelity of white croaker tagged at the both piers to these areas and number of individuals that visited these areas suggest that they provide adequate white croaker habitat. The area surrounding Cabrillo pier offer sediment grain size and TOC concentrations (Figures 4 & 5) that would be considered acceptable to white croaker based on previous habitat selection analyses. Thus, it is surprising that white croaker that visited the piers from other areas did not remain for longer periods of time. Only two white croaker from other regions spent > 1 hr at Cabrillo Pier, and one originated from LA Bait Barge (HCHP 13) and the other Fish Harbor. These different patterns of site fidelity suggest that some individuals may show higher temporal affinity for some areas, but not over periods longer than a few months. This again, may result from extended patch foraging or periodic refuging from predators or unsuitable environmental conditions (Lowe and Bray 2006).

Site fidelity varied among halibut tagged at Cabrillo Pier, which were present between 3 and 358 days; however, fourteen of the 26 halibut tagged at Cabrillo Pier stayed longer than 50 d, with six staying longer than 5 months, indicating that the area near Cabrillo Pier offers suitable habitat for halibut. In past tag and recapture studies along the California coast, most (55-64%) individual CA halibut were recaptured within the same area (0-10 km) as they were tagged, indicating halibut may not move long distances if resources are available (Tupen 1990; Domeier and Chun 1995; Posner and Lavenberg 1999). One halibut (tag ID 11393) from Cabrillo Pier spent a total of 358 d within a 200 m by 100 m area in the northeast region of the Cabrillo Pier array, just to the west-side of the reef. This halibut did eventually leave Cabrillo Pier and was detected at HCHP 13 (LAOH Bait Barge) right before the transmitter's battery died, indicating this fish sustained itself at Cabrillo Pier for almost a year.

California halibut tagged at Pier J did not spend as many days present within the Pier J receiver array compared to those tagged at Cabrillo Pier. Five of the six halibut tagged at Pier J spent less than 2 months present within the array, but one was present for approximately 257 days. This halibut (tag ID 11399), the largest halibut tagged in the Phase II study, was not continuously detected at Pier J, rather it routinely moved between Queen's Gate and Pier J for the entirety of the transmitter's battery life (363 d). Another halibut was tagged just outside of detection range of receivers at Pier J and was not detected until 6.5 months after it was tagged. It is unclear whether this halibut left Pier J and returned months later or if it had remained near Pier J but just outside of detection range. It is also likely that halibut tagged in the eastern side of the Harbor utilize this side of the Harbor more frequently also taking advantage of prey associated with the Los Angeles River and the Queen's Gate entrance to the Harbor.

4.1.3.2 <u>Association of white croaker and California halibut to the Cabrillo Pier</u>

White croaker were not found to exhibit a strong association to Cabrillo Pier or the associated ecotone of the pier and neighboring reef (Figure 22B & 23). Only one white croaker (originally tagged in Fish Harbor) showed any affinity for the Cabrillo Pier. This individual accounted for 37% of the VPS positions of all croaker detected, was found to move along the deeper area approximate 30 m from the pier. This habitat is primarily sand/mud sediment and is typical of white croaker habitat. Other individuals showed an association to the area approximately 35 - 120 m from the pier, which again is characterized as a sand/mud substratum. No white croaker was detected within 10 m of the Cabrillo pier, which could be due to the area underneath the pier being relative shallow (< 3 m) and more sandy. White croaker have been shown to avoid shallow habitats (Love et al. 1984; Ahr 2014), and are most likely to avoiding the habitat underneath Cabrillo Pier to avoid predators (e.g. diving birds) that could see them in the shallow water. White croaker may be avoiding the pier itself to reduce encountering predators that associate with structure (such as*Paralabrax sp.*) (Lowe et al. 2003; Mason and Lowe 2010; Able et al. 2013).

California halibut tagged in the vicinity of Cabrillo Pier showed not only a high site fidelity to the area compared to white croaker, but were also found to use areas much closer to the pier. It was clear from VPS-rendered positions that halibut were utilizing most of the benthic habitat along the pier but also using ecotone habitat associated with low-relief reef running northeast perpendicular from the southeast end of the pier. This habitat use distribution pattern brings halibut much closer to the pier where this is a greater likelihood of potential capture. Halibut selected areas between 25-135 m from the pier, with peaks of selection at 35-40 m and 70-75 m, with most of this benthic habitat consisting of sand/mud substratum (Figure 25). This association with the pier and reef ecotone, suggests that halibut may be using these areas because of their known higher prey densities. Ecotone habitat has been documented increase species richness and abundance in many marine and terrestrial ecosystems (Lidicker Jr 1999; Baker et al. 2002; Ries and Sisk 2004; Moenting and Morris 2006). Halibut are known ambush predators where they lay-in-wait in areas waiting for prey to come to them (Haaker 1975). Barred sand bass, another ambush predator have also been shown to use similar ecotone habitats, probably for the same higher chance of encountering more mobile prey associated with structure (e.g., piers, reefs) (Mason and Lowe 2010; Teesdale 2015). Previous active tracking studies of juvenile California halibut in southern California estuaries have found that 54% of the time halibut were within 2 m of eelgrass (*Zostera pacifica*) beds, and most frequently in channels where there was easy access to tidal delivery of prey (Espasandin 2012; Freedman 2014). It is also possible that halibut remained in this area due to its close proximity to Angel's Gate and tidal delivery of potential prey.

We observed relatively few VPS-rendered positions of white croaker when compared to the total number of CA halibut VPS-rendered positions. The VPS array at Cabrillo Pier was installed on 22 December 2013, and by that point in the Phase II study very few white croaker were being detected by any Harbor receiver. White croaker caught and release in the vicinity of Cabrillo Pier did stay with detection range of the initial three receivers (C1-3) for approximately 32 days, so had we been able to install the VPS array sooner we may have recorded more VPS-rendered positions of both species. In addition, we did lose some valuable data due to the loss of receivers C3 and C2 potentially to commercial seine fishing vessels fishing for baitfish. Two receivers and the detection data they contained were lost and not recovered, and others were dragged from mooring locations multiple times during the summer of 2014, resulting in the inability to trilaterate positions of tagged fish from the Cabrillo Pier VPS array during those times. White croaker were rarely detected during the times when receivers were removed so it is likely that we did not lose too many chances at rendering positions of white croaker during the summer of 2014.

Both white croaker and CA halibut had virtually no VPS-rendered positions underneath or within 5 m of the Cabrillo Pier, showing both species do not select for the habitat directly in contact with the pier. This is surprising since pier pilings offer vertical relief, which has been noted to increase fish diversity and richness in other marine ecosystem (Rilov and Benayahu 1998; Reubens et al. 2013). For example, oil platform pillars in southern California, which are similar to pier piling, have been documented to attract schools of pelagic fishes (Caselle et al. 2002; Martin and Lowe 2010). When the invertebrate community was removed from one of these oil platforms, the abundance of small invertivore fishes dropped significantly; however, the pelagic baitfish (e.g. *Sardinops sagax* and *Engraulis mordax*) remained (Martin et al. 2012). This indicates that these bait fishes could be drawn to the vertical profile of the structure regardless if the associated invertebrate community is absent or present. One study found that small pelagic bait fish selected the pier shade edge (the zone 0-5 m underneath the pier) or just beyond the pier in open water (Able et al. 2013). If baitfish are attracted to vertical relief and shade of Cabrillo Pier, then halibut may move closer to the pier to take advantage of pelagic schooling prey. The attraction of baitfish to pier is most likely what drew in the commercial bait seining boat that caught and removed our receivers. One possibility for not detecting either species underneath the pier is that the piling could be shadowing the acoustic signal transmitted by the transmitter, but we would still expect to see more detection within a couple meters of the pier if both species were truly selecting the habitat directly under the pier.

While it is well known that both white croaker and halibut are frequently caught off the Cabrillo pier, only 13.9% and 0.35% of the VPS-rendered positions for halibut and white croaker respectively, were within this casting range from the pier. This suggests that it would have been unlikely for a fisher from the pier to catch any of our fish. Of 26 California halibut tagged in the vicinity of Cabrillo Pier (all halibut were fitted with external ID tags), none were reported as captured by a fishers. It is unclear if the degree of fishing activity (e.g., amount of bait in the water) may attract white croaker and halibut from further distances from the pier, to the pier. Unfortunately, we had no way of knowing how much fishing was occurring on a daily basis on the public fishing pier to determine whether periods of greater fishing activity attracted tagged fish closer to the pier.

5.0 CONCLUSIONS

White croaker tagged and tracked within the Harbor use certain areas for periods ranging from several weeks to month, before moving to other locations in the Harbor or exiting the Harbor. While the movements exhibited by white croaker within the Harbor are variable, the general trend is that the habitat within the inner Harbor, particularly the Consolidated Slip, is utilized more intensely than other parts of the Harbor. Both white croaker and California halibut are using areas characterized as having high sediment TOC, which increases benthic infaunal prey abundance and attracts forage fish. California halibut show much higher residencies to certain areas (Cabrillo Pier, Fish Harbor, Consolidated Slip), particularly those with moderate to high TOC, ecotone, and relatively high tidal exchange. Since some of these areas of the Harbor are known to contain the highest sediment-bound concentrations of DDT and PCBs measured anywhere within the Harbor, it is likely a primary source of the contaminants found in the tissues of white croaker and halibut sampled within the Harbor. Additionally, the degree to which white croaker exploited the habitat within the Consolidated Slip varied greatly among individuals; ranging from never entering the area to being detected there every day for the battery life of the transmitters. This variable exploitation of the most contaminated habitat could likely account for some of the variability in tissue contaminant levels. It has been suggested that the Palos Verdes Shelf Superfund Site may also be a primary source of contaminants found in white croaker within the Harbor, and this cannot be ruled out based on the findings from this study and that by Lowe (2013). Given the findings of this study, any habitat remediation efforts intended to reduce contaminant levels in white croaker within the Harbor should address the Consolidated Slip and Fish Harbor as areas of primary concern based on the degree to which both white croaker and California halibut use these areas.

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7.0 FIGURES AND TABLES

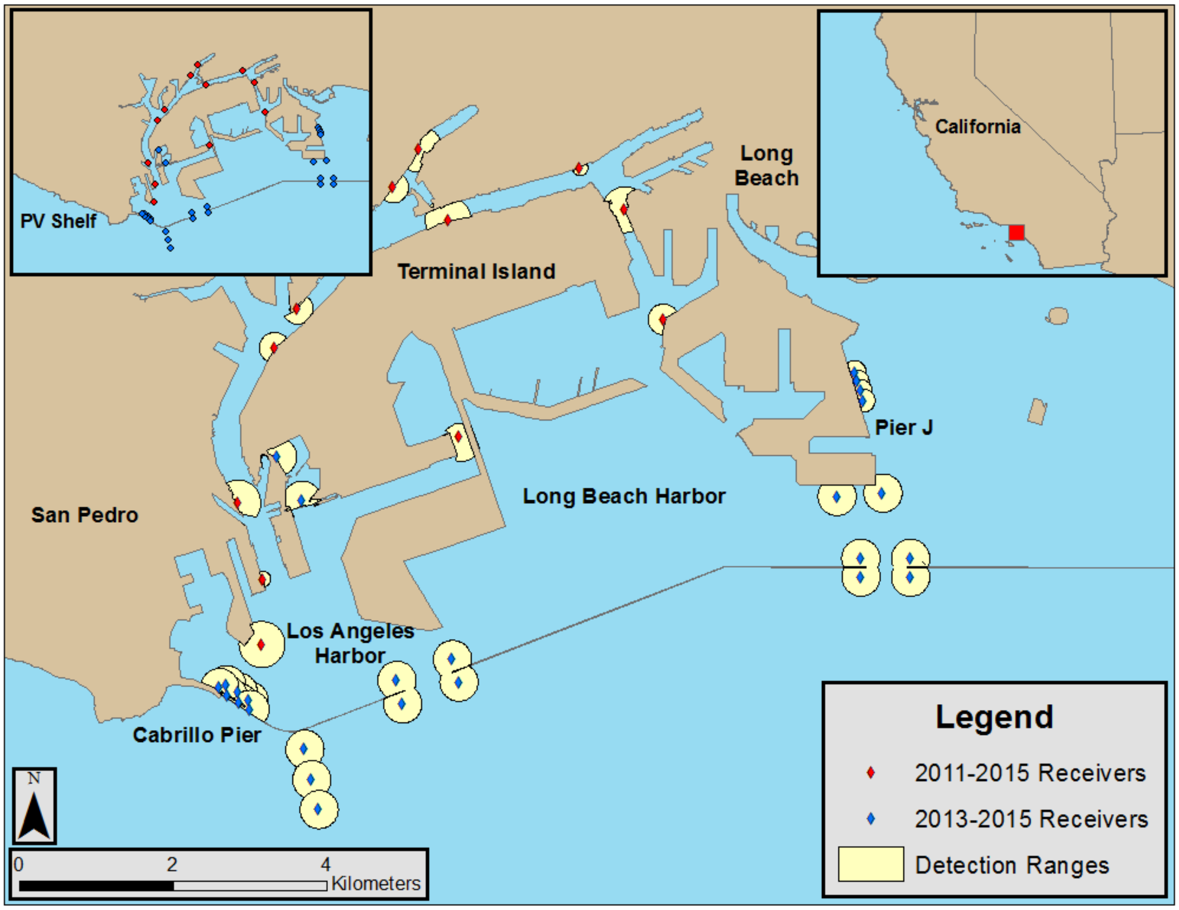


Figure 1. Map of locations of VR2W receivers within the Los Angeles and Long Beach Harbor for Phase I and Phase II studies, represented by red (Phase I) and blue dots (Phase II – additional receivers added). Buffer zones surrounding receiver locations represent the approximate detection range of that receiver as determined by on-site range testing. Inset in upper left shows the study area in reference to the PV Shelf and the inset in the upper right shows the location of the study site relative to the State of California.

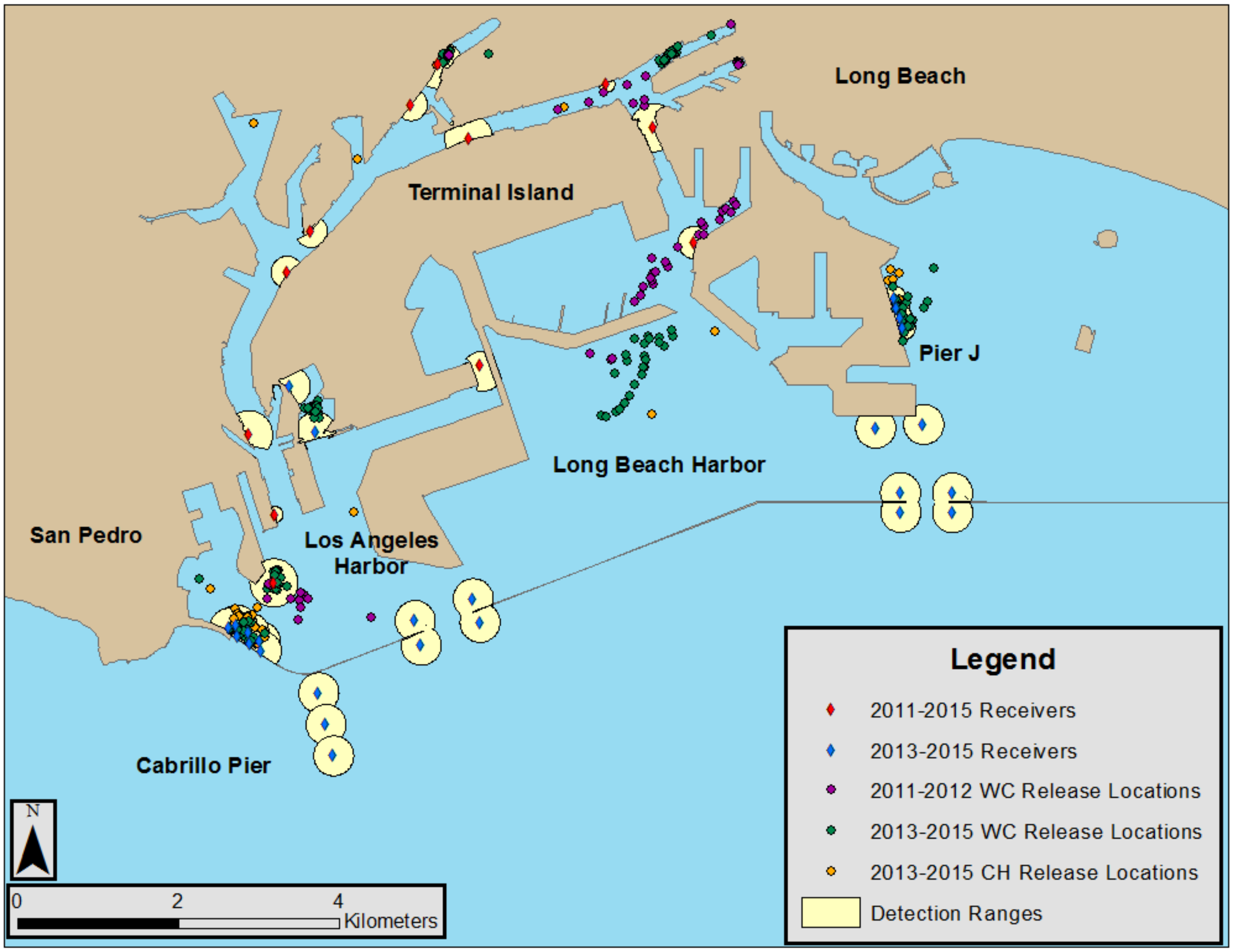


Figure 2. Map of capture and release locations of passively tracked white croaker and halibut. Red dots indicate release locations of white croaker tagged in Phase I and blue dots represented white croaker released in Phase II and green dots represent locations of release for halibut tagged in Phase II.

Table 1. The numbers of fish captures, tagged and released with coded acoustic transmitters by area and by Phase.

