DATA GAPS ANALYSIS FOR BIOACCUMULATION MODEL DEVELOPMENT

GREATER LOS ANGELES AND LONG BEACH HARBOR WATERS

In Support of

Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Load

Prepared for

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TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 Overview 1
1.2 Background 1
1.3 Study Area Description 3
1.4 Model Development 4
1.5 Data Gap Analyses 5
2 DATA SOURCES AND DATA HANDLING 6
2.1 Sediment, Fish Tissue, and Mussel Tissue Chemical and Physical Data 6
2.1.1 Project Data Sources 6
2.1.2 Data Availability and Data Gaps 7
2.1.3 Data Treatments for Preliminary Data Analysis 8
2.2 Additional Data to Support the Conceptual Site Model and Bioaccumulation Model11
2.2.1 Fish Tracking Study 11
2.2.2 Aquatic Habitat 12
2.2.3 Benthic Infauna Abundance 13
2.2.4 Fish Abundance 13
2.2.5 Bathymetry 13
3 FISH MOVEMENT EVALUATION 14
3.1 Analysis of Fish Movement Data and Determination of Zones 14
3.2 Comparison of Fish Movement with Harbor Habitat and Prey Abundance 15
3.2.1 Habitat Data Comparison 15
3.2.2 Benthic Infauna and Polychaete Abundance Comparison 16
3.2.3 Fish Abundance Comparison 17
3.3 Fish Movement Zones and Data Gaps 17
4 PCBS AND DDTS SPATIAL DISTRIBUTION EVALUATION 19
4.1 Spatial Distribution of PCB and DDT Concentrations 19
4.1.1 Sediment 20
4.1.2 Fish Tissue 21
4.2 Relationships Between TPCB and TDDT Concentrations in Sediment and Fish Tissue 22

4.2.1 Comparison of Sediment and Fish Tissue PCBs and DDTs by Zone 22
4.3 TPCB and TDDT Concentrations in Regional Fish Tissue 24
4.3.1 Comparison of TPCB and TDDT Concentrations in Harbor Fish with Regional Data 25

5 NATURAL RECOVERY EVALUATION 26
5.1 Temporal Trend Analyses of TPCB and TDDT Concentrations in Surface Sediment and Biota 27
5.1.1 Temporal Trends in Sediments 27
5.1.1.1 Surface Sediments 27
5.1.2 Vertical Contaminant Trend Analyses 29
5.1.3 Temporal Trends in Mussels 30
5.1.4 Temporal Trends in White Croaker 31
5.1.5 Evidence for Natural Recovery...32
5.2 Natural Recovery Data Gaps 32

6 CONCEPTUAL SITE MODEL OVERVIEW AND BIOACCUMULATION MODEL PARAMETERS 34
6.1 Harbor Food Web and Bioaccumulation 34
6.1.1 Food Web Structure 34
6.1.1.1 California Halibut.. 34
6.1.1.2 White Croaker 35
6.1.1.3 Shiner Surfperch... 35
6.1.1.4 Invertebrates 35
6.1.1.5 Representativeness of Selected Species 36
6.1.2 Diet Parameterization 36
6.1.2.1 California Halibut.. 37
6.1.2.2 White Croaker 37
6.1.2.3 Shiner Surfperch... 38
6.1.3 Invertebrate Diets..38
6.2 Bioenergetics and Toxicokinetics 39
6.2.1 Growth Rates 39
6.2.1.1 California Halibut.. 39
6.2.1.2 White Croaker 40

6.2.1.3 Shiner Surfperch 40
6.2.2 Respiration 40
6.2.3 Lipid Contents 41
6.2.4 Contaminant Mass Transfer at the Gill 41
6.3 Exposure Characterization 42
7 DATA GAPS SUMMARY 44
7.1 Fish Movement Data Gaps 44
7.2 Biota and Sediment PCB and DDT Data Gaps 45
7.2.1 Biota 45
7.2.2 Sediment 47
7.3 Food Web Structure 48
7.4 Other Data Gaps 49
8 REFERENCES 51

List of Tables

Table 2-1 Summary of Additional Ports of Long Beach and Los Angeles Sediment Chemical and Physical Datasets
Table 2-2 Summary of Additional Ports of Long Beach and Los Angeles Fish Tissue Chemistry Datasets
Table 2-3 Sediment Data Counts per TMDL Waterbody and Other Areas
Table 2-4 Fish Data Counts per TMDL Waterbody and Other Areas
Table 2-5 Mussel Data Counts per TMDL Waterbody and Other Areas
Table 3-1 Narrative Description of Preliminary Fish Movement Zones
Table 5-1 Surface Weighted Average TPCB and TDDT Concentrations for Zones 7 and 11
Table 6-1 California Halibut Food Web
Table 6-2 White Croaker Food Web
Table 6-3 Shiner Surfperch Food Web
Table 6-4 California Halibut Growth Rate Equations
Table 6-5 White Croaker Growth Rate Equations
Table 6-6 Shiner Surfperch Growth Rate Equations

Table 7-1 Data Gaps
Table 7-2 Aroclor-only and Congener TPCB Fish Data Counts per Year
Table 7-3 Aroclor-only and Congener TPCB Surface Sediment Data Counts per Year

List of Figures

Figure 1-1 Study Area
Figure 2-1 Sediment Sampling Locations (1998-2012; top 16 cm)
Figure 2-2 Fish Tissue Sampling Locations (1998-2012)
Figure 2-3 Mussel Tissue Sampling Locations (1977-2009)
Figure 2-4 Comparison Between Congener and Aroclor TPCB in Surface Sediment
Figure 2-5a TPCB versus TOC in Surface Sediment
Figure 2-5b TDDT versus TOC in Surface Sediment
Figure 2-6a TPCB Concentration versus Percent Lipid in California Halibut
Figure 2-6b TDDT Concentration versus Percent Lipid in California Halibut
Figure 2-6c TPCB Concentration versus Percent Lipid in Jack Smelt
Figure 2-6d TDDT Concentration versus Percent Lipid in Jack Smelt
Figure 2-6e TPCB Concentration versus Percent Lipid in Queenfish
Figure 2-6f TDDT Concentration versus Percent Lipid in Queenfish
Figure 2-6g TPCB Concentration versus Percent Lipid in Sand Bass
Figure 2-6h TDDT Concentration versus Percent Lipid in Sand Bass
Figure 2-6i TPCB Concentration versus Percent Lipid in Topsmelt
Figure 2-6j TDDT Concentration versus Percent Lipid in Topsmelt
Figure 2-6k TPCB Concentration versus Percent Lipid in White Croaker
Figure 2-6l TDDT Concentration versus Percent Lipid in White Croaker
Figure 2-6m TPCB Concentration versus Percent Lipid in White Surfperch
Figure 2-6n TDDT Concentration versus Percent Lipid in White Surfperch
Figure 2-7a Temporal of Percent Lipid in California Halibut
Figure 2-7b Temporal of Percent Lipid in White Croaker
Figure 2-8 White Croaker Catch and Receiver Locations
Figure 3-1 Preliminary Fish Movement Zones of White Croaker
Figure 3-2 Habitat Areas
Figure 3-3 Thiessen Polygons Showing Total Organic Carbon in Surface Sediment