Region	**White Croaker (2011-2012)**	**White croaker (2013-2015)**	**CA halibut (2013-2015)**
Cabrillo Pier	0	29	26
LA Outer Harbor (Bait Barge)	25	29	2
LA Inner Harbor (Consolidated Slip)	24	26	4
Fish Harbor	0	30	0
LB Outer Harbor	25	25	2
LB Inner Harbor	25	25	2
Pier J	0	25	6
Palos Verdes Shelf	0	9	0

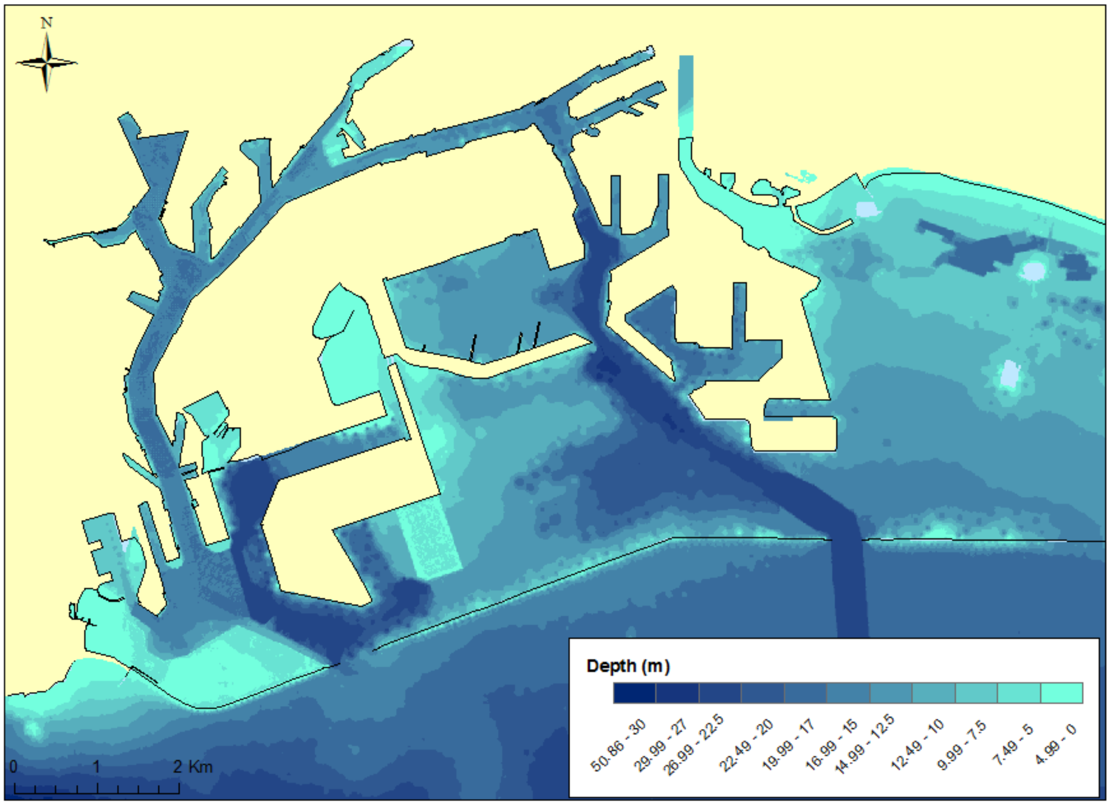


Figure 3. IDW interpolation map of bathymetry data from 2001 to 2009. Bathymetry data was provided by Anchor QEA, LLC.

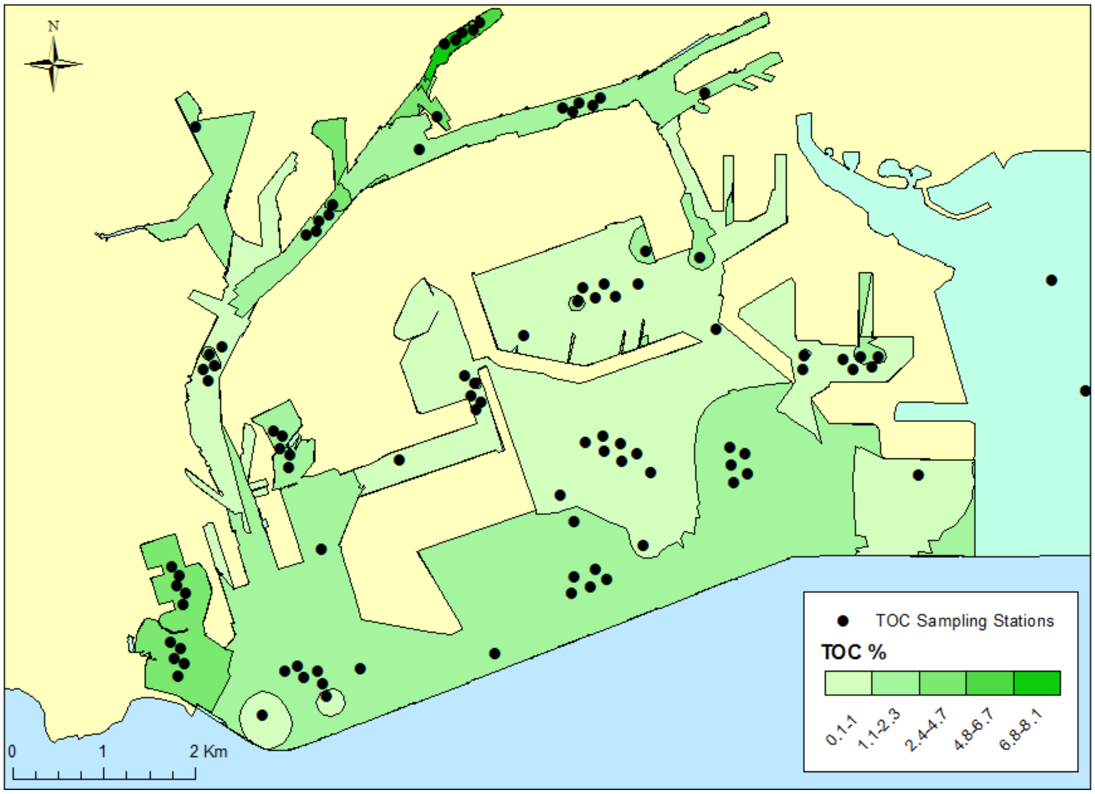


Figure 4. IDW interpolation map of sediment total organic carbon (%) from Bight 2008 and Weston 2011 sampling. Sampling locations are indicated by black points.

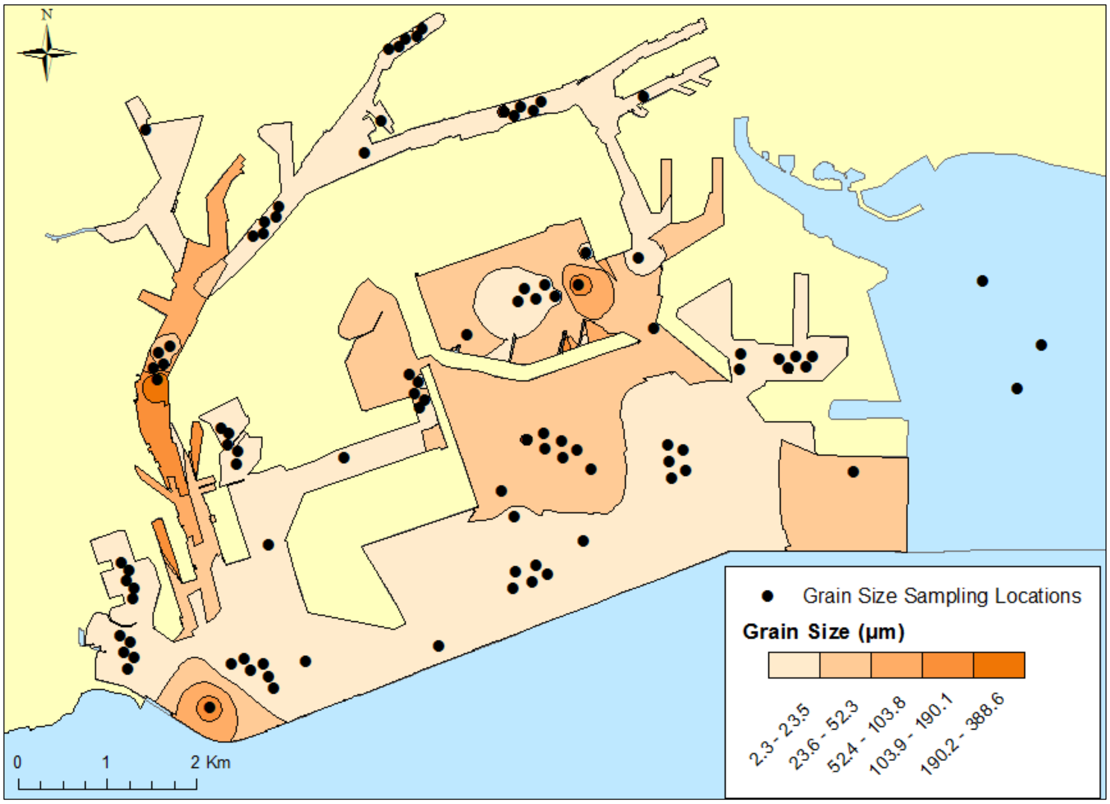


Figure 5. IDW interpolation map of grain size (µm) from Bight 2008 and Weston 2011 sampling. Sampling locations are indicated by the black points and are the same locations as the total organic carbon sampling locations.

Table 2. Total numbers of white croaker caught and hours fished at various areas within the Harbor and on the Palos Verdes Shelf in Phase II (2013-2015). CPUE is the number of fish caught per hook hr^{-1}.

Location	Hours Fished	# Croaker Caught	CPUE
PV Shelf	159.75	15	0.00765
LAOH (Bait Barge)	11	107	3.28791
Cabrillo Pier	40.5	54	0.22499
Fish Harbor	21.5	70	0.38241
LAIH (Consolidated Slip)	20.5	41	0.25316
LBIH (Piers A&B)	11.25	41	0.5037
LBOH	11.75	53	0.46559
Pier J	14.25	36	0.51126

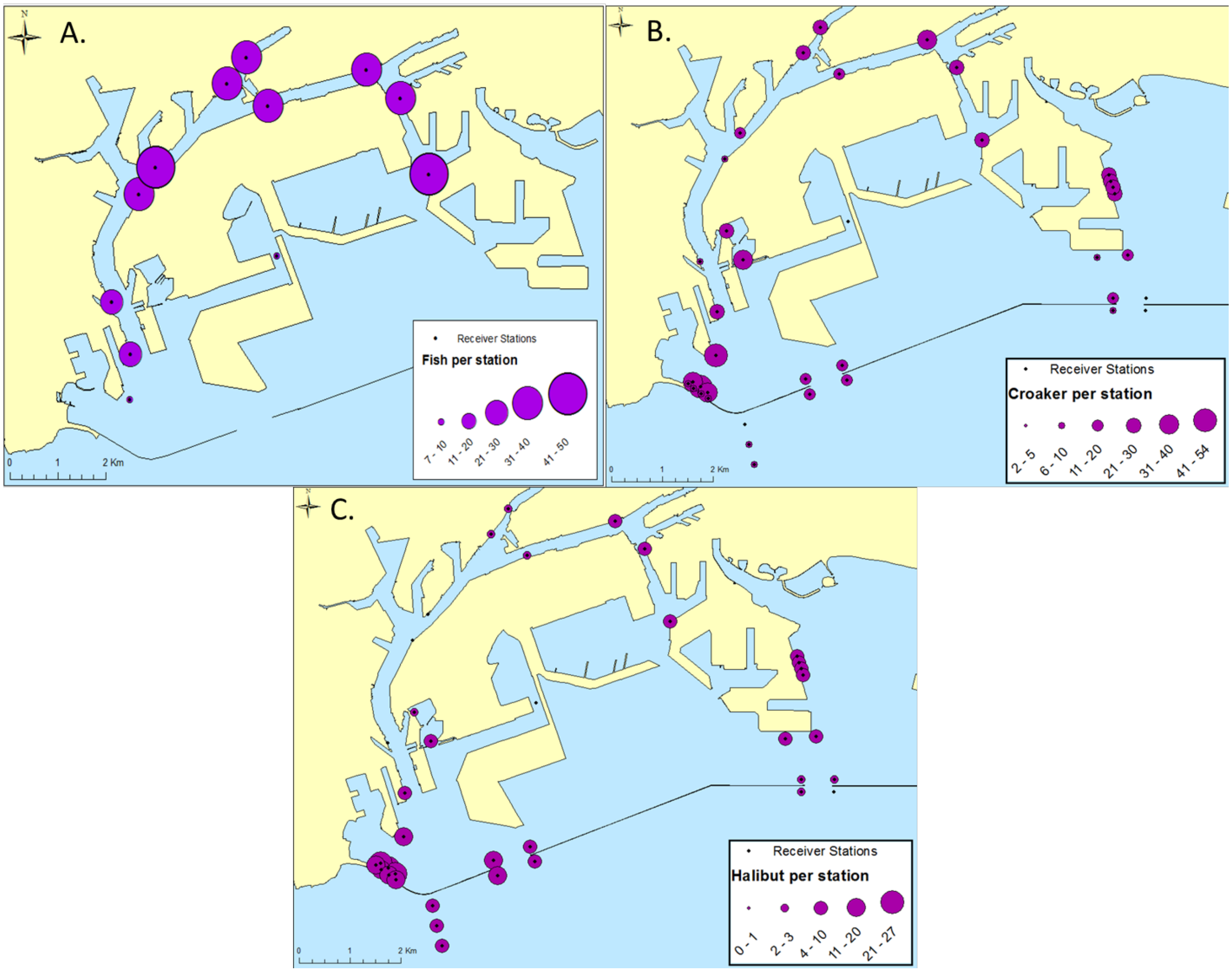


Figure 6. Bubble plot of the number of fish detected at each receiver over the course of the study. A. The number of individual white croaker detected at each receiver over the course of the Phase I study (2011-2012, n = 99), B., the number of white croaker detected at each receiver over the course of the Phase II study (2013-2015, n = 198), and C., the number of CA halibut detected at each receiver over the course of the Phase II study (2013-2015).

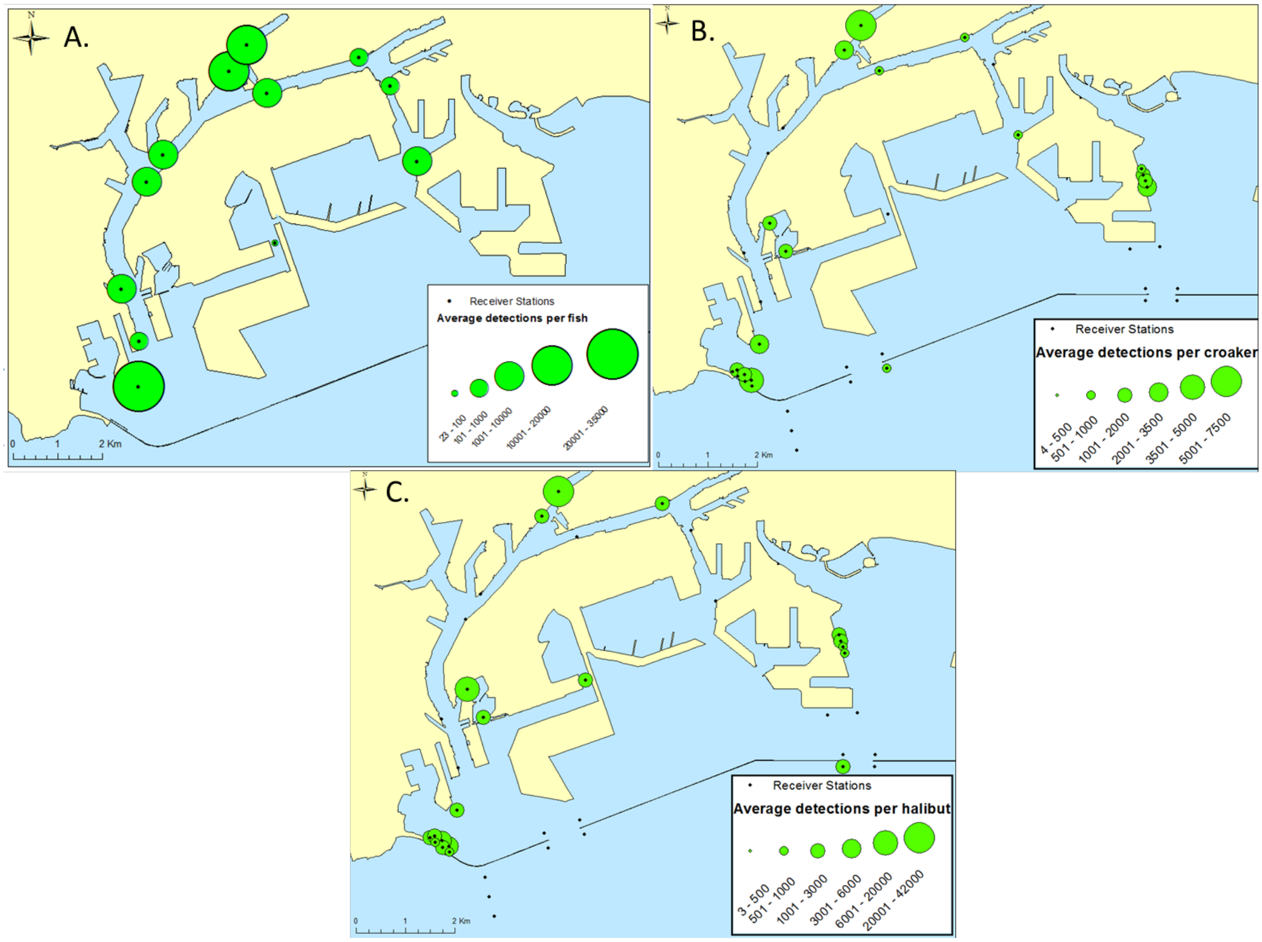


Figure 7. Bubble plot of the average number of detections per white croaker at each receiver over the course of the study. A. The average number of detections per white croaker at each receiver over the course of the Phase I study (2011-2012, n = 99), B., the average number of detections per white croaker at each receiver over the course of the Phase II study (2013-2015, n = 198), and C., the average number of detections per CA halibut at each receiver over the course of the Phase II study (2013-2015).

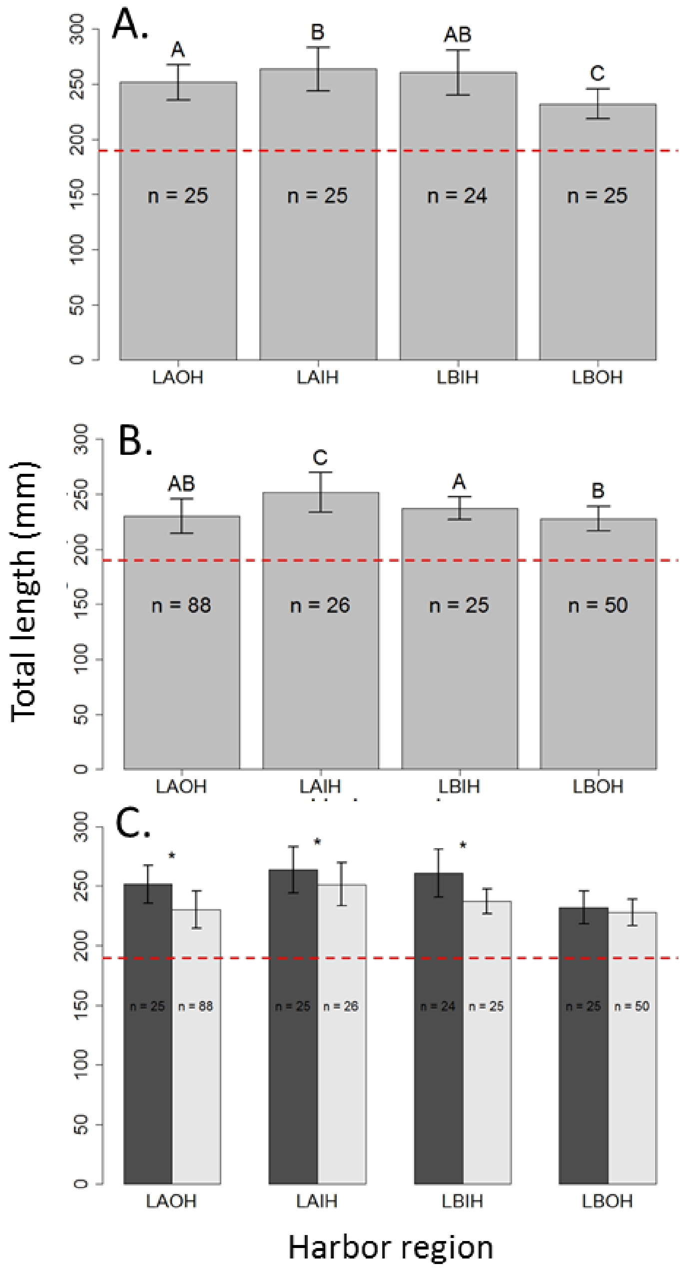


Figure 8. Comparison of the total length (mm) of white croaker captured among regions. A. Average length (± SD) of fish caught and tagged in 2011-2012 among the four Harbor regions ($F = 16.53$, $df = 3$, $p < 0.001$), B. average length of fish caught and tagged in 2013-2015 ($F = 18.31$, $df = 3$, $p < 0.001$), and C., a comparison of fish caught during both Phases I & II 2011-2012 (dark grey bars) and 2013-2015 (light grey bars). Fish tagged in 2011-2012 were significantly larger than fish tagged in 2013-2015 in all regions (t-test, $p < 0.05$) except the outer Long Beach Harbor. Dashed red line represents size (TL) at 100% maturity (190 mm) (Love *et al*, 1984). Letters over bars represent, which regions were different from each other. Asterisks indicate significant differences.

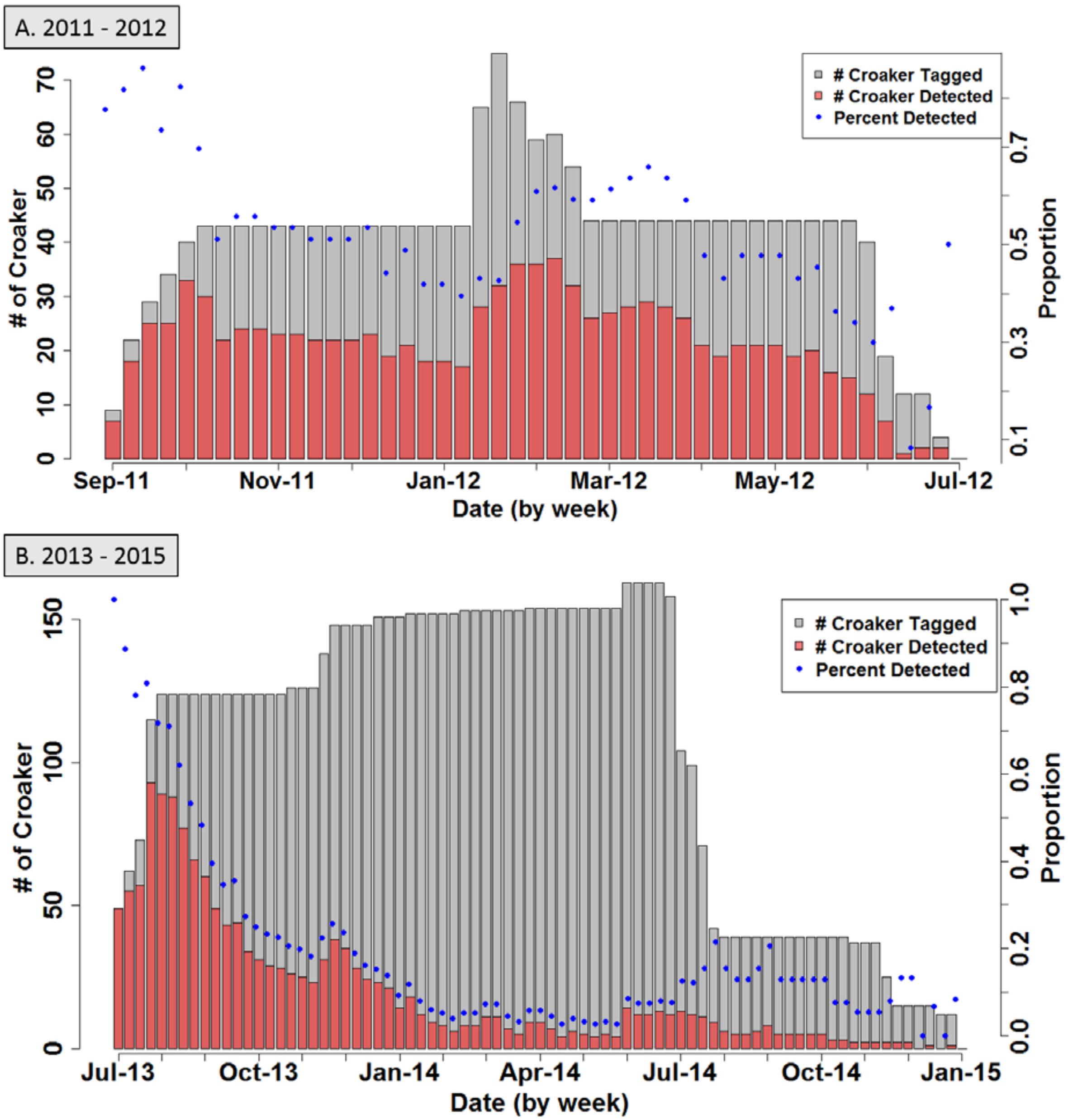


Figure 9. Weekly presence of white croaker throughout the entire receiver array for years (A) 2011-2012 and (B) 2013-2015. Number of white croaker detected per week are the red bars and total number of white croaker tagged and capable of being detected are the grey bars. Blue dots present the proportion of white croaker being detecting per week.

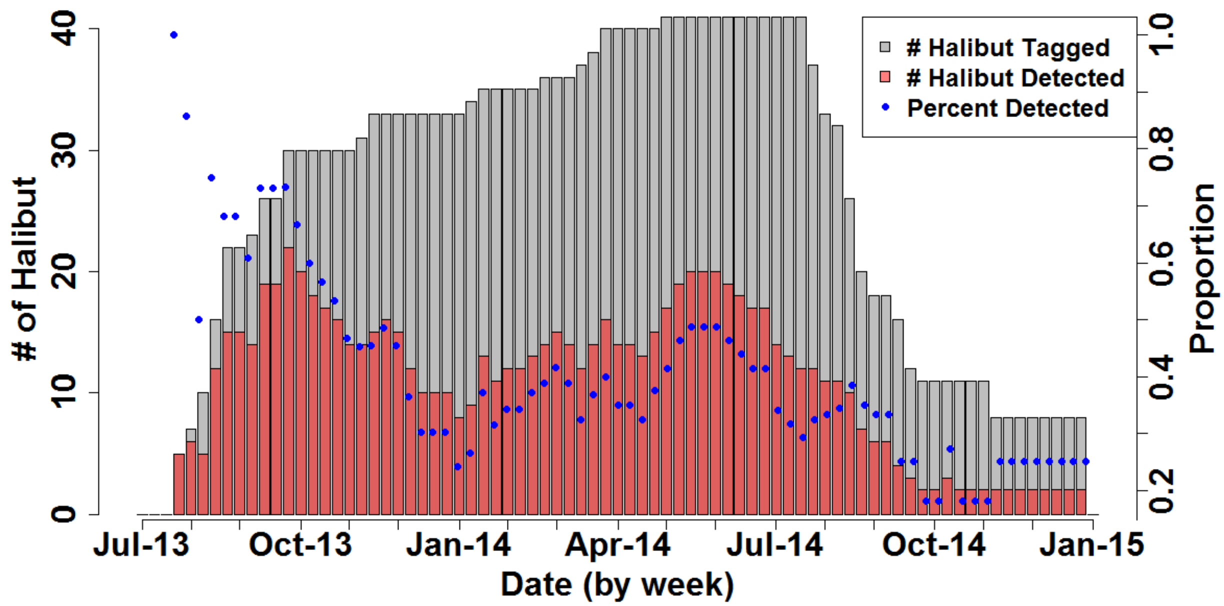


Figure 10. Weekly presence of CA halibut throughout the entire receiver array for years 2013-2015. Number of CA halibut detected per week are the red bars and total number of CA halibut able to be detected are the grey bars. Blue dots present the proportion of CA halibut being detecting per week.

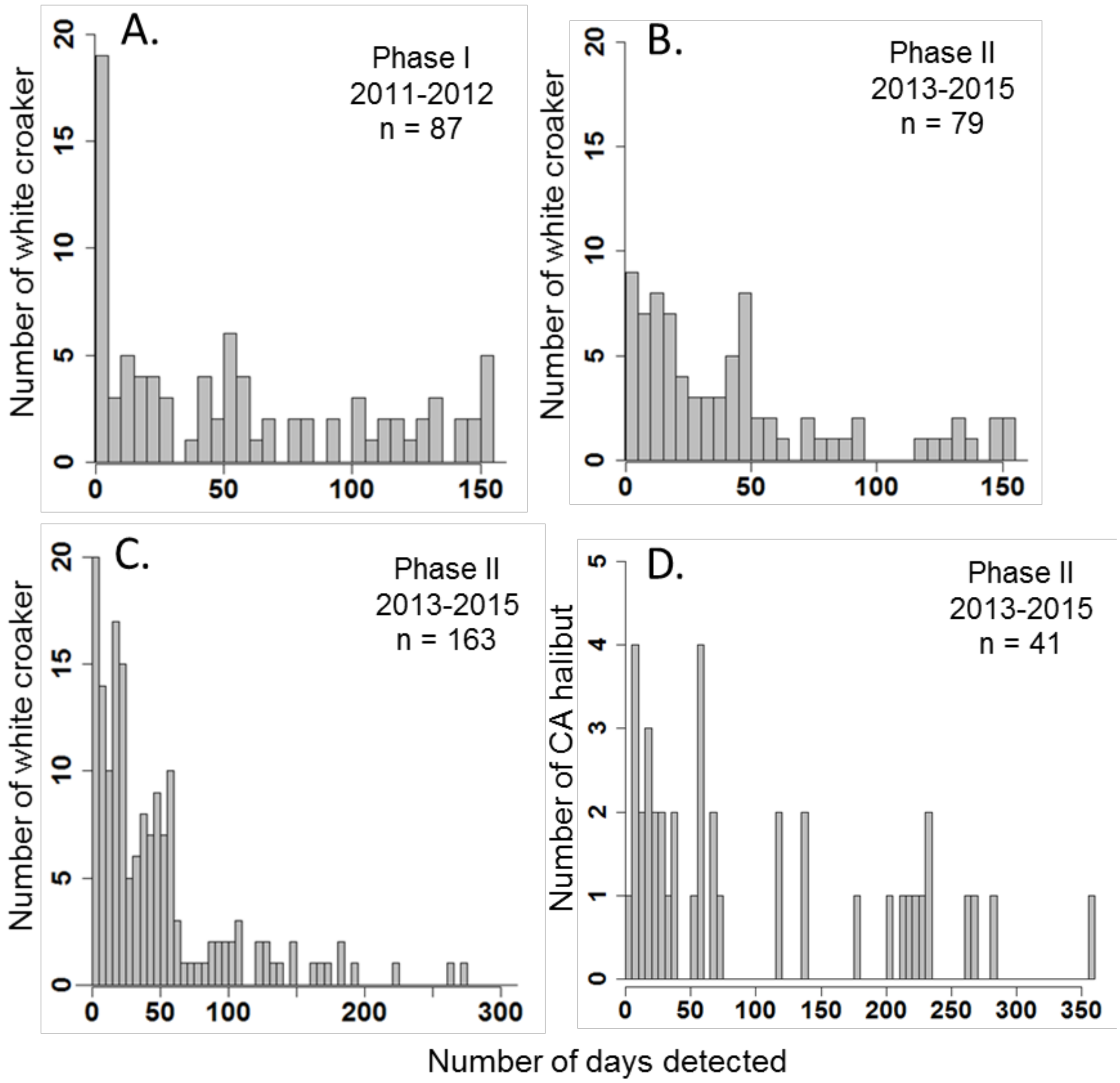


Figure 11. Site fidelity of the entire harbor for (A) white croaker from years 2011-2012 (n=87), (B) for white croaker from year 2013-2015 (n=73) but with the same array, tagging locations, and battery life of years 2011-2012, (C) for white croaker from years 2013-2015 for the entire array (n=163), and (D) California halibut years 2013-2015 (n=41).

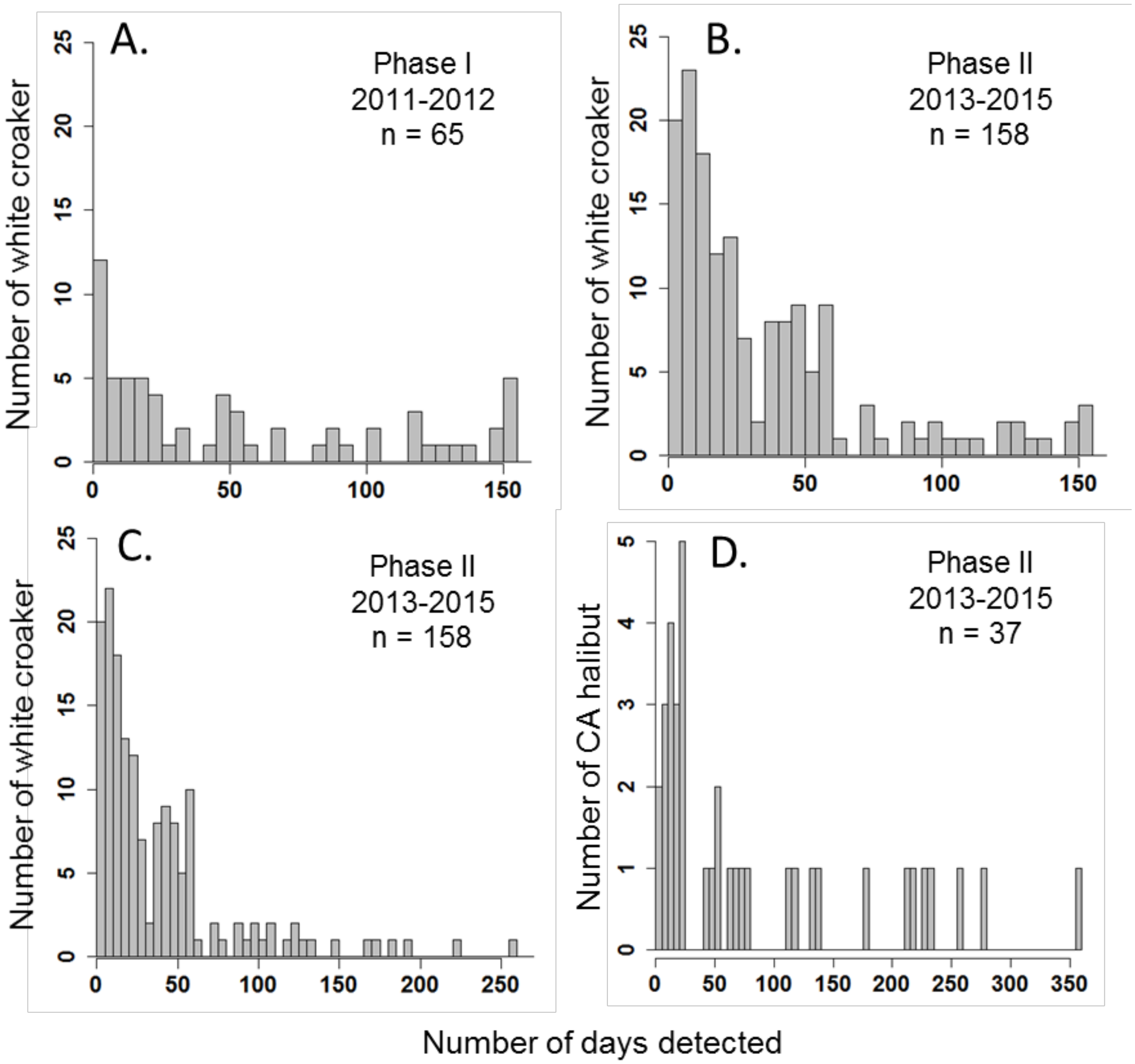


Figure 12. Site fidelity to initial capture location for (A) white croaker from years 2011-2012 (n=65), (B) for white croaker from year 2013-2015 (n=158) but with the same array, tagging locations, and battery life of years 2011-2012, (C) for white croaker from years 2013-2015 for the entire array (n=158), and (D) California halibut years 2013-2015 (n=37).