Figure 3-4 Thiessen Polygons Showing Percent Fines in Surface Sediment
Figure 3-5 Thiessen Polygons Showing Benthic Infauna Abundance
Figure 3-6 Thiessen Polygons Showing Polychaete Density
Figure 3-7 Bathymetry
Figure 3-8 CSULB Fish Tracking Study Phase II Receiver Locations
Figure 4-1 Box Plots of TPCB Concentrations in Surface Sediment
Figure 4-2 Box Plots of TDDT Concentrations in Surface Sediment
Figure 4-3 Thiessen Polygons Showing TPCB Concentrations in Surface Sediment
Figure 4-4 Thiessen Polygons Showing TDDT Concentrations in Surface Sediment
Figure 4-5a Box Plots of TPCB Concentrations in California Halibut
Figure 4-5b Box Plots of TPCB Concentrations in Queenfish
Figure 4-5c Box Plots of TPCB Concentrations in Topsmelt
Figure 4-5d Box Plots of TPCB Concentrations in White Croaker
Figure 4-6a Box Plots of TDDT Concentrations in California Halibut
Figure 4-6b Box Plots of TDDT Concentrations in Queenfish
Figure 4-6c Box Plots of TDDT Concentrations in Topsmelt
Figure 4-6d Box Plots of TDDT Concentrations in White Croaker
Figure 4-7a TPCB in California Halibut versus Surface Sediment
Figure 4-7b TPCB in Queenfish versus Surface Sediment
Figure 4-7c TPCB in Topsmelt versus Surface Sediment
Figure 4-7d TPCB in White Croaker versus Surface Sediment
Figure 4-8a TDDT in California Halibut versus Surface Sediment
Figure 4-8b TDDT in Queenfish versus Surface Sediment
Figure 4-8c TDDT in Topsmelt versus Surface Sediment
Figure 4-8d TDDT in White Croaker versus Surface Sediment
Figure 4-9a TPCB in White Croaker versus Surface Sediment from the Palos Verdes Shelf
Figure 4-9b TDDT in White Croaker versus Surface Sediment from the Palos Verdes Shelf
Figure 4-10 Surface Sediment TPCB Concentrations on a Dry-Weight Basis (1998-2012)
Figure 4-11 Surface Sediment TDDT Concentrations on a Dry-Weight Basis (1998-2012)
Figure 4-12 White Croaker TPCB Concentrations on a Wet-Weight Basis (1998-2012)
Figure 4-13 White Croaker TDDT Concentrations on a Wet-Weight Basis (1998-2012)
Figure 4-14 Wet–Weight White Croaker TPCB Concentrations versus Distance Along Coastline

Figure 4-15 Wet–Weight White Croaker TDDT Concentrations versus Distance Along Coastline
Figure 4-16 Local and Regional Background Areas
Figure 4-17a White Croaker TDDT Concentrations Compared to Background Levels
Figure 4-17b White Croaker Congener TPCB Concentrations Compared to Background Levels
Figure 5-1a Temporals of Dry–Weight TDDT Concentrations in Surface Sediment from the LA/LB Harbor Area
Figure 5-1b Temporals of OC–Normalized TDDT Concentrations in Surface Sediment from the LA/LB Harbor Area
Figure 5-2a Temporals of Dry–Weight TDDT Concentrations in Surface Sediment from Palos Verdes Shelf
Figure 5-2b Temporals of OC–Normalized TDDT Concentrations in Surface Sediment from Palos Verdes Shelf
Figure 5-3a Temporals of Dry–Weight TPCB Concentrations in Surface Sediment from the LA/LB Harbor Area
Figure 5-3b Temporals of OC–Normalized TPCB Concentrations in Surface Sediment from the LA/LB Harbor Area
Figure 5-4a Temporals of Dry–Weight TPCB Concentrations in Surface Sediment from Palos Verdes Shelf
Figure 5-4b Temporals of OC–Normalized TPCB Concentrations in Surface Sediment from Palos Verdes Shelf
Figure 5-5 Consolidated Slip Core Locations
Figure 5-6a Dry–Weight TPCB Concentrations in Sediment Cores from Consolidated Slip
Figure 5-6b Dry–Weight TDDT Concentrations in Sediment Cores from Consolidated Slip
Figure 5-7a OC–Normalized TPCB Concentrations in Sediment Cores from Consolidated Slip
Figure 5-7b OC–Normalized TDDT Concentrations in Sediment Cores from Consolidated Slip
Figure 5-8 Temporal of TPCB and TDDT Concentration in Mussel Collected near Cabrillo Pier and Palos Verdes Shelf
Figure 5-9a Temporal of Wet-Weight TDDT Concentrations in White Croaker
Figure 5-9b Temporal of Lipid-Normalized TDDT Concentrations in White Croaker

Figure 5-10a Wet-Weight TDDT Concentrations in White Croaker from Palos Verdes Shelf
Figure 5-10b Lipid-Normalized TDDT Concentrations in White Croaker from Palos Verdes Shelf
Figure 5-11a Temporal of Wet-Weight TPCB Concentrations in White Croaker
Figure 5-11b Temporal of Lipid-Normalized TPCB Concentrations in White Croaker
Figure 5-12a Wet-Weight TPCB Concentrations in White Croaker from Palos Verdes Shelf
Figure 5-12b Lipid-Normalized TPCB Concentrations in White Croaker from Palos Verdes Shelf
Figure 5-13 Palos Verdes Shelf Segments
Figure 6-1 PCB Accumulation in the Food Web
Figure 6-2a Lipid-Normalized TPCB Concentrations in Fish Species
Figure 6-2b Lipid-Normalized TDDT Concentrations in Fish Species
Figure 6-3a California Halibut Length at Age
Figure 6-3b California Halibut Weight at Length
Figure 6-4a White Croaker Length at Age
Figure 6-4b White Croaker Weight at Length
Figure 6-5a Shiner Surfperch Length at Age
Figure 6-5b Shiner Surfperch Weight at Length
Figure 7-1 Proposed White Croaker Sampling Locations, Food Web Sampling Program
Figure 7-2 Proposed California Halibut Sampling Locations, Food Web Sampling Program
Figure 7-3 Proposed Shiner Surfperch Sampling Locations, Food Web Sampling Program
Figure 7-4 Proposed Polychaete Sampling Locations, Food Web Sampling Program
Figure 7-5 Proposed Mussel Sampling Locations, Food Web Sampling Program
Figure 7-6 Counts of Surface Sediment Congener TPCB Data per Year
Figure 7-7 Comparison Between Congener and Aroclor TPCB in Sediment
Figure 7-8 Proposed Sediment Sampling Locations Overview

List of Appendices

Appendix A NOAA Charts of San Pedro Bay

LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	microgram per kilogram
µm	micrometer
cm	centimeter
Bight	Southern California Bight Regional Monitoring Program
CSM	Conceptual Site Model
CSULB	California State University Long Beach
DDT	dichlorodiphenyltrichloroethane
Harbor Toxics TMDL	*Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Load*
HTWG	Harbor Technical Work Group
LA	Los Angeles
LB	Long Beach
MDL	method detection limit
mm	millimeter
MNR	monitored natural recovery
Montrose	Montrose Chemical Corporation
NRDA	Natural Resource Damage Assessment
OC	organic carbon
OEHHA	Office of Environmental Health Hazard Assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
Ports	Ports of Long Beach and Los Angeles
RWQCB	Regional Water Quality Control Board
SQO	Sediment Quality Objective
SWAC	surface-weighted average concentration
LATIWRP	Los Angeles Terminal Island Water Reclamation Plant