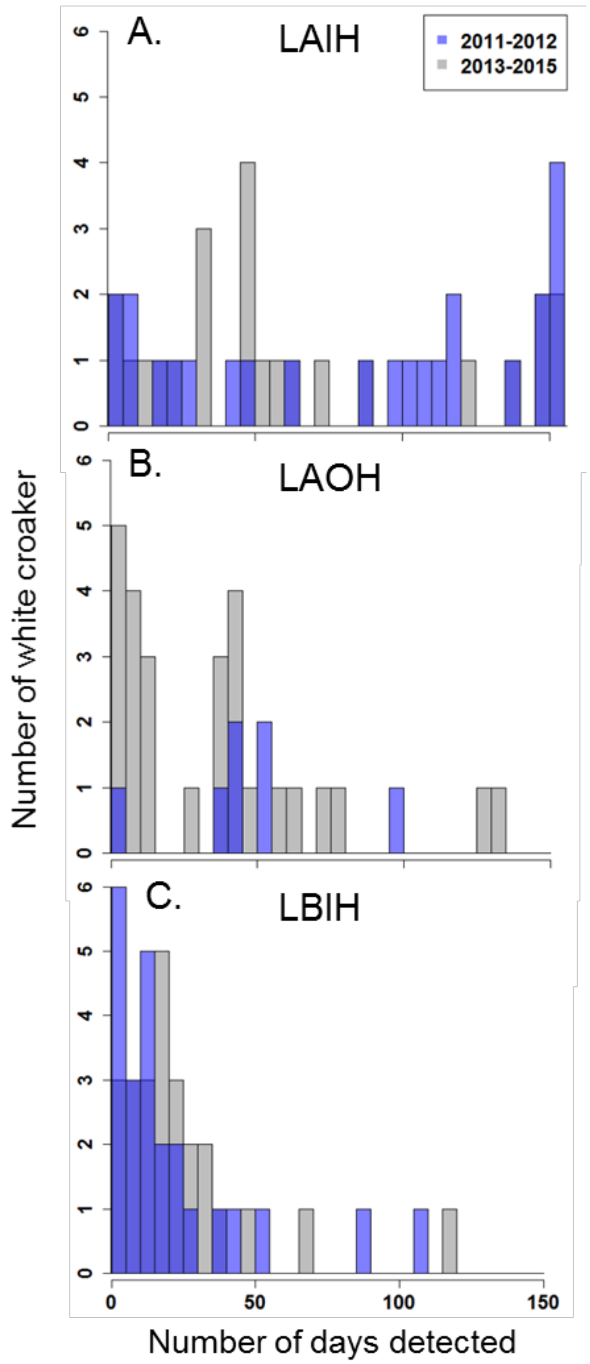


Figure 13. (A) Comparison of site fidelity measure in number of days white croaker were detected at LAIH between years 2011-2012 and 2013-2015. Both projects had an n = 24. p = 0.0701. (B) Comparison of site fidelity measure in number of days white croaker were detected at LAOH between years 2011-2012 and 2013-2015. Phase I had an n=7 and Phase II had an n= 29. p = 0.3621. (C) Comparison of site fidelity measured in number of days white croaker were detected at LBIH between years 2011-2012 and 2013-2015. Phase I had an n=24 and Phase II had an n= 25. p = 0.6008

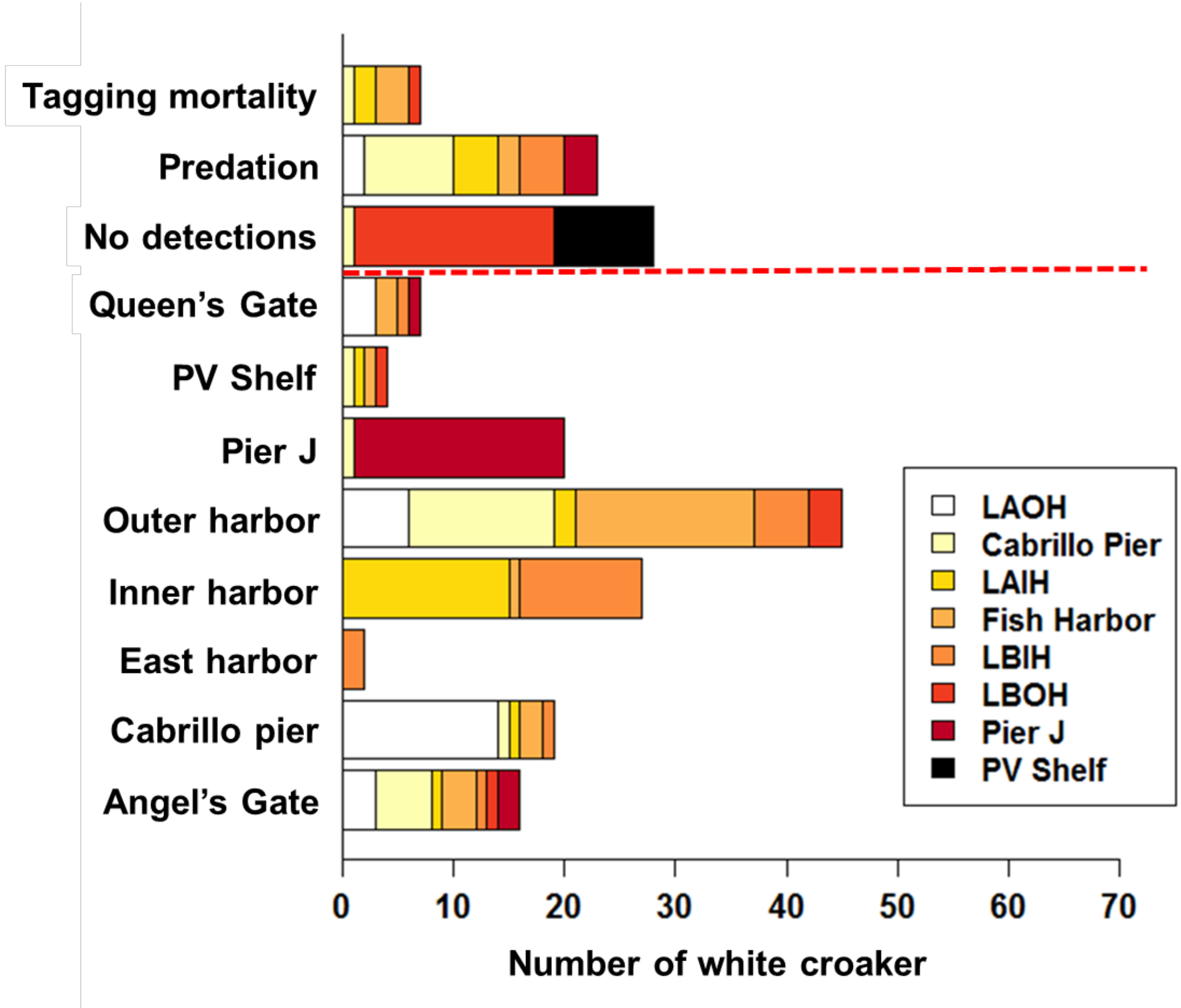


Figure 14. Estimated fate of white croaker from 2013-2015. Colors of the bar represent where the croaker was originally tagged. The top three bars are croaker that were killed or never detected. The remaining columns are where the surviving croaker were last detected.

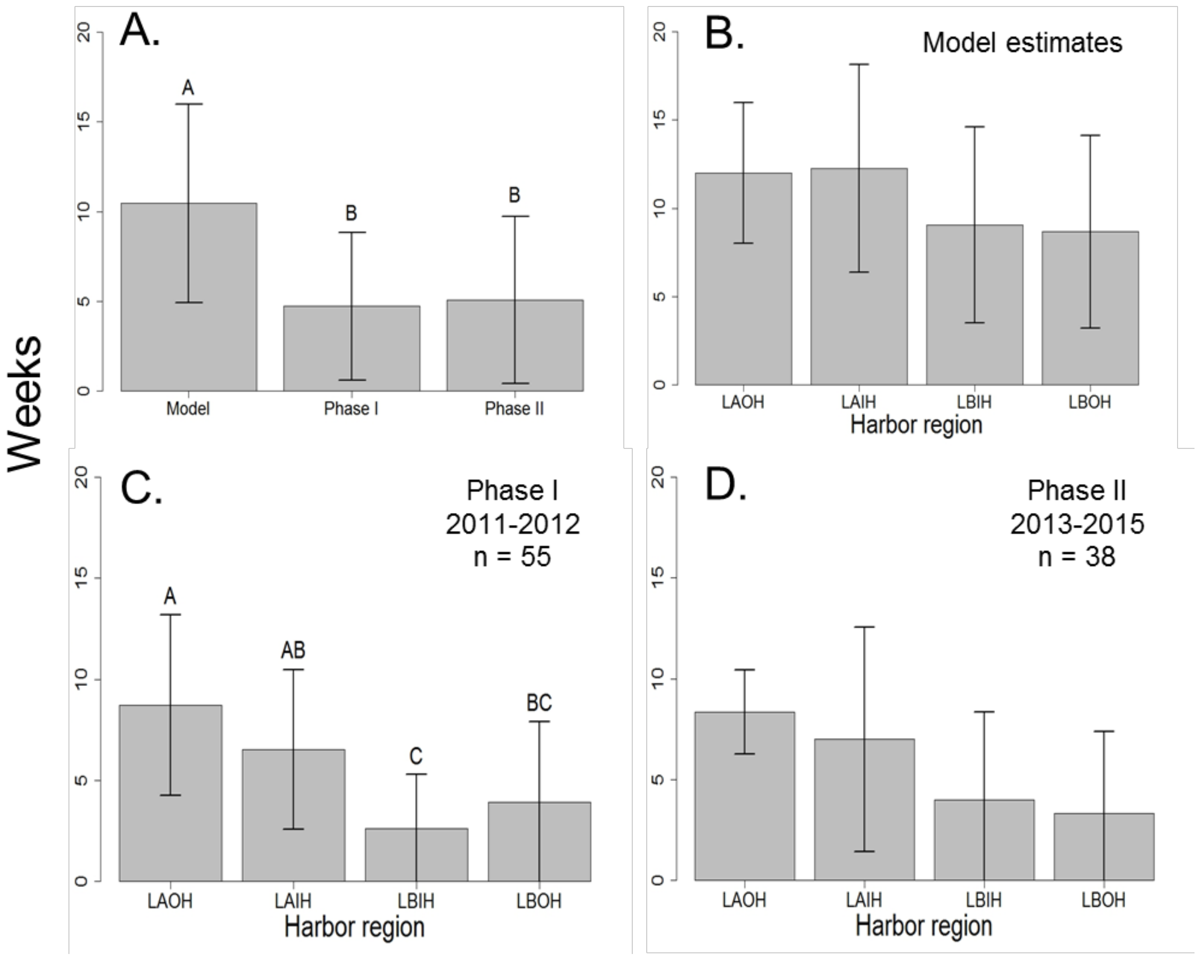


Figure 15. (A) The duration (weeks) predicted by the integrative dispersal movement model was significantly longer than what was observed during passive tracking in either 2011-2012 or 2013-2015 ($F_2 = 24.35$, $p < 0.001$). (B) There was no difference in the rate of dispersal movement among regions as predicted by the integrative movement model for fish tagged in each region ($F_3 = 2.161$, $p = 0.102$). (C) Time (weeks) for fish passively tracked in Phase I (2011-2012) in different regions to migrate to another region of the Harbor ($F_3 = 9.23$, $p < 0.001$). (D) Time (weeks) for fish passively tracked in Phase II (2013-2015) in different regions to migrate to another region of the Harbor ($F_3 = 1.11$, $p = 0.364$).

Table 3. Number of white croaker detected by region in Phase I (2011-2012). Columns indicate region where fish were originally tagged and release, rows indicate regions where fish were subsequently detected.

	LAOH	LAIH	LBIH	LBOH
LBOH	1	3	18	22
LBIH	2	19	24	11
LAOH	17	11	0	4
LAIH	8	24	8	3

Table 4. Number of white croaker detected by regions in Phase II (2013-2015). Columns indicate region where fish were originally tagged and release, rows indicate regions where fish were subsequently detected.

	PV Shelf	Cabrillo Pier	LAOH	Fish Harbor	LAIH	LBIH	LBOH	Pier J
LAOH	0	18	27	9	3	2	1	0
Fish Harbor	0	3	2	29	0	2	1	0
Angel's Gate	0	5	8	7	3	2	1	2
Cabrillo Pier	0	28	20	5	3	3	0	0
Queen's Gate	0	3	2	0	1	4	1	4
PV-Cabrillo Beach	0	1	3	3	3	1	2	0
LBOH	0	0	0	2	1	14	3	0
Pier J	0	0	0	1	0	2	0	25
LAIH	0	0	4	1	24	8	0	1
LBIH	0	0	0	1	9	25	2	0

Table 5. Number of individual CA Halibut detected in regions in Phase II (2013-2015). Columns indicate region where fish were originally tagged and release, rows indicate regions where fish were subsequently detected.

	Cabrillo Pier	LAOH	LAIH	LBIH	LBOH	Pier J
LAOH	18	1	1	0	1	0
Angel's Gate	15	1	1	0	1	2
PV-Cabrillo Beach	9	1	0	0	1	1
Cabrillo Pier	26	0	0	0	0	1
Fish Harbor	2	1	0	0	1	0
LAIH	0	0	3	0	0	0
Queen's Gate	0	0	1	1	0	2
LBIH	0	0	1	2	0	0
Pier J	0	0	0	0	0	6

LBOH	0	0	0	2	1	0

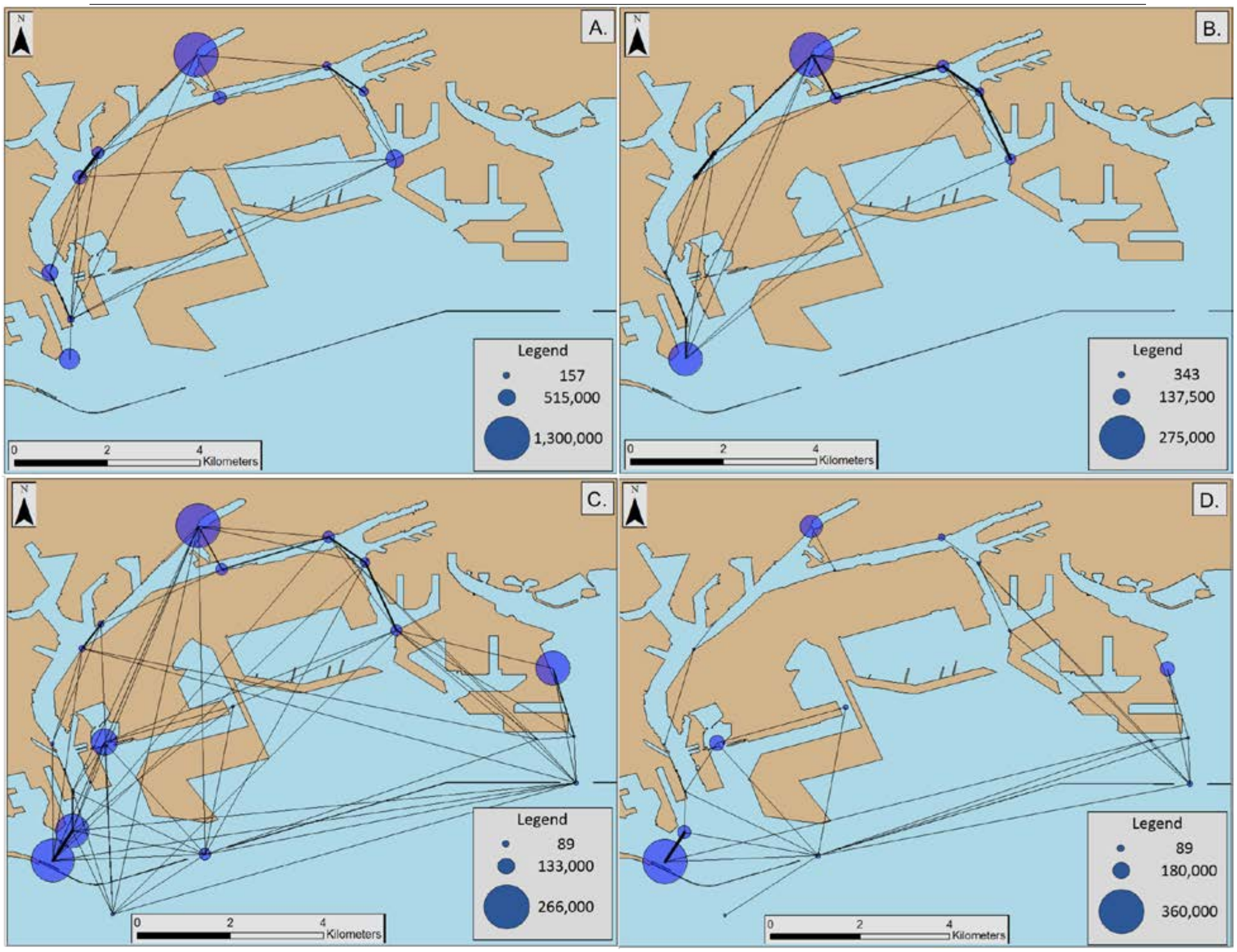


Figure 16. Network-based representation of movements within the Harbor of (A) 2011-2012 white croaker, (B) 2013-2015 white croaker with only receiver array of 2011-2012 (C) 2013-2015 white croaker with 2013-2015 receiver array, and (D) 2013-2015 CA halibut, Diameter of nodes (circles) represents number of transitions back to the same node. Thickness of edges represents number of transitions along that edge.

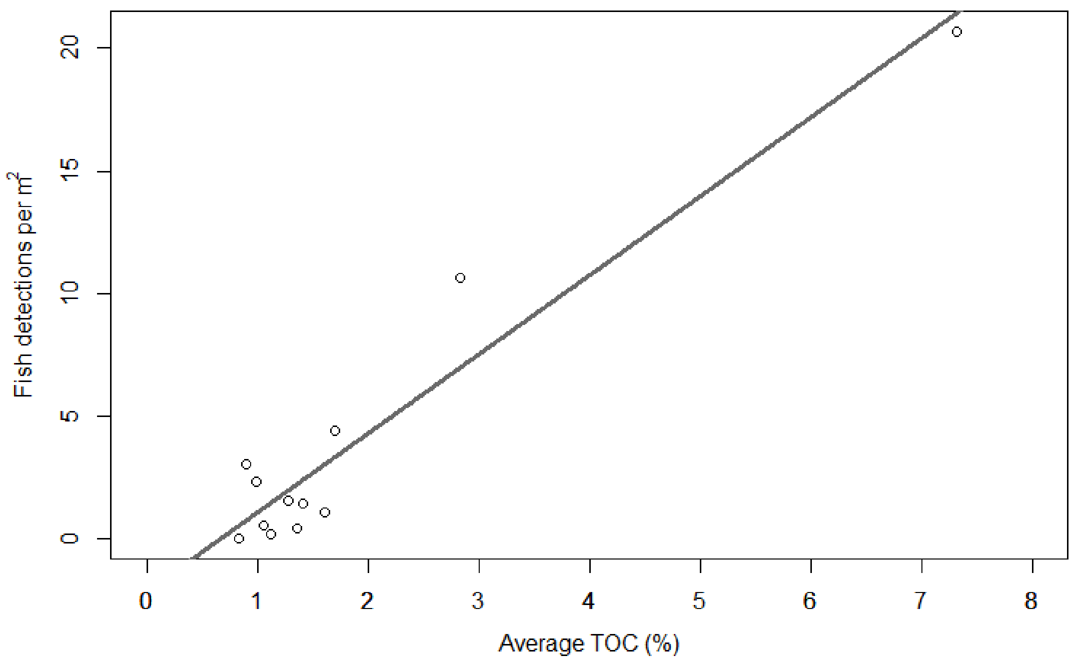


Figure 17. Positive correlation between number of fish detections per receiver/estimated receiver range area (detections per m^2) and average sediment total organic carbon (%) within the receiver range for each station ($t = 10.6$, $p = 9.216 \times 10^{-07}$, $r = 0.95$)

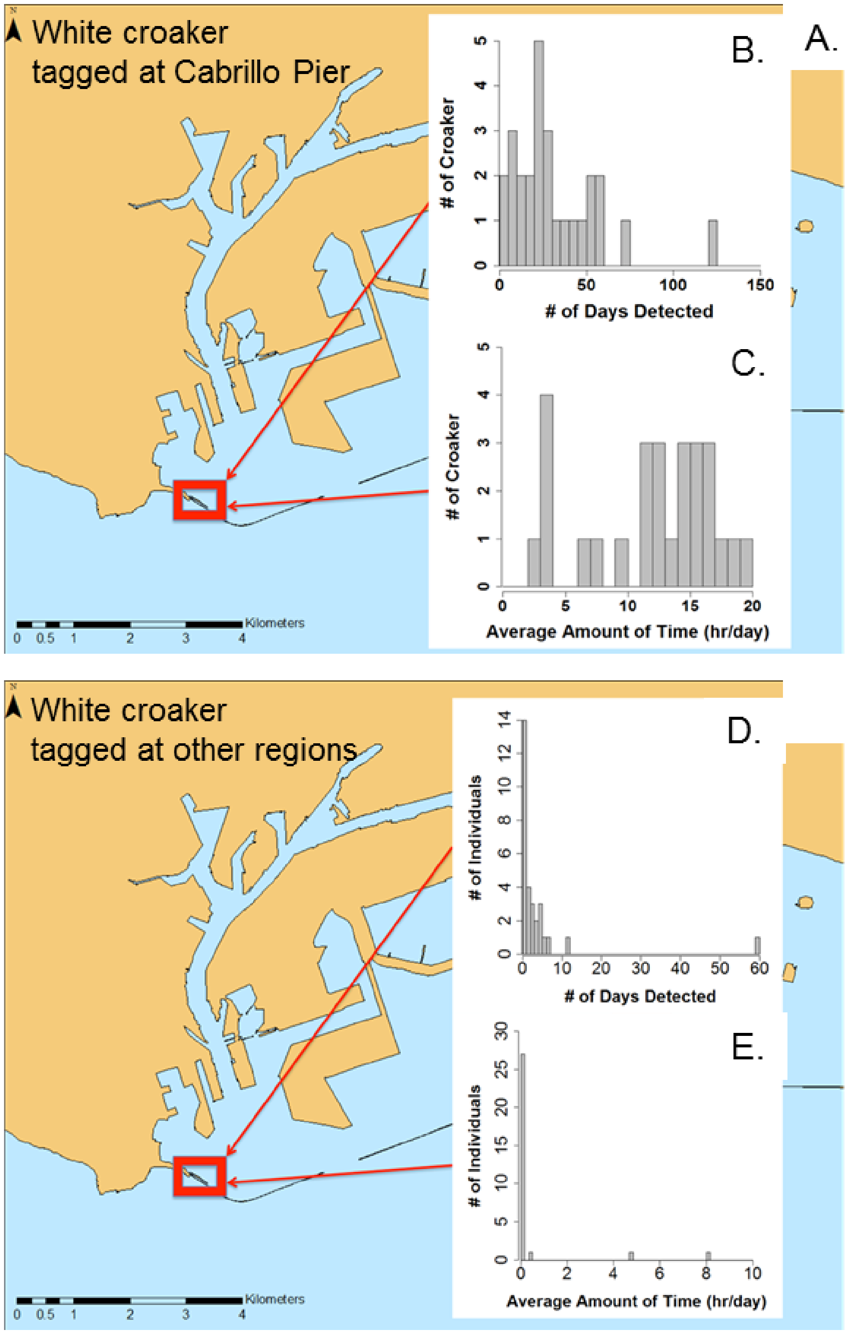


Figure 18. (A) Map of the Harbor with Cabrillo Pier outlined by red box. (B) The number of days individual white croaker tagged at Cabrillo Pier were detected within the Cabrillo Pier receiver array. (C) The mean amount of time (hr/d) white croaker tagged at Cabrillo spent at the pier when detected. (D) The number of days individual white croaker tagged at other regions within the Harbor were detected within the Cabrillo Pier receiver array. (C) The mean amount of time (hr/d) white croaker tagged at other regions within the Harbor spent at the pier when detected.

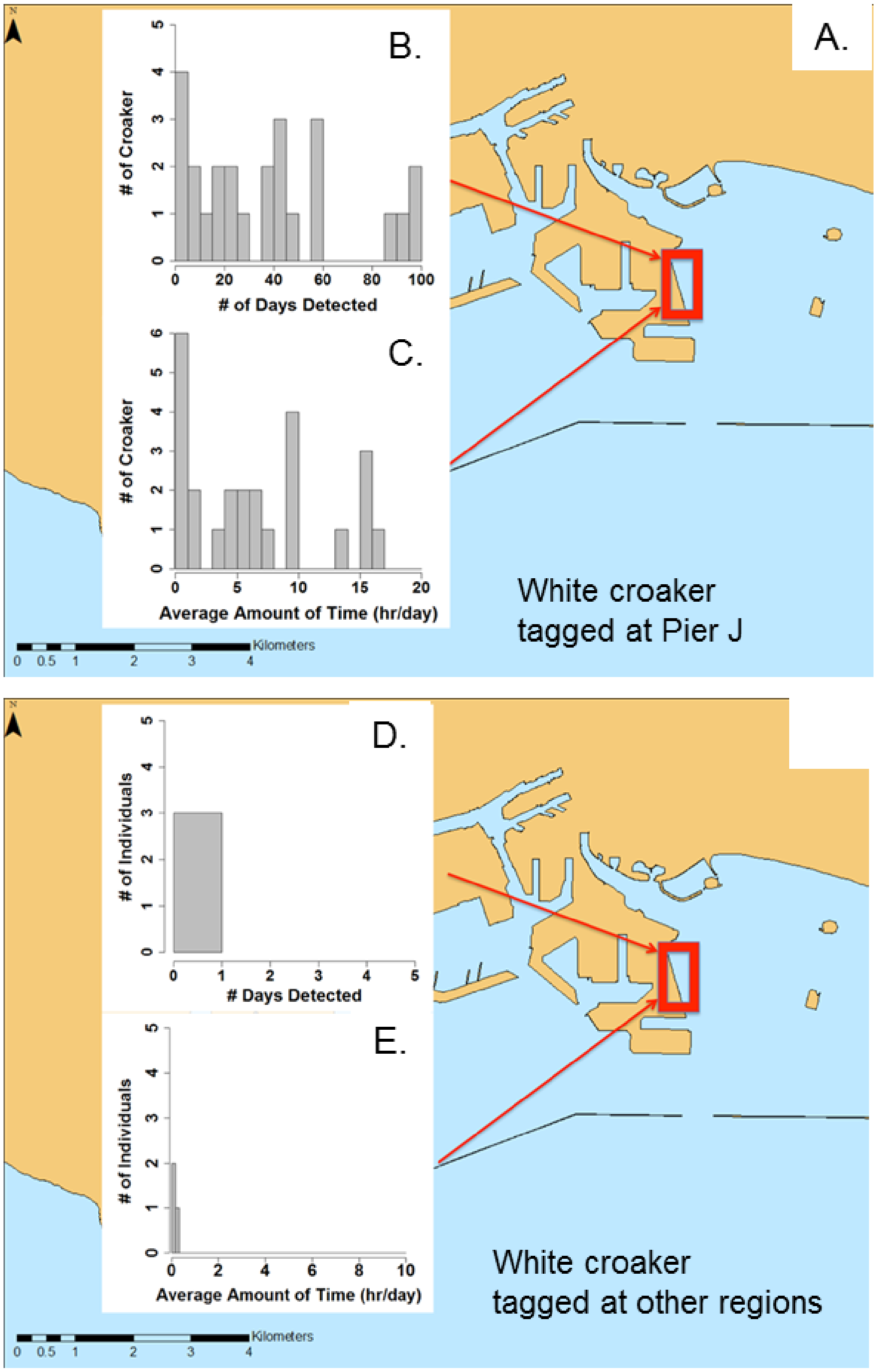


Figure 19. (A) Map of the Harbor with Pier J outlined by red box. (B) The number of days individual white croaker tagged at Pier J were detected within the Pier J receiver array. (C) The mean amount of time (hr/d) white croaker tagged at Pier J spent at the pier when detected. (D) The number of days individual white croaker tagged at other regions within the Harbor were detected within the Pier J receiver array. (C) The mean amount of time (hr/d) white croaker tagged at other regions within the Harbor spent at the pier when detected.

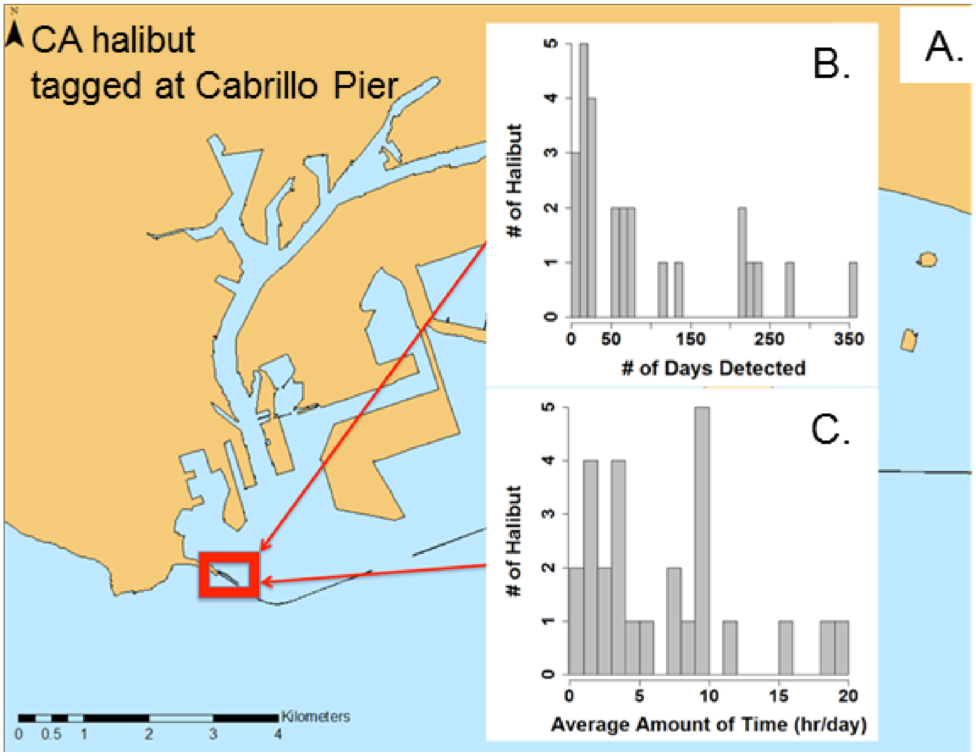


Figure 20. (A) Map of the Harbor with Cabrillo Pier outlined by red box. (B) The number of days individual California halibut tagged at Cabrillo Pier were detected within the Cabrillo Pier receiver array. (C) The mean amount of time (hr/d) California halibut tagged at Cabrillo spent at the pier when detected.

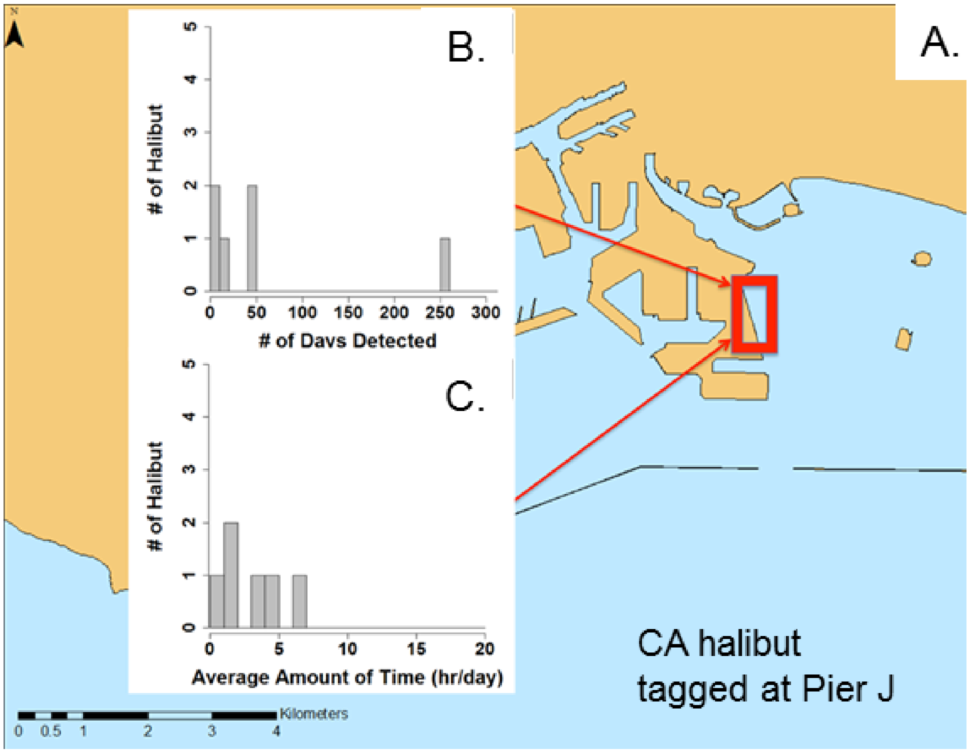


Figure 21. (A) Map of the Harbor with Pier J outlined by red box. (B) The number of days individual California halibut tagged at Pier J were detected within the Pier J receiver array. (C) The mean amount of time (hr/d) California halibut tagged at Pier J spent at the pier when detected.

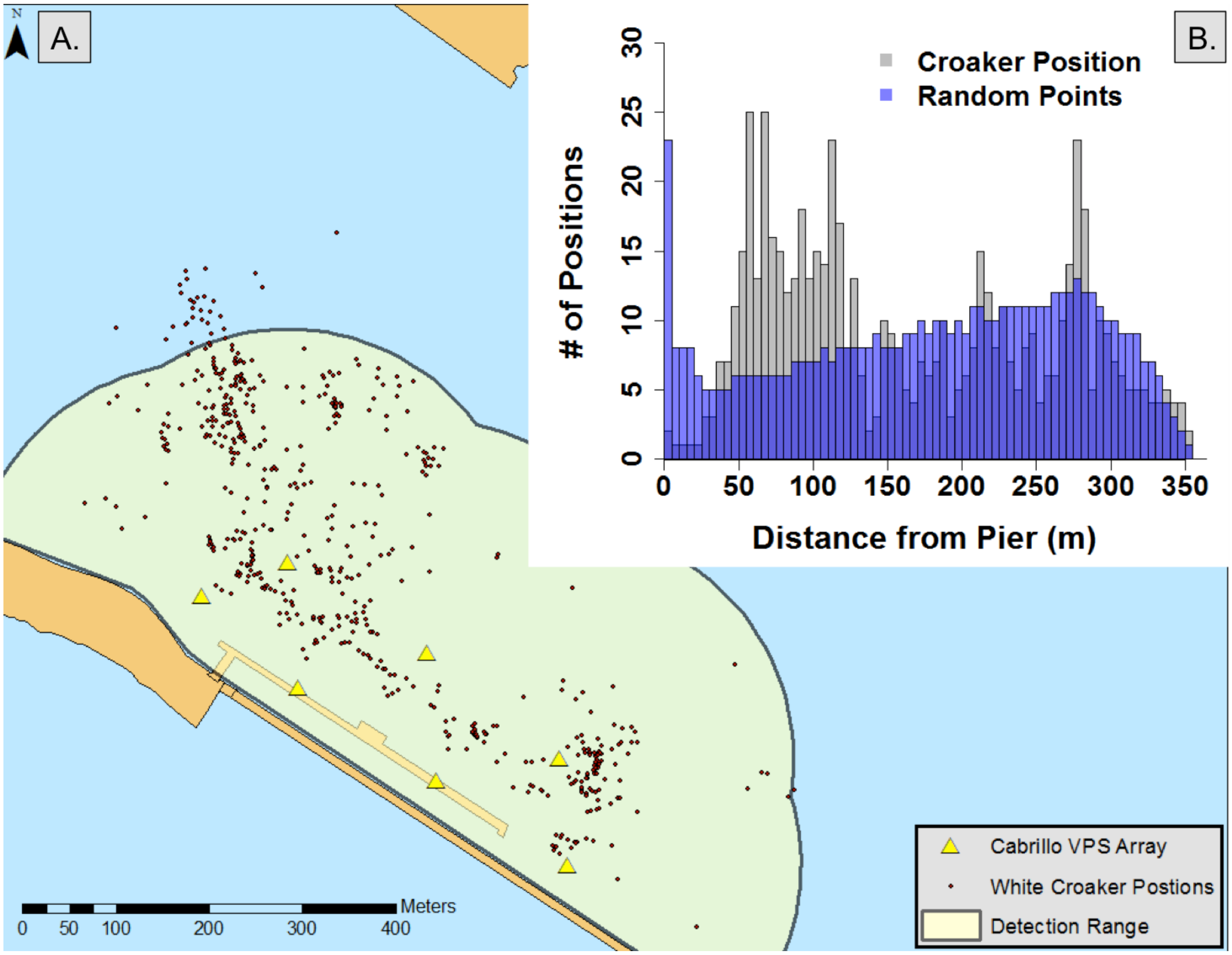


Figure 22. (A) Map of VPS-rendered positions of white croaker detected at Cabrillo Pier. (B) Frequency distribution of least distance (m) of white croaker VPS rendered positions and an equal sample size of randomized positions compared to Cabrillo Pier. Observed and randomized positions are significantly different (Pearson's chi-squared test, $X^2 = 429.085$, df = 71, $p < 0.001$).