TDDT	total dichlorodiphenyltrichloroethane
TMDL	total maximum daily load
TPCB	total polychlorinated biphenyl
TOC	total organic carbon
UCL	upper confidence limit
USEPA	U.S. Environmental Protection Agency
WRAP	Water Resources Action Plan

1 INTRODUCTION

1.1 Overview

Addressing indirect human health effects of sediment-borne contaminants due to the consumption of fish from the Los Angeles/Long Beach (LA/LB) Harbor is a critical component of the recent *Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Load* (Harbor Toxics TMDL; RWQCB and USEPA 2011). To better understand how compliance with Harbor Toxics TMDL indirect targets may be achieved, the Ports of Long Beach and Los Angeles (together termed the Ports) are developing a bioaccumulation model as part of a Sediment Quality Objective (SQO) indirect effects Tier III assessment of the LA/LB Harbor. The objective of the bioaccumulation model is to develop a scientifically defensible link between fish contaminant concentrations and contaminant sources to provide the Ports with a tool to identify effective remediation options. To achieve this objective, the model will be based on the Conceptual Site Model (CSM) for indirect effects of contaminants due to the consumption of fish from the LA/LB Harbor, as presented at the February 22, 2013, Harbor Technical Working Group (HTWG) meeting (Anchor QEA and Everest 2013a). The CSM identified receptors of interest for the indirect effects Tier III assessment as fish that are commonly caught in the LA/LB Harbor and contaminants of interest as polychlorinated biphenyl (PCB) and dichlorodiphenyltrichloroethane (DDT). Sediments and the water column are sources of contaminants to the receptors. The pathway that links the PCB and DDT sources to the receptors is determined by the fate and transport processes identified in the CSM for chemical fate in the LA/LB Harbor (Anchor QEA and Everest 2014), as well as habitat areas and movement patterns of the receptors of concern. This report provides an overview of the analyses conducted to inform the CSM and develop the bioaccumulation model.

1.2 Background

The *Final Basin Plan Amendment*, an amendment to the *Water Quality Control Plan – Los Angeles Region to Incorporate the Total Maximum Daily Load for Toxic Pollutants in Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters* (RWQCB 2011), includes fish tissue and sediment total PCB (TPCB) and total DDT (TDDT) numeric targets.[1] A technically sound and logistically feasible management strategy for attaining these targets is needed due to the size and complexity of the LA/LB Harbor, the widespread distribution of legacy pollutants within the region, and the potential ecological and financial costs associated with sediment remediation. Consequently, an approach has been designed to assist the Ports with a strategy for meeting the total maximum daily load (TMDL) goal of reducing fish tissue concentrations within the LA/LB Harbor to levels that are safe for human consumption. This strategy has been previously described in the *Draft Fish Tissue Compliance Strategy* (Anchor QEA 2012) and *Draft Port of Long Beach TMDL Implementation Program* (Anchor QEA and Everest 2012) and is briefly summarized below.

The Ports' overall strategy involves identifying important contributors to fish tissue concentrations and developing a sediment management program that prioritizes management actions based on their effectiveness at reducing fish tissue concentrations. Reducing fish tissue impairments in a cost-effective manner requires knowledge of current sources of chemicals of concern and the physical, chemical, and biological processes that control the transfer of PCBs and DDTs from these sources to fish.

The Ports' strategy includes the use of computer models of physical, chemical, and biological processes within the LA/LB Harbor to evaluate various sources contributing to fish tissue concentrations. The Water Resources Action Plan (WRAP) Model will be used to understand the fate and transport mechanisms affecting PCBs and DDTs in the LA/LB Harbor and will be linked to the bioaccumulation model to evaluate the relative contribution of water column and sediment sources of PCBs and DDTs to the receptors of concern. The linked models will be used to compare the effectiveness of alternative management plans and will provide a way to evaluate how realistic goals may be achieved in a cost-effective manner. Models have been used to understand source contributions to human or wildlife receptors at numerous contaminated sediment sites throughout the United States under the Comprehensive Environmental Response, Compensation, and Liability Act; the Resource Conservation and Recovery Act; and the Clean Water Act's TMDL regulations.

[1] TPCB equals total congener PCB or total Aroclor PCB; specific congeners or Aroclor PCBs analyzed varied by study. TDDT equals total DDT and is comprised of the following constituents: 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,4'-DDT, 2,4'-DDE, and 2,4'-DDD.

1.3 Study Area Description

The LA/LB Harbor is managed by the Port of LA (LA Harbor) and the Port of LB (LB Harbor) and is the primary area of interest for analyses described in this report and for the bioaccumulation model (Figure 1-1). The LA/LB Harbor comprises the western portion of San Pedro Bay and is bounded to the south by the Federal breakwater, which consists of three separate segments. The eastern portion of San Pedro Bay is also protected by the Federal breakwater and mixes with the LA/LB Harbor to the east of Pier J. Although they are connected waterbodies, the LA/LB Harbor and Eastern San Pedro Bay are receiving waterbodies for different watersheds, and the rivers draining these watersheds and the stormwater contaminant sources to the LA/LB Harbor and Eastern San Pedro Bay may also be different. The LA/LB Harbor is the receiving waterbody for the Dominguez Channel Watershed, which encompasses more than 130 square miles and nine cities, and discharges through the Dominguez Channel into the LA/LB Harbor through Consolidated Slip. Both the LA River Watershed and San Gabriel River Watershed discharge into Eastern San Pedro Bay through the LA and San Gabriel Rivers, respectively. The LA/LB Harbor is also directly influenced by nearshore watersheds (i.e., Port of LA Watershed, Port of LB Watershed, and San Pedro Bay Watershed), which consists of the remaining drainage area that discharges directly into the LA/LB Harbor and Eastern San Pedro Bay.

While the LA/LB Harbor is the area of concern for bioaccumulation modeling and the understanding of linkages between contaminant sources and those in fish, Eastern San Pedro Bay is also included in the study area due to the likely exchange of water, sediment, and fish that occurs between the western and eastern portions of San Pedro Bay. The WRAP Model has been previously used to predict the hydrodynamics of the LA/LB Harbor and has predicted that large storms (e.g., 100 year storms) result in discharges from the LA River that not only flow directly into Eastern San Pedro Bay but also flow around Pier J into the LA/LB Harbor (Ports 2009). The rivers that feed into the LA/LB Harbor and Eastern San Pedro Bay (i.e., Dominguez Channel, LA River, and San Gabriel River) are not included in the study area due to differences in sources and responsible parties affecting these estuaries and because the water quality conditions of these estuaries are notably different from those of the LA/LB Harbor and Eastern San Pedro Bay receiving waterbodies.

While not included in the study area, the Palos Verdes Shelf is included in the analyses presented in this report and may be included in the bioaccumulation model due to the potential for migration of white croaker (*Genyonemus lineatus*) between the LA/LB Harbor and the Palos Verdes Shelf.

1.4 Model Development

The bioaccumulation modeling approach was previously described in the *Approach for Developing a Site-Specific Los Angeles and Long Beach Harbor Bioaccumulation Model* (Anchor QEA 2013a) and is briefly summarized below. The bioaccumulation model will be based on the CSM and builds on the framework developed as part of the Montrose Chemical Corporation (Montrose) Natural Resource Damage Assessment (NRDA) project (HydroQual 1997). This model will incorporate contaminant water column and sediment exposure concentrations and account for ongoing sources, regional background concentrations, and natural and anthropogenic recovery. The model will also include multiple sub-populations of fish as well as their migration within the LA/LB Harbor and to and from the Palos Verdes Shelf; a dynamic life-cycle; and site-specific growth rates, diets of target species, and lipid content to accurately represent contaminant dynamics in the harbor food web.

Bioaccumulation model development involves the following steps:

- Compilation of existing data
- Analyses of existing data in support of the CSM, including fish movement patterns, potential source identification, spatial patterns in contaminant concentrations in sediments, water and biota, natural recovery, and regional background concentrations
- Selection of target fish species for bioaccumulation modeling and compliance monitoring
- Identification of data gaps and the design and implementation of special studies to fill them
- Development, parameterization, and calibration of the model

The first step in this process was initiated in fall 2012 when existing data were compiled during a comprehensive data review (Anchor QEA and Everest 2013b; Ports 2013).

This report presents preliminary analyses conducted to develop the CSM and assess fish movement patterns, identify sources, evaluate spatial patterns in sediment and fish PCB and DDT concentrations, evaluate temporal trends for evidence of natural recovery, and characterize regional background PCB and DDT concentrations. The review and analysis of site-specific information, including diet and growth rates that will be used for model parameterization, are also presented. Data gaps were identified during analyses, and recommendations for a targeted food web sampling program designed to fill key data gaps are provided herein.

1.5 Data Gap Analyses

The remainder of this report includes the following:

- Section 2 includes a description of data sources and treatments used in the analyses presented in this report.
- Section 3 presents the evaluation of fish movement patterns.
- Section 4 presents the evaluation of spatial patterns in the PCB and DDT data in sediments and fish.
- Section 5 presents the evaluation of temporal patterns in the sediment, white croaker, and mussel data.
- Section 6 presents the synthesis of the CSM and information sources for key components of the bioaccumulation model.
- Section 7 summarizes data gaps found and provides recommendations for sampling programs to fill those gaps.

2 DATA SOURCES AND DATA HANDLING

This section describes data compilation updates, including new datasets received and other information essential for data analyses described in subsequent sections of this report. Data treatment and processing steps are also described; these steps were necessary for assessing data robustness as part of this data gaps analysis.

2.1 Sediment, Fish Tissue, and Mussel Tissue Chemical and Physical Data

Sediment, fish tissue, and mussel tissue data used in this analysis were based on datasets compiled in April 2013 (Ports 2013). Since then, new data have been received and datasets were updated as described below.

2.1.1 Project Data Sources

Data compiled in April 2013 (Ports 2013) were collected as part of a variety of characterization and monitoring studies conducted between 1977 and 2011 (see Tables 1, 2, and 3 in Ports 2013). Data from the LA/LB Harbor, Eastern San Pedro Bay, Dominguez Channel, and nearshore areas along the Southern California Bight are included in these compilations; the mussel dataset also includes data from other areas along the West Coast. Sediment data include PCBs, DDTs, and physical parameters (e.g., grain size), whereas fish and mussel tissue data include PCBs, DDTs, and lipid content. Polycyclic aromatic hydrocarbons (PAHs), other organochlorine pesticides, and metals were also included when minimal effort was required. Only data meeting basic data quality requirements were included in the data compilation. Sediment data collected by Weston in 2011 (Weston 2012) were excluded from analyses presented herein, because quality assurance is still in progress (Jirik pers. comm.). Quality control focused on accurate data compilation; beyond the requirements in Ports (2013), the quality of individual data sources was not independently evaluated.

Since compiling these datasets in April 2013, additional sediment data collected from 1998 to 2001 and 2006 to 2012 and fish data collected from 1990 to 2012 (primarily from the Palos Verdes Shelf) were acquired. New data added to the sediment and fish tissue data compilations followed the same data handling and treatment procedures for consistency (e.g., adjusting the calculated TDDT values in some studies to be consistent across sampling studies, setting non-detects to half of the method detection limit [MDL] or method reporting limit if no MDL was available, and assigning the highest individual analyte detection limit for TPCB or TDDT concentrations if all individual component concentrations were non-detect), as done for the original compilations. These new sediment and fish datasets are summarized in Tables 2-1 and 2-2, respectively.

In addition to incorporating new data, sediment and fish compilations were modified with new duplicate and coordinate information. The fish data compilation included standardization of fish and tissue names. These changes are documented in a readme file that will be distributed with the next data compilation release.

2.1.2 Data Availability and Data Gaps

Tables 2-3, 2-4, and 2-5 summarize the number of available sediment, fish, and mussel samples for specific analytes within each TMDL waterbody. Figures 2-1, 2-2, and 2-3 show collection locations within the LA/LB Harbor and Eastern San Pedro Bay for sediment, fish, and mussel data, respectively. Summary tables and maps include data from 1998 through 2012, which is the time period that preliminary spatial analyses were focused. Aroclor PCB and DDT data are also available for white croaker in Eastern San Pedro Bay, LA Outer Harbor, Cabrillo Beach and Marina, Cabrillo Pier, Seaplane Lagoon, and Palos Verdes Shelf from 1990 through 1997. Sediment data are available for Palos Verdes Shelf and all fish movement zones, except LA Outer Harbor, from 1980 through 1997 and are included in the preliminary temporal analyses presented in Section 5. The mussel data summary includes all historical data from 1977 through 2008.

As shown in Table 2-3, limitations in the sediment data preclude some spatial and temporal analyses. For sediment, fewer samples have measurements of total organic carbon (TOC) and percent fines than of DDT and Aroclor or congener PCB. Consequently, the organic carbon (OC) normalization of sediment contaminant concentrations is limited to a subset of the dataset.

For fish, more data are available for some species (i.e., white croaker, queenfish [*Seriphus politus*], California halibut [*Paralichthys californicus*], and topsmelt [*Atherinops affinis*]) than for other species in harbor areas and the region (Table 2-4). In addition, sufficient data for evaluating temporal trends are limited to white croaker data collected from Eastern San Pedro Bay, LA Outer Harbor, Cabrillo Beach and Marina, Cabrillo Pier, and Seaplane Lagoon. Consequently, data analyses presented in this report focus on white croaker, queenfish, California halibut, and topsmelt for spatial pattern analyses, and white croaker at Eastern San Pedro Bay, LA Outer Harbor, Cabrillo Beach and Marina, Cabrillo Pier, and Seaplane Lagoon for temporal trend analyses. Fish length and weight data from all species were limited and were therefore not useful as part of spatial or temporal trend analyses (i.e., length- or weight-normalization results in too small of a dataset for analysis; Table 2-4).