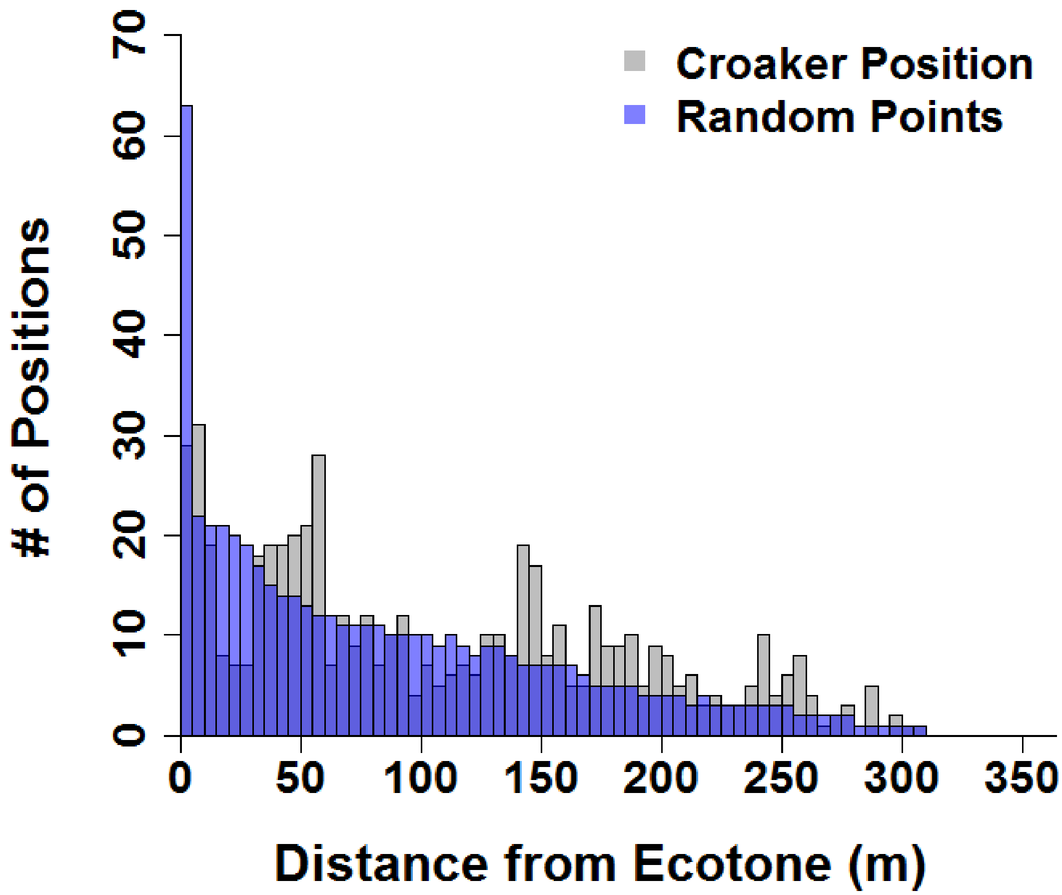


Figure 23. Frequency distribution of least distance (m) of white croaker VPS-rendered positions and an equal sample size of randomized positions compared to ecotone of Cabrillo Pier and neighboring reef. Observed and randomized positions are significantly different (Pearson's chi-squared test, X-squared = 189.3179, df = 64, p = 0.001).

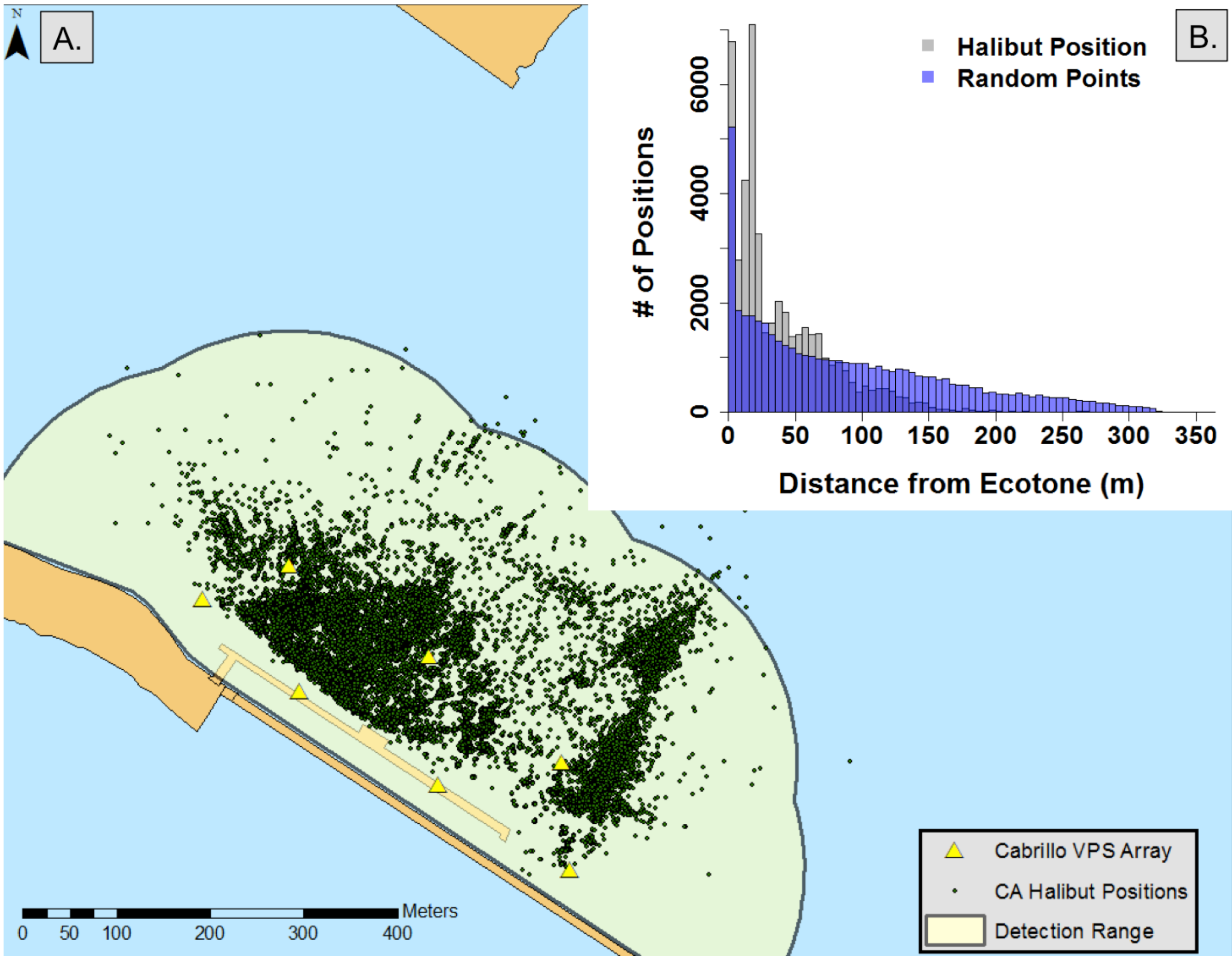


Figure 24. (A) Map of VPS-rendered positions of California halibut detected at Cabrillo Pier. (B) Frequency distribution of least distance (m) of California halibut VPS-rendered positions and an equal sample size of randomized positions compared to ecotone of Cabrillo Pier and neighboring reef. Observed and randomized positions are significantly different (Pearson's chi-squared test, X-squared = 35947.78, df = 64, p-value < 2.2e-16).

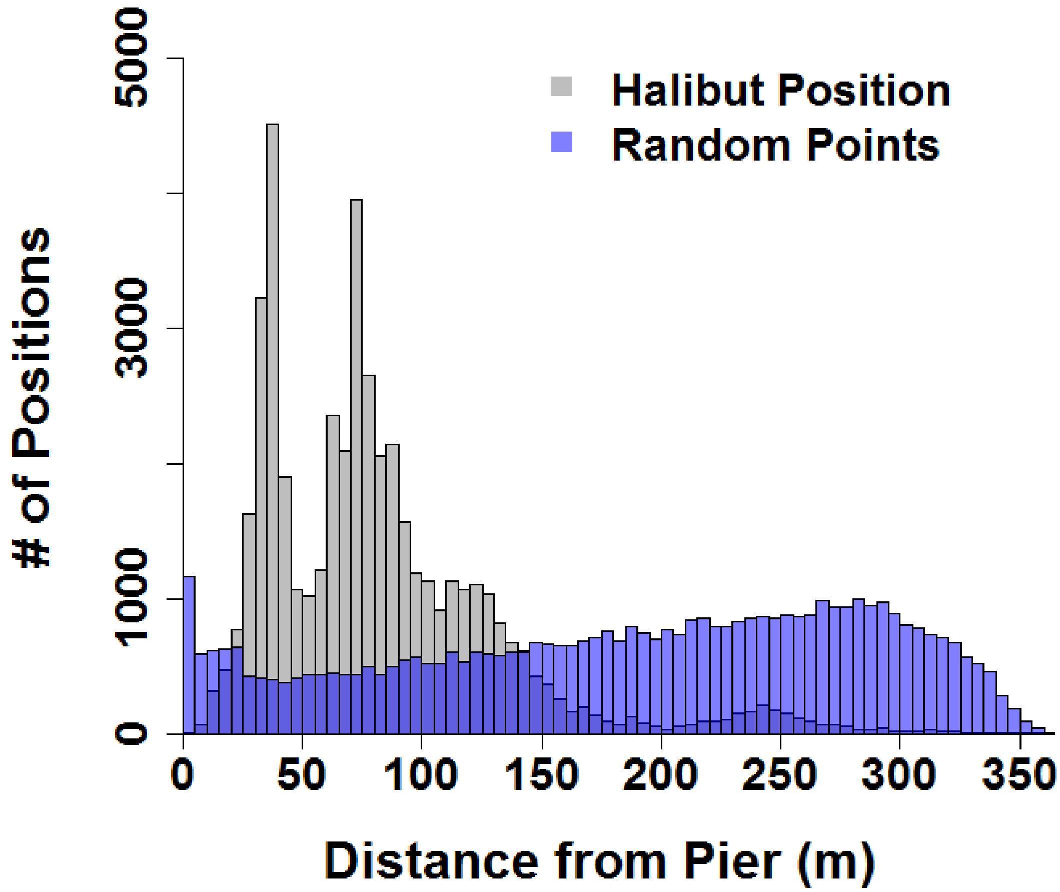
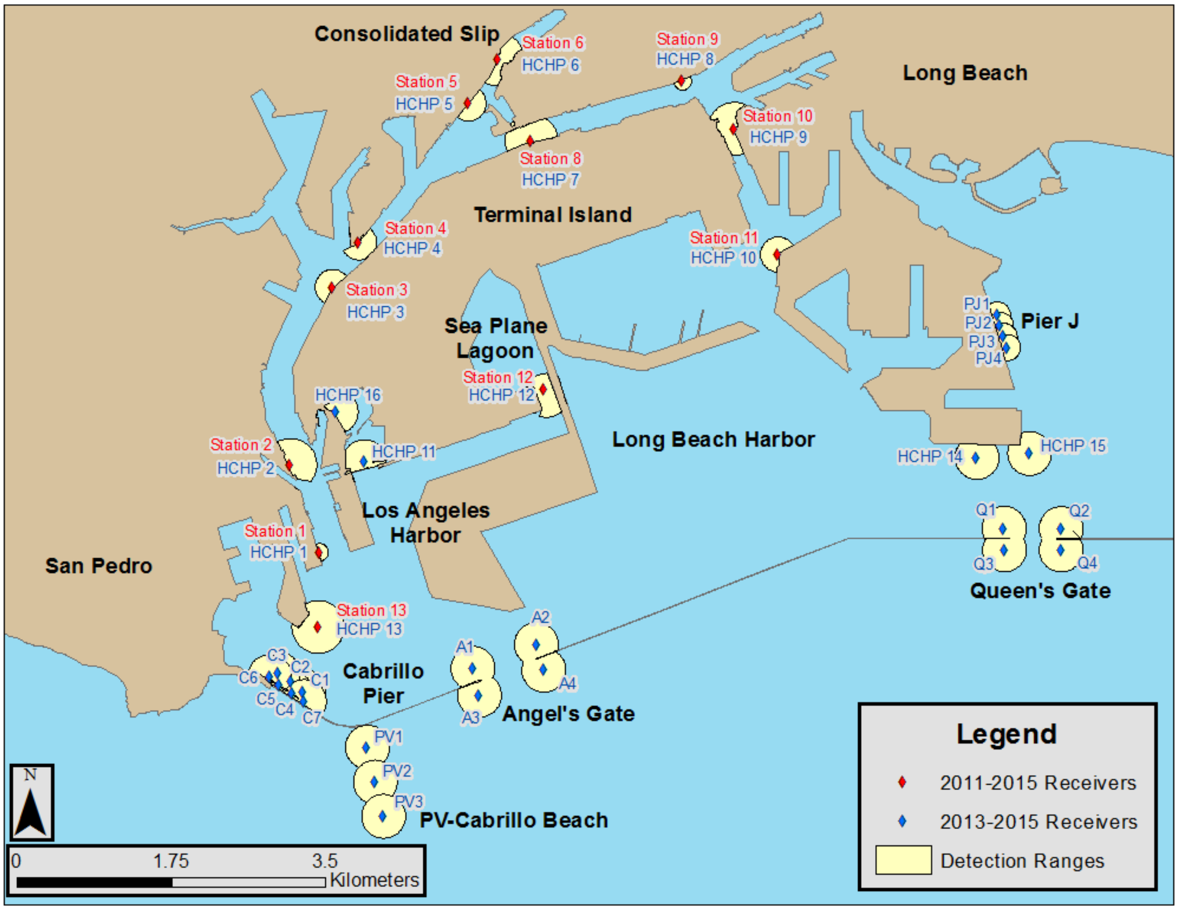


Figure 25. Frequency distribution of least distance (m) of California halibut VPS-rendered positions and an equal sample size of randomized positions compared to Cabrillo Pier. Observed and randomized positions are significantly different (Pearson's chi-squared test, $X^2 = 170146.1$, df = 71, $p < 0.001$).

APPENDIX



Appendix A. Map of all receivers from both Phase I and Phase II with their location names.

Appendix B. Names and locations of all acoustic receiver stations, dates deployed, study and Harbor region.

Phase I Stations	Phase II Stations	Latitude	Longitude	Receiver Deployment
Station 1	HCHP 1	33.72164	-118.27141	*8/16/2011
Station 2	HCHP 2	33.7306	-118.275	*8/13/2011
Station 3	HCHP 3	33.74885	-118.26988	*8/13/2011
Station 4	HCHP 4	33.75343	-118.26664	*8/13/2011
Station 5	HCHP 5	33.76772	-118.25323	*8/13/2011
Station 6	HCHP 6	33.77223	-118.24959	*8/16/2011
Station 8	HCHP 7	33.76393	-118.24548	*8/13/2011
Station 9	HCHP 8	33.77006	-118.2269	*8/12/2011
Station 10	HCHP 9	33.76519	-118.22054	*8/12/2011
Station 11	HCHP 10	33.7523	-118.21513	*8/12/2011
	HCHP 11	33.73094	-118.26595	8/7/2013
Station 12	HCHP 12	33.7378	-118.24357	*8/13/2011
Station 13	HCHP 13	33.71397	-118.27155	*1/28/2012
	HCHP 14	33.73152	-118.19062	6/22/2013
	HCHP 15	33.73193	-118.18416	6/22/2013
	HCHP 16	33.73604	-118.26941	11/21/2013
	A1	33.70978	-118.25252	6/22/2013
	A2	33.71225	-118.24471	6/22/2013
	A3	33.70701	-118.2517	6/22/2013
	A4	33.7096	-118.2438	6/22/2013
	C1	33.70735	-118.27332	6/20/2013
	C2	33.70836	-118.27487	6/20/2013
	C3	33.70922	-118.2765	6/20/2013
	C4	33.70712	-118.27475	12/22/2013
	C5	33.708	-118.27636	12/22/2013
	C6	33.70888	-118.27748	12/22/2013
	C7	33.70632	-118.27322	12/22/2013
	PJ1	33.74613	-118.18817	6/22/2013
	PJ2	33.74503	-118.18777	6/22/2013
	PJ3	33.74393	-118.18732	6/22/2013
	PJ4	33.7428	-118.18692	6/22/2013
	PV1	33.70165	-118.26546	6/20/2013
	PV2	33.69808	-118.26448	6/20/2013
	PV3	33.69457	-118.26344	6/20/2013
	Q1	33.72425	-118.18727	6/22/2013
	Q2	33.72425	-118.18026	6/22/2013
	Q3	33.72205	-118.18722	6/22/2013

	Q4	33.72204	-118.18026	6/22/2013

*represent receivers that were deployed 2011-2012 and 2013-2015

Appendix C. Summary data for all white croaker and CA halibut tagged for passive tracking in both Phase I & II

Species	ID#	Date Tagged	Phase	TL (mm)	Lat	Long	Region
White Croaker	41734	24-Aug-2011	One	252	33.71252	-118.26771	LAOH
White Croaker	41728	24-Aug-2011	One	255	33.71252	-118.26771	LAOH
White Croaker	41733	24-Aug-2011	One	257	33.71252	-118.26734	LAOH
White Croaker	41727	24-Aug-2011	One	259	33.71250	-118.26732	LAOH
White Croaker	41738	25-Aug-2011	One	246	33.71206	-118.26805	LAOH
White Croaker	41731	25-Aug-2011	One	238	33.71218	-118.26915	LAOH
White Croaker	41737	25-Aug-2011	One	251	33.71114	-118.26789	LAOH
White Croaker	41736	25-Aug-2011	One	240	33.71281	-118.26784	LAOH
White Croaker	41730	25-Aug-2011	One	258	33.71211	-118.26689	LAOH
White Croaker	41732	25-Aug-2011	One	276	33.70980	-118.26825	LAOH
White Croaker	41729	25-Aug-2011	One	238	33.71013	-118.25839	LAOH
White Croaker	41735	30-Aug-2011	One	246	33.71218	-118.27232	LAOH
White Croaker	41697	30-Aug-2011	One	270	33.77334	-118.24824	LAIH
White Croaker	41698	30-Aug-2011	One	267	33.77338	-118.24825	LAIH
White Croaker	41699	30-Aug-2011	One	245	33.77339	-118.24828	LAIH
White Croaker	41707	30-Aug-2011	One	280	33.77340	-118.24819	LAIH
White Croaker	41701	1-Sep-2011	One	253	33.77320	-118.24815	LAIH
White Croaker	41703	1-Sep-2011	One	269	33.77326	-118.24812	LAIH
White Croaker	41704	1-Sep-2011	One	245	33.77329	-118.24817	LAIH
White Croaker	41709	1-Sep-2011	One	259	33.77327	-118.24815	LAIH