For mussels, TPCB and TDDT concentration data are limited to Cabrillo Marina, Consolidated Slip, LB Inner and Outer Harbor areas, LA Inner and Outer Harbor areas, and San Pedro Bay (Table 2-5). Lipids were measured in a limited data subset. Consequently, the temporal trend analyses on mussel tissue data focused on PCBs and DDTs on a dry-weight basis.

2.1.3 Data Treatments for Preliminary Data Analysis

Data treatments are detailed below.

- Sediment data treatment
  - The bioaccumulation model will rely on surface sediment exposure concentrations. Surface sediment was assumed to be the top 16 centimeters (cm). The surface sediment layer that is bioavailable to deposit-feeding organisms, and ultimately to fish, generally varies between 2 and 15 cm (McCall and Tevesz 1982; Kristensen 2005). Boudreau (1998) found a world-wide average mixed layer depth in marine sediments of 9.8 cm, with a standard deviation of 4.5 cm. The majority of sediment data collected in the LA/LB Harbor includes surface intervals that are 16 cm. Thus, a depth cutoff of 16 cm allows for retention of the majority of available data and provides a reasonable and likely conservative estimate of bioavailable sediment concentrations. The exception was for grain size data, where surface sediment was considered to be the top 1 foot due to the vertical segmenting of the majority of available data. Note that this depth cutoff is specific to the analyses of historical data presented in this report.

- Sedimentation rates in the LA/LB Harbor are predicted to be 1 to 10 millimeters (mm) per year (Everest 2012); at these rates, the top 10 cm can represent 10 to 100 years of deposition. For temporal trend analyses of surface sediment, the depth interval was further limited to minimize differences associated with different sample depths. Data from sample depths of 0 to 2, 0 to 5, 0 to 8, and 0 to 10 cm were retained for the temporal trend analyses.
- Data collected prior to 1998 were excluded from sediment data analyses, except for temporal comparisons, because this cutoff year retained the majority of the compiled dataset while excluding older data that do not reflect current conditions in the LA/LB Harbor. The cutoff year will be re-evaluated following the planned collection of sediment data as part of the Ports' TMDL program.
- Aroclor PCB data were excluded from data analyses when concurrent congener PCB data were available due to the higher accuracy and reliability of the congener PCB analytical methodology.
- Due to data limitations, Aroclor PCB data were used in temporal and spatial analyses for stations where no concurrent congener PCB data were available. Congener-based TPCB concentrations in sediments are compared with Aroclor-based TPCB concentrations in the same samples in Figure 2-4. As shown in these paired samples, Aroclor data are generally unbiased relative to the congener data (data tend to scatter around the 1-to-1 line), and the majority of congener- and Aroclor-based concentrations are within a factor of two of each other. However, it is uncertain whether TPCB concentrations based on historical Aroclor data are not biased compared with congener-based TPCB concentrations; in some subareas, the distribution of Aroclor-based TPCB concentrations compared with that of congener-based TPCB concentrations do show a bias (data not shown). For this reason, Aroclor- and congener-based concentrations were plotted separately with different symbols, and the results are interpreted with caution. Additionally, future analyses will be based on a refined data set (see Section 7).
- Surface sediment TPCB and TDDT concentrations show strong relationships with OC content (Figure 2-5); therefore, spatial and temporal trends are presented on an OC-normalized and dry-weight basis.
- Percent fines were mapped to evaluate potential biota habitat areas. Total fines were calculated as the sum of grain size data described as silt or clay. Where data

were not described as silt or clay, diameters were calculated from data reported on a phi scale; fines were assumed to be particles less than 62.5 micrometers (µm) in diameter.

- Fish data treatment
  - The majority of available sport fish samples were prepared as fillets while prey fish (i.e., topsmelt) were prepared as whole body. Because the concentration of organic contaminants may differ on a wet-weight basis in fillets versus whole body, data included on wet-weight plots were restricted to the most available preparation type. Sport fish plots included fillet samples (skin-off or skin-on), and prey fish plots included whole body samples. Lipid-normalization eliminates contaminant concentration differences in fillet and whole body preparations and thus lipid-normalized plots included fillet as well as whole body. Data for other body part preparations (e.g., liver or offal [fish guts]) were excluded.
  - Data collected prior to 1998 were excluded from fish data analyses, except for temporal comparisons and cross plots between TPCB and TDDT concentrations and between concentrations and lipid contents. This cutoff year retains the majority of the compiled dataset while excluding older data that do not reflect current conditions in the LA/LB Harbor.
  - TPCB and TDDT concentrations are generally correlated with lipid content for species and zones with sufficient sample sizes (Figure 2-6). Thus, temporal trends were evaluated on a lipid-normalized basis, in addition to a wet-weight basis, to account for temporal variability in lipid content (Figure 2-7).
  - Aroclor PCB data were excluded from the analysis where concurrent congener PCB data were available, due to the higher accuracy and reliability of the congener PCB analytical methodology. Aroclor-based TPCB concentrations were included where no concurrent congener-based concentrations were available.
  - Ten non-detect white croaker PCB data from the 2002 Los Angeles Terminal Island Water Reclamation Plant (LATIWRP) study were excluded due to the high Aroclor PCB detection limits[2] of 1,000 micrograms per kilogram (µg/kg) wet

[2] During dataset compilation, the highest detection limit among individual Aroclors was assigned as the TPCB concentration for samples with non-detect results for all reported Aroclors.

weight, which were 6 to 100 times higher than other Aroclor detection levels in the data compilation.

- One white croaker sample (IH5-FFF-7WC) was excluded from lipid-normalized plots due to a low lipid content of 0.05 percent.

- Mussel data treatment
  - Aroclor-based TPCB concentrations are included in temporal analyses for stations where no concurrent congener PCB data were available. Aroclor- and congener-based concentrations were plotted separately with different symbols.
  - Mussel temporal trend analyses presented include sand clam (*Macoma secta)*, resident California mussel (*Mytilus californianus*), and resident bay mussel (*Mytilus edulis*). Transplanted California mussel and transplanted freshwater clam were excluded.

2.2 Additional Data to Support the Conceptual Site Model and Bioaccumulation Model

A fish tracking study and a habitat quality analysis were performed to support the pathway component of the CSM and bioaccumulation model (Section 3). Datasets acquired to conduct these analyses include: 1) fish tracking study; 2) aquatic habitat; 3) benthic abundance; 4) fish abundance; and 5) bathymetry.

2.2.1 Fish Tracking Study

Fish movement data were obtained from a fish tracking study conducted from 2011 to 2013 by a California State University Long Beach (CSULB) team led by Dr. Christopher Lowe of the Department of Biological Sciences (Lowe et al. 2013). For this study, white croaker movements were tracked both passively and actively using acoustic telemetry. For passive tracking, 99 white croaker (equally distributed between the Inner and Outer Harbor areas) were caught using rod and reel and were surgically implanted with acoustic transmitters with a battery life of about 174 days. Forty-nine and 50 white croaker were tagged in summer 2011 and winter 2012, respectively. Catch locations for white croaker are shown in Figure 2-8. Twelve stationary underwater receivers were placed throughout the LA/LB Harbor from 2011 to 2012 (up to 12 months) and detected tagged white croaker when a fish was within range of the receiver (i.e., 150-meter radius). All receivers were deployed prior to fish tagging—except for receiver station 13 at the San Pedro Bait Barge, which was deployed on January 28, 2012—at the locations shown in Figure 2-8. Of the 99 white croaker tagged, 94 were detected by receivers for a total of 1,811,685 detections used for the analysis. For active tracking occurring intermittently between May 2011 and 2013, an additional 20 white croaker were tagged and actively tracked via transmitters emitting a signal every 2 seconds and a boat-mounted receiver for either a 24- or 48-hour period; multiple field surveys were conducted and most fish were tracked at least twice. Passive fish tracking data were provided by CSULB in spreadsheet format and were the focus of the fish movement evaluation. Active tracking data were used for comparative purposes.

2.2.2 Aquatic Habitat

Aquatic habitat data, including kelp and eelgrass information, were reviewed as part of this study as some fish and aquatic organisms use these habitats for food and protection. Four aquatic habitat studies were available for the LA/LB Harbor. A biological baseline study conducted in 2000 (MEC 2002), including mapping of eelgrass and kelp distributions, was the first comprehensive examination of the status of biological communities within the Inner and Outer Harbor areas since the 1970s. This baseline study was the first to map both distributions throughout both Ports. In 2008, environmental studies (SAIC 2010) were conducted in the LA/LB Harbor with the goal of providing updated quantitative information from the previous biological baseline study. Additional eelgrass information collected in 2012 was obtained for the NRG LB Generating Station Intake Area and Cerrito Channel Site, as part of two separate studies (MBC 2012a, 2012b).

The translation of eelgrass and kelp information from study reports to a usable format for spatial analyses required some processing and approximation. The location and extents of eelgrass and kelp data from the 2000 and 2008 studies were provided as shapefiles by the Ports. For each of the two eelgrass areas monitored in 2012, one set of coordinates was provided at roughly the center of the main patch of eelgrass; spatial delineations were estimated in ArcMap based on textual descriptions of the eelgrass beds.

2.2.3 Benthic Infauna Abundance

Benthic infauna are exposed to sediment-associated chemicals and are prey to benthic feeding fish species. Accordingly, benthic infauna are a key link in the transfer of chemicals from sediment to higher trophic levels within the food web. Benthic infauna data were compiled based on four recent studies. During a 2006 survey, samples collected from 60 locations within the Inner, Middle, and Outer Harbor areas using a Van Veen grab sampler were sorted and quantified into five main taxonomic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla (Weston 2008). A Ports' 2008 Biological Baseline Study (SAIC 2010) included quantification of benthic invertebrates in surface sediment from 29 stations within the LA/LB Harbor; samples were collected using a box core sampler[3] during winter and summer. Data from Southern California Bight Regional Monitoring Program (Bight) 2008 were provided by the Ports in spreadsheet format (CLAEMD 2010a, 2010b). Benthic taxonomy data collected from 11 locations in 2012 were obtained from Weston Solutions, Inc., in spreadsheet format (Weston 2012).

2.2.4 Fish Abundance

Studies of adult and juvenile fish abundance were conducted quarterly from January to July 2008 as part of the Ports' Biological Baseline Study within the LA/LB Harbor (SAIC 2010; also described in Section 2.2.2). A total of 62 taxa were collected. For analyses described in this report, mean fish abundance data from three sampling events (January, April, and June), based on fish collected by otter trawl alone, were manually extracted and compiled from report tables.

2.2.5 Bathymetry

An interpolated bed elevation surface based on the most recent bathymetry surveys of the LA/LB Harbor and Eastern San Pedro Bay was obtained from Everest International Consultant, Inc. (Everest 2013). The AutoCAD file contained 2- to 3-meter contours nearshore and 5-meter contours in deeper areas.

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[3] Some stations were also sampled with a Van Veen grab sampler. A comparison study to determine the comparability of data obtained with the two sampling techniques found no statistical differences in abundance or number of species between equipment types (SAIC 2010).

3 FISH MOVEMENT EVALUATION

The white croaker tracking study performed by CSULB between 2011 and 2013 characterized croaker movement within and outside the LA/LB Harbor to determine if croaker have a preference for specific habitats or areas within the LA/LB Harbor. Additional details about this study are provided in Section 2.2.1. Passive tracking data were evaluated to determine if sub-populations of white croaker exist with different movement patterns and consequently receive different exposures to PCBs and DDTs in the LA/LB Harbor.

3.1 Analysis of Fish Movement Data and Determination of Zones

Movements of individual white croaker were qualitatively categorized by movement patterns, based on the number of times they were detected in different zones of the LA/LB Harbor (i.e., at different receivers within the different zones) and their initial locations for capture and release.

Results indicate four major movement patterns:

- *Movement Pattern 1*: Fish caught and released in LA Outer Harbor that tend to stay in this area or move into LA Inner Harbor
- *Movement Pattern 2*: Fish caught and released in LA Inner Harbor (Consolidated Slip) that tend to stay in this area or move into LB Inner Harbor
- *Movement Pattern 3*: Fish caught and released in LB Inner Harbor that tend to move around all of LB Inner Harbor and LA Inner Harbor
- *Movement Pattern 4*: Fish caught and released in LB Inner Harbor that tend to stay in LB Inner Harbor

These movement patterns were used to develop the preliminary fish movement zones described in Table 3-1 and depicted in Figure 3-1. Movement Pattern 1 was used to establish Zone 1, which encompasses the portion of LA Outer Harbor where fish were detected. Movement Pattern 2 was used to establish Zones 3 and 4, which represent the area just downstream of Consolidated Slip (LA East Basin), and Consolidated Slip (as defined in the Harbor Toxics TMDL and by the Superfund program), respectively. Consolidated Slip was delineated as a separate zone from the LA East Basin, because it is targeted for future sediment management or remediation (City of Los Angeles 2014). Movement Patterns 3 and

4 were used to establish Zone 5, which encompasses LB Inner Harbor. Movement Pattern 3 fish traverse Zones 1 through 5, while Movement Pattern 4 fish prefer Zone 5 but in a few cases migrate as far as Zone 3. In addition to the zones established by the four major movement patterns described above, Fish Harbor was established as Zone 9, because it is targeted for remediation or sediment management (City of Los Angeles 2014). Furthermore, transition areas used by more than one fish movement group (i.e., Zone 2), areas where few fish were detected (i.e., Zone 10), and areas where fish movement was not measured (i.e., Zones 6, 7, 8, and 11) were incorporated into the overall delineation of the LA/LB Harbor. Preliminary fish movement zones are labeled as Zones 1 through 11 (and are not descriptive) to avoid confusion with the TMDL waterbody names used by the Regional Water Quality Control Board (RWQCB) and U.S. Environmental Protection Agency (USEPA) in the Harbor Toxics TMDL (Figure 3-1).

These fish movement zones were used to group data for analyses discussed in this report but should be considered preliminary. Results of the sediment and fish spatial analyses, along with the review of potential fish habitat characteristics (i.e., eelgrass and kelp, sediment characteristics, and bathymetry), prey abundance, and fish abundance, will be used with additional data and information collected as part of the 2013 fish tracking study and the harbor food web and compliance monitoring sampling programs to delineate final fish movement zones.