White Croaker	41708	1-Sep-2011	One	235	33.77326	-118.24813	LAIH
White Croaker	41705	1-Sep-2011	One	315	33.77327	-118.24813	LAIH
White Croaker	41706	1-Sep-2011	One	239	33.77328	-118.24809	LAIH
White Croaker	41702	1-Sep-2011	One	247	33.77328	-118.24811	LAIH
White Croaker	41700	1-Sep-2011	One	258	33.77326	-118.24810	LAIH
White Croaker	41720	5-Sep-2011	One	275	33.77678	-118.21013	LBIH
White Croaker	41715	6-Sep-2011	One	228	33.76710	-118.23344	LBIH
White Croaker	41717	8-Sep-2011	One	249	33.76783	-118.22325	LBIH
White Croaker	41719	8-Sep-2011	One	241	33.76988	-118.22412	LBIH
White Croaker	41714	8-Sep-2011	One	235	33.76759	-118.22179	LBIH
White Croaker	41712	11-Sep-2011	One	279	33.77093	-118.22154	LBIH
White Croaker	41711	13-Sep-2011	One	249	33.76904	-118.22730	LBIH
White Croaker	41713	13-Sep-2011	One	224	33.76795	-118.22924	LBIH
White Croaker	41722	15-Sep-2011	One	310	33.76832	-118.22170	LBIH
White Croaker	41718	15-Sep-2011	One	263	33.77251	-118.20934	LBIH
White Croaker	41710	15-Sep-2011	One	240	33.77255	-118.20934	LBIH
White Croaker	41721	15-Sep-2011	One	269	33.77254	-118.20931	LBIH
White Croaker	41743	20-Sep-2011	One	234	33.74727	-118.22195	LBOH
White Croaker	41740	20-Sep-2011	One	237	33.74953	-118.21851	LBOH
White Croaker	41744	21-Sep-2011	One	208	33.74888	-118.22048	LBOH
White Croaker	41726	21-Sep-2011	One	245	33.75054	-118.22079	LBOH
White Croaker	41741	25-Sep-2011	One	229	33.74628	-118.22218	LBOH
White Croaker	41742	25-Sep-2011	One	214	33.74566	-118.22301	LBOH
White Croaker	41746	25-Sep-2011	One	229	33.74757	-118.22062	LBOH

White Croaker	41745	25-Sep-2011	One	240	33.74799	-118.22078	LBOH
White Croaker	41723	25-Sep-2011	One	250	33.74824	-118.22093	LBOH
White Croaker	41724	25-Sep-2011	One	229	33.74892	-118.22016	LBOH
White Croaker	41725	25-Sep-2011	One	225	33.75001	-118.21883	LBOH
White Croaker	41739	25-Sep-2011	One	228	33.75172	-118.21719	LBOH
White Croaker	2535	9-Jan-2012	One	240	33.71399	-118.27180	LAOH
White Croaker	2534	9-Jan-2012	One	260	33.71399	-118.27180	LAOH
White Croaker	2536	9-Jan-2012	One	248	33.71399	-118.27180	LAOH
White Croaker	2538	9-Jan-2012	One	294	33.71399	-118.27180	LAOH
White Croaker	2537	10-Jan-2012	One	241	33.71372	-118.27208	LAOH
White Croaker	2542	10-Jan-2012	One	243	33.71372	-118.27208	LAOH
White Croaker	2543	10-Jan-2012	One	260	33.71372	-118.27208	LAOH
White Croaker	2541	10-Jan-2012	One	265	33.71372	-118.27208	LAOH
White Croaker	2544	10-Jan-2012	One	262	33.71372	-118.27208	LAOH
White Croaker	2539	10-Jan-2012	One	221	33.71372	-118.27208	LAOH
White Croaker	2540	10-Jan-2012	One	239	33.71372	-118.27208	LAOH
White Croaker	2545	10-Jan-2012	One	276	33.71372	-118.27208	LAOH
White Croaker	2546	12-Jan-2012	One	228	33.71376	-118.27221	LAOH
White Croaker	2547	12-Jan-2012	One	259	33.77336	-118.24815	LAIH
White Croaker	2548	12-Jan-2012	One	251	33.77336	-118.24815	LAIH
White Croaker	2549	12-Jan-2012	One	285	33.77311	-118.24821	LAIH
White Croaker	2550	12-Jan-2012	One	294	33.77315	-118.24816	LAIH
White Croaker	2551	12-Jan-2012	One	251	33.77319	-118.24821	LAIH
White Croaker	2552	12-Jan-2012	One	267	33.77314	-118.24826	LAIH

White Croaker	2553	12-Jan-2012	One	269	33.77316	-118.24821	LAIH
White Croaker	2554	13-Jan-2012	One	242	33.77328	-118.24807	LAIH
White Croaker	2555	13-Jan-2012	One	270	33.77328	-118.24812	LAIH
White Croaker	2556	13-Jan-2012	One	251	33.77335	-118.24815	LAIH
White Croaker	2557	14-Jan-2012	One	275	33.77316	-118.24816	LAIH
White Croaker	2558	14-Jan-2012	One	295	33.77317	-118.24815	LAIH
White Croaker	2559	14-Jan-2012	One	271	33.77234	-118.20905	LBIH
White Croaker	2565	14-Jan-2012	One	261	33.77234	-118.20905	LBIH
White Croaker	2560	16-Jan-2012	One	270	33.77234	-118.20899	LBIH
White Croaker	2561	16-Jan-2012	One	274	33.77241	-118.20902	LBIH
White Croaker	2562	16-Jan-2012	One	269	33.77241	-118.20894	LBIH
White Croaker	2563	17-Jan-2012	One	265	33.77228	-118.20903	LBIH
White Croaker	2564	17-Jan-2012	One	261	33.77233	-118.20904	LBIH
White Croaker	2566	17-Jan-2012	One	299	33.77237	-118.20905	LBIH
White Croaker	2567	17-Jan-2012	One	262	33.77235	-118.20900	LBIH
White Croaker	2568	17-Jan-2012	One	250	33.77240	-118.20892	LBIH
White Croaker	2578	18-Jan-2012	One	254	33.77221	-118.20911	LBIH
White Croaker	2574	18-Jan-2012	One	259	33.77224	-118.20907	LBIH
White Croaker	2575	30-Jan-2012	One	227	33.75406	-118.21368	LBOH
White Croaker	2572	30-Jan-2012	One	243	33.73982	-118.22906	LBOH
White Croaker	2577	3-Feb-2012	One	216	33.73913	-118.22614	LBOH
White Croaker	2576	3-Feb-2012	One	234	33.73922	-118.22598	LBOH
White Croaker	2582	5-Feb-2012	One	228	33.75447	-118.21414	LBOH
White Croaker	2579	5-Feb-2012	One	251	33.75577	-118.21127	LBOH

White Croaker	2571	5-Feb-2012	One	259	33.75688	-118.20979	LBOH
White Croaker	2580	6-Feb-2012	One	240	33.75319	-118.21444	LBOH
White Croaker	2573	6-Feb-2012	One	223	33.75317	-118.21377	LBOH
White Croaker	2581	6-Feb-2012	One	238	33.75478	-118.21152	LBOH
White Croaker	2583	10-Feb-2012	One	201	33.75606	-118.21077	LBOH
White Croaker	2570	10-Feb-2012	One	245	33.75647	-118.20937	LBOH
White Croaker	2569	10-Feb-2012	One	230	33.75558	-118.21014	LBOH
White Croaker	11246	1-Jul-2013	Two	220	33.71318	-118.27104	LAOH
White Croaker	11247	1-Jul-2013	Two	237	33.71444	-118.271	LAOH
White Croaker	11248	1-Jul-2013	Two	260	33.71533	-118.27082	LAOH
White Croaker	11245	1-Jul-2013	Two	223	33.71381	-118.27081	LAOH
White Croaker	11249	1-Jul-2013	Two	234	33.71532	-118.27107	LAOH
White Croaker	11250	1-Jul-2013	Two	222	33.71518	-118.27154	LAOH
White Croaker	11251	2-Jul-2013	Two	227	33.71331	-118.27232	LAOH
White Croaker	11252	2-Jul-2013	Two	252	33.71319	-118.2715	LAOH
White Croaker	11253	2-Jul-2013	Two	227	33.71327	-118.27113	LAOH
White Croaker	11255	2-Jul-2013	Two	233	33.71356	-118.26971	LAOH
White Croaker	11254	2-Jul-2013	Two	229	33.71535	-118.27115	LAOH
White Croaker	11256	2-Jul-2013	Two	227	33.71535	-118.27115	LAOH
White Croaker	11257	2-Jul-2013	Two	231	33.71522	-118.27115	LAOH
White Croaker	11259	2-Jul-2013	Two	225	33.71383	-118.27135	LAOH
White Croaker	11258	2-Jul-2013	Two	226	33.71404	-118.27129	LAOH
White Croaker	11260	2-Jul-2013	Two	244	33.71423	-118.27149	LAOH
White Croaker	11261	2-Jul-2013	Two	250	33.71423	-118.27155	LAOH

White Croaker	11262	2-Jul-2013	Two	235	33.71423	-118.27158	LAOH
White Croaker	11263	2-Jul-2013	Two	240	33.71382	-118.27094	LAOH
White Croaker	11265	2-Jul-2013	Two	237	33.71382	-118.27094	LAOH
White Croaker	11267	2-Jul-2013	Two	235	33.71419	-118.27157	LAOH
White Croaker	11268	2-Jul-2013	Two	229	33.7142	-118.27149	LAOH
White Croaker	11266	2-Jul-2013	Two	256	33.7142	-118.2715	LAOH
White Croaker	11264	2-Jul-2013	Two	225	33.71422	-118.27161	LAOH
White Croaker	11269	3-Jul-2013	Two	231	33.70869	-118.27578	Cabrillo Pier
White Croaker	11270	3-Jul-2013	Two	240	33.70855	-118.27517	Cabrillo Pier
White Croaker	11271	3-Jul-2013	Two	218	33.70869	-118.27505	Cabrillo Pier
White Croaker	11272	3-Jul-2013	Two	225	33.70823	-118.27273	Cabrillo Pier
White Croaker	11273	5-Jul-2013	Two	233	33.7737	-118.24791	LAIH
White Croaker	11274	5-Jul-2013	Two	227	33.77372	-118.24792	LAIH
White Croaker	11275	5-Jul-2013	Two	242	33.77374	-118.24792	LAIH
White Croaker	11276	5-Jul-2013	Two	257	33.77373	-118.24794	LAIH
White Croaker	11277	5-Jul-2013	Two	290	33.7737	-118.24789	LAIH
White Croaker	11278	5-Jul-2013	Two	272	33.7733	-118.24834	LAIH
White Croaker	11279	5-Jul-2013	Two	272	33.77333	-118.24832	LAIH
White Croaker	11280	5-Jul-2013	Two	255	33.77334	-118.24833	LAIH
White Croaker	11281	5-Jul-2013	Two	270	33.77333	-118.24282	LAIH
White Croaker	11282	5-Jul-2013	Two	242	33.77282	-118.24917	LAIH
White Croaker	11283	5-Jul-2013	Two	255	33.77284	-118.24854	LAIH
White Croaker	11284	5-Jul-2013	Two	241	33.77284	-118.24857	LAIH
White Croaker	11285	5-Jul-2013	Two	238	33.77284	-118.2486	LAIH

White Croaker	11286	5-Jul-2013	Two	238	33.77285	-118.24867	LAIH
White Croaker	11287	5-Jul-2013	Two	290	33.77285	-118.2486	LAIH
White Croaker	11288	5-Jul-2013	Two	233	33.77284	-118.24865	LAIH
White Croaker	11289	6-Jul-2013	Two	256	33.7728	-118.24857	LAIH
White Croaker	11290	6-Jul-2013	Two	244	33.7728	-118.24856	LAIH
White Croaker	11291	6-Jul-2013	Two	251	33.77279	-118.24855	LAIH
White Croaker	11292	6-Jul-2013	Two	234	33.7728	-118.24854	LAIH
White Croaker	11293	6-Jul-2013	Two	247	33.77279	-118.2486	LAIH
White Croaker	11316	7-Jul-2013	Two	228	33.71361	-118.71361	LAOH
White Croaker	11317	7-Jul-2013	Two	219	33.70794	-118.27482	Cabrillo Pier
White Croaker	11318	7-Jul-2013	Two	244	33.70944	-118.27446	Cabrillo Pier
White Croaker	11319	7-Jul-2013	Two	237	33.70959	-118.27479	Cabrillo Pier
White Croaker	11320	8-Jul-2013	Two	225	33.7441	-118.18687	Pier J
White Croaker	11321	8-Jul-2013	Two	229	33.74546	-118.18782	Pier J
White Croaker	11322	8-Jul-2013	Two	226	33.74353	-118.18554	Pier J
White Croaker	11323	8-Jul-2013	Two	219	33.74551	-118.18639	Pier J
White Croaker	11325	8-Jul-2013	Two	239	33.74495	-118.18695	Pier J
White Croaker	11324	8-Jul-2013	Two	226	33.74434	-118.18724	Pier J
White Croaker	11326	8-Jul-2013	Two	217	33.74286	-118.18597	Pier J
White Croaker	11328	8-Jul-2013	Two	209	33.74354	-118.18625	Pier J
White Croaker	11329	8-Jul-2013	Two	247	33.74369	-118.18637	Pier J
White Croaker	11327	8-Jul-2013	Two	231	33.74563	-118.18358	Pier J
White Croaker	11215	9-Jul-2013	Two	231	33.70645	-118.32267	PV Shelf
White Croaker	11294	12-Jul-2013	Two	223	33.70735	-118.27477	Cabrillo Pier

White Croaker	11295	12-Jul-2013	Two	225	33.70799	-118.27557	Cabrillo Pier
White Croaker	11296	15-Jul-2013	Two	226	33.70759	-118.27393	Cabrillo Pier
White Croaker	11297	15-Jul-2013	Two	228	33.7078	-118.2745	Cabrillo Pier
White Croaker	11216	16-Jul-2013	Two	224	33.70622	-118.32113	PV Shelf
White Croaker	11218	16-Jul-2013	Two	240	33.70538	-118.32086	PV Shelf
White Croaker	11298	17-Jul-2013	Two	206	33.74066	-118.21911	LBOH
White Croaker	11299	17-Jul-2013	Two	234	33.74169	-118.2178	LBOH
White Croaker	11300	17-Jul-2013	Two	223	33.74159	-118.21971	LBOH
White Croaker	11301	17-Jul-2013	Two	243	33.74087	-118.22176	LBOH
White Croaker	11302	17-Jul-2013	Two	231	33.74104	-118.21971	LBOH
White Croaker	11303	17-Jul-2013	Two	237	33.74244	-118.21797	LBOH
White Croaker	11304	17-Jul-2013	Two	224	33.73945	-118.22163	LBOH
White Croaker	11305	17-Jul-2013	Two	227	33.73912	-118.2216	LBOH
White Croaker	11306	18-Jul-2013	Two	218	33.73829	-118.22166	LBOH
White Croaker	11307	18-Jul-2013	Two	237	33.73819	-118.22181	LBOH
White Croaker	11308	18-Jul-2013	Two	215	33.74174	-118.22127	LBOH
White Croaker	11309	18-Jul-2013	Two	220	33.74145	-118.22111	LBOH
White Croaker	11310	19-Jul-2013	Two	229	33.73284	-118.22758	LBOH
White Croaker	11311	19-Jul-2013	Two	216	33.73284	-118.22758	LBOH
White Croaker	11312	19-Jul-2013	Two	215	33.7327	-118.22691	LBOH
White Croaker	11313	19-Jul-2013	Two	211	33.73326	-118.22553	LBOH
White Croaker	11314	19-Jul-2013	Two	215	33.73348	-118.225	LBOH
White Croaker	11315	19-Jul-2013	Two	214	33.73415	-118.22442	LBOH
White Croaker	11338	19-Jul-2013	Two	234	33.73509	-118.22366	LBOH

White Croaker	11339	19-Jul-2013	Two	226	33.73625	-118.22305	LBOH
White Croaker	11340	19-Jul-2013	Two	225	33.73746	-118.22204	LBOH
White Croaker	11341	19-Jul-2013	Two	245	33.73891	-118.22404	LBOH
White Croaker	11342	19-Jul-2013	Two	212	33.73751	-118.22574	LBOH
White Croaker	11343	19-Jul-2013	Two	225	33.73968	-118.22426	LBOH
White Croaker	11344	19-Jul-2013	Two	225	33.74142	-118.22297	LBOH
White Croaker	11345	19-Jul-2013	Two	219	33.70831	-118.27596	Cabrillo Pier
White Croaker	11346	19-Jul-2013	Two	215	33.70824	-118.27582	Cabrillo Pier
White Croaker	11217	20-Jul-2013	Two	236	33.74739	-118.18827	Pier J
White Croaker	11220	20-Jul-2013	Two	244	33.74129	-118.18684	Pier J
White Croaker	11219	20-Jul-2013	Two	251	33.74368	-118.18589	Pier J
White Croaker	11222	20-Jul-2013	Two	233	33.74621	-118.18623	Pier J
White Croaker	11221	20-Jul-2013	Two	205	33.74586	-118.18777	Pier J
White Croaker	11234	21-Jul-2013	Two	232	33.70663	-118.33135	PV Shelf
White Croaker	11228	21-Jul-2013	Two	253	33.7097	-118.32606	PV Shelf
White Croaker	11347	22-Jul-2013	Two	232	33.77553	-118.21284	LBIH
White Croaker	11330	22-Jul-2013	Two	242	33.77267	-118.21889	LBIH
White Croaker	11331	22-Jul-2013	Two	230	33.77351	-118.21751	LBIH
White Croaker	11332	22-Jul-2013	Two	248	33.77337	-118.21783	LBIH
White Croaker	11333	22-Jul-2013	Two	239	33.77284	-118.21872	LBIH
White Croaker	11334	22-Jul-2013	Two	224	33.77312	-118.21874	LBIH
White Croaker	11335	22-Jul-2013	Two	257	33.77312	-118.21874	LBIH
White Croaker	11336	22-Jul-2013	Two	213	33.77382	-118.21801	LBIH
White Croaker	11337	22-Jul-2013	Two	258	33.77426	-118.21725	LBIH