3.2 Comparison of Fish Movement with Harbor Habitat and Prey Abundance

Results of the comparison between fish movement data, harbor habitat information, fish abundance, and prey abundance are described below.

3.2.1 Habitat Data Comparison

Fish movement was not associated with the presence of eelgrass and kelp in the LA/LB Harbor (Figure 3-2); data available to date indicated that white croaker do not tend to move to areas or stay within areas where eelgrass and/or kelp are present. For example, the receiver station within the highest density of eelgrass within the entire harbor complex (receiver station 12 located in Seaplane Lagoon; Figure 2-8) had the lowest number of detections of all receiver stations; only two fish out of the 94 white croaker tagged visited that receiver over the course of the study. Note, however, that data are limited to the specific locations of receivers and of habitat data currently available within the LA/LB Harbor. Also, eelgrass may be an important habitat area for other target fish species, such as California halibut. Fish movement of halibut, in addition to white croaker, will be evaluated as part of the next phase of the fish tracking study and will provide additional fish movement data in areas with eelgrass and/or kelp.

TOC content in surface sediment (Figure 3-3) may be a factor in white croaker habitat selection, because benthic prey items typically are more abundant in areas with higher carbon contents. TOC was elevated in sediments in Zones 1, 3, and 4, areas in which white croaker were detected repeatedly. However, TOC is likely not the only factor influencing croaker habitat selection, because TOC was not elevated in Zone 5, another area of the harbor in which white croaker frequently visited in the study.

Grain size distribution was also compared with fish movement zones, because like TOC, fine-grained sediments are typically associated with a higher abundance of benthic organisms. As shown in Figure 3-4, grain size (measured as percent fine-grained sediment) also may influence white croaker movement patterns. Specifically, percent fines were elevated in the same areas of Zones 1, 3, and 4 where TOC was elevated. Percent fines were also elevated at some stations within Zone 5 where TOC was not elevated, but where fish have been shown to visit frequently. Due to limitations in the fish tracking study and therefore limited fish movement data in these areas, it is unknown whether white croaker prefer habitat in Zones 7 and 11, which also have some elevated fines concentrations.

3.2.2 Benthic Infauna and Polychaete Abundance Comparison

The abundance of potential prey items in specific zones may partially explain white croaker movement patterns and site fidelity. As shown in Figures 3-5 and 3-6, benthic infauna abundance (including polychaetes) and polychaete abundance, respectively, are highest in Zones 1, 3, 4, and 5. White croaker tagged in Zone 4 exhibited high site fidelity to the area, likely due to the higher abundance of polychaetes and other benthic infauna relative to most other areas. Fish that did travel outside of Zone 4 tended to only move to the adjacent Zone 5 and did not travel to other areas in the harbor, suggesting that white croaker show preference for these two zones. While not reviewed in detail as part of this report, active tracking data collected by CSULB support the findings of the passive tracking data. Actively tracked white croaker spent significantly more time per area in areas with moderately high polychaete abundance as compared to areas with lower abundance (Lowe et al. 2014).

The high abundance of food items in Zone 4 may explain in part why some fish tagged elsewhere in the LA/LB Harbor frequently move into this area. However, it is also possible that competition for food in Zone 4 influenced the movement of fish towards Zone 1. In addition, the higher abundance of food items in Zone 1 relative to other areas may have influenced white croaker movement from the Palos Verdes Shelf into this area (Lowe et al. 2013; Wolfe 2013).

3.2.3 Fish Abundance Comparison

White croaker abundance measured by otter trawl in the Ports' 2008 Biological Baseline Study (SAIC 2010) is not fully consistent with the movement patterns from the tracking study. White croaker showed the highest abundance in Zone 8, Zone 9, and the LB West Basin (southernmost portion of Zone 5). Movement data showed that some white croaker prefer Zone 5; however, due to limitations in receivers in or adjacent to Zones 8 and 9, it is unclear whether white croaker show preferences for Zones 8 and 9. The comparison between abundance and area preferences is also limited by differences in the size of fish used in the fish tracking study versus those caught in the 2008 Biological Baseline Study. Fish caught in otter trawls in the 2008 Biological Baseline Study represented a smaller size range (i.e., the majority of fish were 2 to 12 cm and 16 to 22 cm) than those used in the fish tracking study (ranged in size from 20 to 30 cm). Consequently, abundance data on immature croaker from the 2008 Biological Baseline Study may not accurately reflect where mature white croaker prefer to spend their time.

3.3 Fish Movement Zones and Data Gaps

Based on the review of existing data, data gaps (for understanding fish movement and habitat preferences) have been identified at several key locations in the LA/LB Harbor, including fishing piers (i.e., Cabrillo Pier and Pier J), entrances to slips and zones (e.g., Fish Harbor), shallow water habitat near Cabrillo Beach (which includes an abundance of eelgrass), and boundaries or transition areas between zones (e.g., between Zones 1 and 8). Specifically, the preference of white croaker for the areas adjacent to fishing piers relative to other areas is not well understood. The preference of white croaker or California halibut (being tracked in the second phase of the fish tracking study) for eelgrass in the shallow water habitat near Cabrillo Beach is also unclear. In addition, the tendency of white croaker to move into Fish Harbor or move from the LA Outer Harbor to the LB Outer Harbor, Palos Verdes Shelf, and Eastern San Pedro Bay is not well understood.

The second phase of the fish tracking study will be able to fill many of these data gaps, because receivers have been placed at key locations (e.g., fishing piers, the entrance to Fish Harbor, and boundaries between areas), as shown in Figure 3-8. The second phase of the fish tracking study, which is underway by CSULB, includes a higher sample size of white croaker being tracked (target sample size of n>150) and a secondary species (California halibut) to refine the contaminant exposure pathway of these two target species in the harbor food web.

The preliminary fish movement zones will be reevaluated and potentially modified. Final decisions about zone divisions will be determined after completing the second phase of the fish tracking study and the receipt and analysis of new data collected through the harbor food web and compliance monitoring programs. Potential modifications to be considered will be based on a review of fish movement data alongside sediment/fish contaminant relationships, habitat data, and fish and prey abundance data.

4 PCBS AND DDTS SPATIAL DISTRIBUTION EVALUATION

The spatial distribution of TPCB and TDDT concentrations in sediment and fish from the LA/LB Harbor was evaluated using the initial fish movement zones presented in Section 3 to assess gradients in contamination and the relationship between TPCB and TDDT concentrations in sediments relative to fish. The presence or absence of concentration gradients across zones was evaluated to support refinement of zone delineations. Sediment/fish relationships were quantified to provide evidence regarding exposure sources that similarly can aid in delineating zones; deviations from the overall LA/LB Harbor sediment/fish relationships can provide a means of identifying a possible misrepresentation of exposure sources. Finally, spatial analyses were used to identify data gaps in sediment and fish tissue PCB and DDT data; filling these data gaps will allow for a better understanding of sediment/fish relationships and improved model accuracy.

To put the TPCB and TDDT sediment and fish tissue concentrations into a regional context, these concentrations were also evaluated alongside regional fish/sediment relationships as described in more detail below.