White Croaker	11348	22-Jul-2013	Two	236	33.77358	-118.2179	LBIH
White Croaker	11349	22-Jul-2013	Two	239	33.77254	-118.21951	LBIH
White Croaker	11350	22-Jul-2013	Two	233	33.77233	-118.2195	LBIH
White Croaker	11351	22-Jul-2013	Two	237	33.77256	-118.2194	LBIH
White Croaker	11352	22-Jul-2013	Two	245	33.77365	-118.21809	LBIH
White Croaker	11353	22-Jul-2013	Two	238	33.77235	-118.2194	LBIH
White Croaker	11354	22-Jul-2013	Two	236	33.77357	-118.21848	LBIH
White Croaker	11233	23-Jul-2013	Two	240	33.74943	-118.18276	Pier J
White Croaker	11232	23-Jul-2013	Two	240	33.74505	-118.18409	Pier J
White Croaker	11357	24-Jul-2013	Two	249	33.77294	-118.21888	LBIH
White Croaker	11358	24-Jul-2013	Two	241	33.77291	-118.21887	LBIH
White Croaker	11359	24-Jul-2013	Two	233	33.77291	-118.21887	LBIH
White Croaker	11360	24-Jul-2013	Two	221	33.77328	-118.21861	LBIH
White Croaker	11361	24-Jul-2013	Two	249	33.77276	-118.21972	LBIH
White Croaker	11362	24-Jul-2013	Two	229	33.77288	-118.21896	LBIH
White Croaker	11363	24-Jul-2013	Two	231	33.77258	-118.21907	LBIH
White Croaker	11364	24-Jul-2013	Two	235	33.77272	-118.2191	LBIH
White Croaker	11365	24-Jul-2013	Two	238	33.77348	-118.21811	LBIH
White Croaker	11366	24-Jul-2013	Two	263	33.77259	-118.24855	LAIH
White Croaker	11367	24-Jul-2013	Two	263	33.77257	-118.24858	LAIH
White Croaker	11231	25-Jul-2013	Two	241	33.70775	-118.323	PV Shelf
White Croaker	11368	25-Jul-2013	Two	236	33.70866	-118.27602	Cabrillo Pier
White Croaker	11369	25-Jul-2013	Two	223	33.70874	-118.27618	Cabrillo Pier
White Croaker	11370	25-Jul-2013	Two	213	33.70874	-118.27618	Cabrillo Pier

White Croaker	11372	25-Jul-2013	Two	208	33.70884	-118.27729	Cabrillo Pier
White Croaker	11374	25-Jul-2013	Two	208	33.70725	-118.27477	Cabrillo Pier
White Croaker	11375	25-Jul-2013	Two	231	33.70739	-118.27436	Cabrillo Pier
White Croaker	11376	25-Jul-2013	Two	208	33.70725	-118.27472	Cabrillo Pier
White Croaker	11377	25-Jul-2013	Two	242	33.70737	-118.2748	Cabrillo Pier
White Croaker	11378	28-Jul-2013	Two	233	33.70776	-118.27415	Cabrillo Pier
White Croaker	11379	28-Jul-2013	Two	209	33.70747	-118.2748	Cabrillo Pier
White Croaker	11380	28-Jul-2013	Two	216	33.7095	-118.27557	Cabrillo Pier
White Croaker	11382	29-Jul-2013	Two	224	33.74426	-118.18722	Pier J
White Croaker	11383	29-Jul-2013	Two	239	33.74488	-118.18784	Pier J
White Croaker	11384	29-Jul-2013	Two	244	33.74335	-118.18694	Pier J
White Croaker	11385	29-Jul-2013	Two	234	33.74426	-118.18706	Pier J
White Croaker	11386	29-Jul-2013	Two	230	33.74596	-118.18797	Pier J
White Croaker	11387	29-Jul-2013	Two	227	33.74289	-118.18639	Pier J
White Croaker	11388	29-Jul-2013	Two	234	33.74222	-118.18668	Pier J
White Croaker	11389	29-Jul-2013	Two	237	33.74287	-118.18629	Pier J
White Croaker	11390	31-Jul-2013	Two	216	33.70742	-118.27448	Cabrillo Pier
White Croaker	11223	13-Aug-2013	Two	242	33.70543	-118.32904	PV Shelf
White Croaker	11227	13-Aug-2013	Two	221	33.70745	-118.33062	PV Shelf
White Croaker	11224	17-Aug-2013	Two	229	33.70643	-118.32048	PV Shelf
White Croaker	11415	23-Oct-2013	Two	228	33.73438	-118.26562	Fish Harbor
White Croaker	11416	23-Oct-2013	Two	219	33.73372	-118.26598	Fish Harbor
White Croaker	11420	17-Nov-2013	Two	245	33.73335	-118.26636	Fish Harbor
White Croaker	11421	17-Nov-2013	Two	227	33.73322	-118.2667	Fish Harbor

White Croaker	11422	17-Nov-2013	Two	264	33.73385	-118.26617	Fish Harbor
White Croaker	11423	17-Nov-2013	Two	223	33.7329	-118.26604	Fish Harbor
White Croaker	11424	17-Nov-2013	Two	241	33.73354	-118.26652	Fish Harbor
White Croaker	11425	17-Nov-2013	Two	234	33.73357	-118.2674	Fish Harbor
White Croaker	11426	17-Nov-2013	Two	235	33.7331	-118.26559	Fish Harbor
White Croaker	11427	17-Nov-2013	Two	242	33.73367	-118.26599	Fish Harbor
White Croaker	11428	17-Nov-2013	Two	225	33.73359	-118.26595	Fish Harbor
White Croaker	11429	17-Nov-2013	Two	224	33.7329	-118.26566	Fish Harbor
White Croaker	11430	17-Nov-2013	Two	226	33.73317	-118.26627	Fish Harbor
White Croaker	11431	17-Nov-2013	Two	222	33.73352	-118.26618	Fish Harbor
White Croaker	11432	23-Nov-2013	Two	217	33.73363	-118.26654	Fish Harbor
White Croaker	11433	23-Nov-2013	Two	220	33.73374	-118.26646	Fish Harbor
White Croaker	11434	23-Nov-2013	Two	223	33.73387	-118.26587	Fish Harbor
White Croaker	11435	23-Nov-2013	Two	226	33.73354	-118.26658	Fish Harbor
White Croaker	11436	23-Nov-2013	Two	241	33.73354	-118.26586	Fish Harbor
White Croaker	11437	23-Nov-2013	Two	228	33.73348	-118.26644	Fish Harbor
White Croaker	11438	23-Nov-2013	Two	236	33.73359	-118.26601	Fish Harbor
White Croaker	11439	23-Nov-2013	Two	248	33.73388	-118.26573	Fish Harbor
White Croaker	11440	23-Nov-2013	Two	214	33.73378	-118.26582	Fish Harbor
White Croaker	11441	23-Nov-2013	Two	222	33.73359	-118.26561	Fish Harbor
White Croaker	11442	23-Nov-2013	Two	219	33.7336	-118.26698	Fish Harbor
White Croaker	11443	20-Dec-2013	Two	216	33.77237	-118.24889	LAIH
White Croaker	11444	20-Dec-2013	Two	253	33.77321	-118.24864	LAIH
White Croaker	11445	20-Dec-2013	Two	260	33.77341	-118.24887	LAIH

White Croaker	11446	21-Dec-2013	Two	256	33.70848	-118.27552	Cabrillo Pier
White Croaker	11448	9-Jan-2014	Two	222	33.70885	-118.27654	Cabrillo Pier
White Croaker	11450	14-Feb-2014	Two	222	33.71439	-118.28156	Cabrillo Pier
White Croaker	11454	28-Mar-2014	Two	329	33.70869	-118.27641	Cabrillo Pier
White Croaker	11236	26-May-2014	Two	214	33.73286	-118.26589	Fish Harbor
White Croaker	11237	26-May-2014	Two	238	33.73245	-118.26552	Fish Harbor
White Croaker	11238	26-May-2014	Two	220	33.73243	-118.26608	Fish Harbor
White Croaker	11239	26-May-2014	Two	226	33.73244	-118.26614	Fish Harbor
White Croaker	11240	27-May-2014	Two	226	33.73316	-118.26595	Fish Harbor
White Croaker	11241	27-May-2014	Two	233	33.71442	-118.27134	LAOH
White Croaker	11242	27-May-2014	Two	230	33.71452	-118.2706	LAOH
White Croaker	11243	27-May-2014	Two	219	33.71391	-118.271	LAOH
White Croaker	11244	27-May-2014	Two	231	33.71484	-118.2713	LAOH
CA Halibut	11355	23-Jul-2013	Two	310	33.70906	-118.2767	Cabrillo Pier
CA Halibut	11356	23-Jul-2013	Two	394	33.70742	-118.27423	Cabrillo Pier
CA Halibut	11371	25-Jul-2013	Two	480	33.70712	-118.27427	Cabrillo Pier
CA Halibut	11373	25-Jul-2013	Two	446	33.70728	-118.27264	Cabrillo Pier
CA Halibut	11381	28-Jul-2013	Two	374	33.70838	-118.27636	Cabrillo Pier
CA Halibut	11391	3-Aug-2013	Two	423	33.77229	-118.24923	LAIH
CA Halibut	11230	3-Aug-2013	Two	413	33.74957	-118.18889	Pier J
CA Halibut	11229	3-Aug-2013	Two	390	33.74882	-118.18644	Pier J
CA Halibut	11392	11-Aug-2013	Two	547	33.70943	-118.27655	Cabrillo Pier
CA Halibut	11393	11-Aug-2013	Two	366	33.70875	-118.27333	Cabrillo Pier
CA Halibut	11394	14-Aug-2013	Two	460	33.7095	-118.2757	Cabrillo Pier

CA Halibut	11395	14-Aug-2013	Two	412	33.70863	-118.27602	Cabrillo Pier
CA Halibut	11396	14-Aug-2013	Two	540	33.70869	-118.2759	Cabrillo Pier
CA Halibut	11397	14-Aug-2013	Two	560	33.7085	-118.27534	Cabrillo Pier
CA Halibut	11398	14-Aug-2013	Two	568	33.70997	-118.27311	Cabrillo Pier
CA Halibut	11399	15-Aug-2013	Two	782	33.74517	-118.1879	Pier J
CA Halibut	11400	15-Aug-2013	Two	549	33.74853	-118.189	Pier J
CA Halibut	11401	21-Aug-2013	Two	462	33.77215	-118.24969	LAIH
CA Halibut	11402	22-Aug-2013	Two	518	33.70868	-118.27614	Cabrillo Pier
CA Halibut	11403	22-Aug-2013	Two	661	33.70901	-118.27623	Cabrillo Pier
CA Halibut	11404	23-Aug-2013	Two	549	33.70829	-118.27554	Cabrillo Pier
CA Halibut	11405	24-Aug-2013	Two	381	33.70897	-118.27665	Cabrillo Pier
CA Halibut	11406	31-Aug-2013	Two	572	33.74325	-118.21284	LBOH
CA Halibut	11407	11-Sep-2013	Two	410	33.70874	-118.2768	Cabrillo Pier
CA Halibut	11408	11-Sep-2013	Two	537	33.70917	-118.27702	Cabrillo Pier
CA Halibut	11409	11-Sep-2013	Two	416	33.70907	-118.27647	Cabrillo Pier
CA Halibut	11410	21-Sep-2013	Two	635	33.76551	-118.27435	LAIH
CA Halibut	11411	21-Sep-2013	Two	450	33.75755	-118.27466	LAIH
CA Halibut	11412	22-Sep-2013	Two	395	33.70993	-118.26641	Cabrillo Pier
CA Halibut	11413	22-Sep-2013	Two	439	33.77236	-118.22031	LBIH
CA Halibut	11414	22-Sep-2013	Two	394	33.772	-118.22092	LBIH
CA Halibut	11417	6-Nov-2013	Two	392	33.74907	-118.18974	Pier J
CA Halibut	11418	6-Nov-2013	Two	390	33.74622	-118.18812	Pier J
CA Halibut	11419	7-Nov-2013	Two	612	33.71694	-118.2429	LBOH
CA Halibut	11447	9-Jan-2014	Two	371	33.70904	-118.27718	Cabrillo Pier

CA Halibut	11449	16-Jan-2014	Two	369	33.70821	-118.27583	Cabrillo Pier
CA Halibut	11451	14-Feb-2014	Two	350	33.71507	-118.2793	Cabrillo Pier
CA Halibut	11452	15-Mar-2014	Two	451	33.70723	-118.27377	Cabrillo Pier
CA Halibut	11453	20-Mar-2014	Two	610	33.73183	-118.26573	LAOH
CA Halibut	11225	28-Mar-2014	Two	413	33.70714	-118.27361	Cabrillo Pier
CA Halibut	11226	28-Mar-2014	Two	560	33.7091	-118.27643	Cabrillo Pier
CA Halibut	11235	29-Apr-2014	Two	399* (SL)	33.70021	-118.25009	LAOH

Appendix D. Transition matrix of all white croaker tagged in Phase I. Row name represents the location where the fish was previously detected (origin) and the column names represent the location of subsequent detection (destination).

	Station 1	Station 2	Station 3	Station 4	CSlip	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13
Station 1	7130	223	0	0	0	0	0	0	1	3	40
Station 2	224	98806	45	1	0	0	0	0	0	0	0
Station 3	1	42	59460	2822	0	0	0	0	1	0	0
Station 4	1	1	2814	38435	98	18	0	0	0	0	0
CSlip	1	0	1	70	1022943	183	2	0	0	0	0
Station 8	0	0	0	34	162	59235	47	0	0	0	0
Station 9	0	0	0	0	4	41	14033	1177	3	0	0
Station 10	0	0	0	0	0	0	1173	22059	58	0	0
Station 11	0	0	1	0	0	0	4	65	135749	0	0
Station 12	2	0	0	0	0	0	0	0	2	154	0
Station 13	43	0	0	0	0	0	0	0	0	0	178044

Appendix E. Transition matrix of all white croaker tagged in Phase II using only detection among Phase I receiver array configuration. Row name represents the location where the fish was previously detected (origin) and the column names represent the location of subsequent detection (destination).

	Station 1	Station 2	Station 3	Station 4	CSlip	Station 8	Station 9	Station 10	Station 11	Station 12	Station 13
Station 1	635	15	0	0	1	0	0	0	0	0	28
Station 2	19	1200	8	2	0	0	0	0	0	0	0
Station 3	0	9	3649	100	0	0	0	0	0	0	0
Station 4	0	2	100	3721	14	1	0	0	0	0	1
CSlip	0	0	0	9	274417	47	1	0	0	0	0
Station 8	0	0	0	5	46	17875	34	0	0	0	0
Station 9	0	0	0	0	0	34	22019	67	3	0	0
Station 10	0	0	0	0	1	0	79	10061	76	0	0
Station 11	0	0	0	0	0	0	0	85	15655	2	0
Station 12	0	0	0	0	0	0	0	0	1	341	1
Station 13	25	0	0	0	1	0	0	1	0	0	156218

Appendix F. Transition matrix of all white croaker tagged in Phase II using entire Phase II receiver array (38 receivers). Row name represents the location where the fish was previously detected (origin) and the column names represent the location of subsequent detection (destination).

	CAB	Bait	HCHP 1	HCHP 2	HCHP 3	HCHP 4	CSlip	HCHP 7	HCHP 8	HCHP 9	HCHP 10	Fish	HCHP 12	AG	PV	QG	HCHP 14	HCHP 15	PJ
CAB	248515	242	0	1	1	0	2	0	1	0	0	3	0	1	0	0	0	0	0
Bait	245	152481	23	0	0	0	1	0	0	0	0	7	0	9	1	0	0	0	0
HCHP 1	0	25	633	15	0	0	1	0	0	0	0	2	0	2	0	0	0	0	0
HCHP 2	0	0	19	1200	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0
HCHP 3	0	0	0	9	3649	100	0	0	0	0	0	0	0	0	0	0	1	0	0
HCHP 4	0	0	0	2	100	3721	14	1	0	0	0	0	0	0	1	0	0	0	0
CSlip	1	0	0	0	0	9	265876	46	1	0	0	1	0	0	0	0	0	0	0
HCHP 7	0	0	0	0	0	5	44	17760	33	0	0	0	0	0	0	0	0	0	0
HCHP 8	0	0	0	0	0	0	0	32	17414	66	2	0	0	0	0	0	1	0	0
HCHP 9	1	0	0	0	0	0	1	0	77	10058	76	0	0	0	0	0	0	0	0
HCHP 10	0	0	0	0	0	0	0	0	0	85	15652	1	2	0	0	2	1	0	0
Fish	2	3	0	0	0	0	0	0	0	0	0	94887	2	1	3	0	0	0	0
HCHP 12	0	1	0	0	0	0	0	0	0	0	1	1	341	1	0	0	0	0	0
AG	5	15	1	0	0	0	2	0	0	1	0	6	0	16770	8	3	0	0	0
PV	0	2	1	0	0	0	1	0	0	0	1	0	0	11	1329	1	0	0	0
QG	4	1	0	0	1	0	0	0	1	0	4	0	0	0	0	2481	1	8	3
HCHP 14	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	67	21	0
HCHP 15	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	10	18	583	28
PJ	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	27	156046

Appendix G. Transition matrix of all California halibut tagged in Phase II using entire Phase II receiver array (38 receivers). Row name represents the location where the fish was previously detected (origin) and the column names represent the location of subsequent detection (destination).

	CAB	Bait	HCHP 1	HCHP 2	HCHP 3	HCHP 4	CSlip	HCHP 7	HCHP 8	HCHP 9	HCHP 10	Fish	HCHP 12	AG	PV	QG	HCHP 14	HCHP 15	PJ
CAB	359575	211	0	0	0	0	0	0	0	0	0	0	0	6	0	0	1	0	0
Bait	217	26836	15	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
HCHP 1	0	15	116	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
HCHP 2	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HCHP 3	0	0	0	0	165	3	0	0	0	0	0	0	0	0	0	0	0	0	0
HCHP 4	0	0	0	0	3	80	0	0	0	0	0	0	0	0	0	0	0	0	0
CSlip	0	0	0	0	0	0	86478	2	0	0	0	0	0	0	0	0	0	0	0
HCHP 7	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0
HCHP 8	0	0	0	0	0	0	0	0	5228	2	0	0	0	0	0	0	0	0	0
HCHP 9	0	0	0	0	0	0	0	0	3	1099	1	0	0	0	0	0	1	0	0
HCHP 10	0	0	0	0	0	0	0	0	0	2	435	0	0	0	0	0	0	0	0
Fish	0	0	1	0	0	0	0	0	0	0	0	36164	1	2	0	0	0	0	0
HCHP 12	0	0	0	0	0	0	0	0	0	0	0	0	2489	1	0	0	0	0	0
AG	15	7	2	0	0	0	0	0	0	0	0	2	0	2024	5	1	0	0	0
PV	0	0	0	0	0	0	0	0	0	0	0	0	0	14	377	0	0	0	0
QG	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	3753	0	5	0
HCHP 14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	177	3	0
HCHP 15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	3	272	14
PJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	10	33059