4.1 Spatial Distribution of PCB and DDT Concentrations

The spatial distributions of sediment and fish tissue TPCB and TDDT concentrations were evaluated with box plots by fish movement zone. The box plots present the median, mean, quartiles, and outliers for each zone. The average concentration in each zone is also provided on the box plots. Zone concentrations are plotted starting with Consolidated Slip on the left and then clockwise around the LA/LB Harbor. Palos Verdes Shelf data are included on the right side of each figure for comparative purposes.

Surface-weighted average concentrations (SWACs) of LA/LB Harbor sediments were calculated using Thiessen polygons to obtain the best estimate of sediment exposure concentrations for comparison with levels in fish. Polygons were generated for the entire harbor using GIS software, followed by hand adjustments to eliminate the influence of data points across land masses. SWACs were then calculated for each harbor zone on both a dry-weight and OC-normalized basis.

4.1.1 Sediment

The spatial distributions of TPCB and TDDT concentrations in surface sediments are shown in Figures 4-1 and 4-2, respectively, on both a dry-weight (top panel) and OC-normalized basis (bottom panel).

The highest average and median sediment TPCB concentrations are found in Zone 4 (Consolidated Slip) and Palos Verdes Shelf, and concentrations generally decrease moving from the Inner to Outer Harbor. Concentrations in Zone 11 (Eastern San Pedro Bay) fall within the mid-range of concentrations measured in the harbor.

The highest TDDT concentrations are also found in Zone 4 (Consolidated Slip) and Palos Verdes Shelf on a dry-weight basis; however, carbon normalization reduces TDDT concentrations in Zone 4 to levels comparable with Zones 2 and 3 (LA Inner Harbor zones). Additionally, Palos Verdes Shelf TDDT concentrations are more than an order of magnitude above concentrations in the LA/LB Harbor zones, whereas the TPCB distribution on Palos Verdes Shelf overlaps with the concentrations in the Zones 2, 3, and 5 (Inner Harbor zones). Also, while TDDT sediment concentrations in Zones 2 and 3 (encompassing LA Main Channel) are greater than those in the rest of the LA/LB Harbor (except for Zone 4 [Consolidated Slip]), a gradient from the Inner to Outer Harbor for TDDT is less than that for TPCB. TDDT concentrations in Zone 11 (Eastern San Pedro Bay) fall within the range of concentrations measured in the zones encompassing Outer Harbor (Zones 7, 8, and 10). Finally, TDDT concentrations in Zone 1 (Cabrillo Marina, Cabrillo Beach, Cabrillo Pier, and adjacent area) approach the concentrations in zones encompassing LA Main Channel (Zones 2 and 3).

Thiessen polygon maps of TPCB concentrations show the same spatial patterns as those shown in the box plots (Figure 4-3). TPCB concentrations were highest in Consolidated Slip and Inner Harbor, were lowest in Outer Harbor, and were mid-range in Eastern San Pedro Bay. Thiessen polygon maps also illustrate where dense or sparse sample results contribute to greater uncertainty in contaminant concentrations within the zones presented in the box plots. For example, samples are densely populated within Consolidated Slip. In contrast, confidence in exposure concentrations is less in zones with lower sample density, especially in areas with large concentration gradients in samples proximate to each other. On a dry-weight basis, most individual sample results in Zones 2, 3, and 5 (Inner Harbor zones) have TPCB concentrations above the TMDL indirect effects target (3.2 µg/kg wet weight) in comparison to Zones 1, 7, and 8 (encompassing Outer Harbor) in which only some individual sample results are elevated above the TMDL indirect effects target.

As with the box plot comparison, the spatial distribution of sediment TDDT concentrations shown on the Thiessen polygon maps of the LA/LB Harbor and Eastern San Pedro Bay show a different pattern than that of TPCB concentrations (Figure 4-4). Most individual TDDT results within the harbor and Eastern San Pedro Bay are greater than the TMDL indirect effects target (1.9 µg/kg).

4.1.2 Fish Tissue

The spatial distribution of TPCB and TDDT concentrations for four fish species (white croaker, queenfish, California halibut, and topsmelt) with data sufficient to evaluate are presented in Figures 4-5 and 4-6, respectively, on a wet-weight (top panel) and lipid (bottom panel) basis. Spatial patterns in fish TPCB concentrations show some similarities to sediment TPCB patterns. All four species had the highest TPCB concentrations (on both a wet-weight and lipid-normalized basis) in Zone 4 (Consolidated Slip). However, TPCB concentrations in white croaker on Palos Verdes Shelf did not approach those seen in Zone 4 and were not elevated compared with the rest of the LA/LB Harbor zones. White croaker median TPCB concentrations in Zone 9 (Fish Harbor) were comparable to those in Zone 4 (Consolidated Slip) on a wet-weight basis; although the median and average TPCB concentrations are somewhat lower on a lipid basis, they are still elevated compared with the rest of the LA/LB Harbor (Figure 4-5d). The spatial distribution of TPCB concentrations in queenfish and California halibut are similar to those in white croaker, although no data are available for Palos Verdes Shelf and the sample sizes are smaller for these species (Figures 4-5a and b, respectively). Average topsmelt TPCB concentrations are relatively constant throughout the harbor, except for within Zone 4 (Consolidated Slip); however, no samples are available from Zone 9 (Fish Harbor; Figure 4-5c) for comparison.

The highest average TDDT concentrations in white croaker from the harbor (more than 1,000 µg/kg wet weight) were found in fish collected from Zone 2 (part of LA Main Channel;

Figure 4-6d). Average white croaker TDDT concentrations in the remainder of the LA/LB Harbor ranged from approximately 100 to 400 µg/kg wet weight (Figure 4-6d). As with sediment, average and median TDDT concentrations in Palos Verdes Shelf white croaker are well above concentrations in the LA/LB Harbor (Figure 4-6d). Average TDDT concentrations in the other fish species were lower when compared with white croaker, ranging between 30 to 200 µg/kg wet weight (Figures 4-6a, b, and c). No consistent spatial patterns in average TDDT concentrations were found for queenfish, California halibut, or topsmelt; however, some of the highest concentrations measured for queenfish and topsmelt were measured in fish from zones encompassing Outer Harbor (Zones 1, 7, and 8). Currently, no data are available for queenfish, California halibut, and topsmelt from Palos Verdes Shelf.

4.2 Relationships Between TPCB and TDDT Concentrations in Sediment and Fish Tissue

4.2.1 Comparison of Sediment and Fish Tissue PCBs and DDTs by Zone

The relationships between sediment and fish tissue TPCB and TDDT concentrations were evaluated by comparing average concentrations in fish tissue to SWAC sediment concentrations within each fish movement zone for the four species, separately (Figures 4-7a, b, c, and d and Figures 4-8a, b, c, and d). Neutral organic contaminants preferentially associate with carbon phases of sediments and biota; thus, comparisons were made on an OC-normalized basis for sediment and a lipid basis for fish tissue.

The three predatory fish species (California halibut, queenfish, and white croaker) contain more TPCB and TDDT per unit of lipid than per unit of total OC (Figures 4-7a, b, and d and Figures 4-8a, b, and d, respectively). For most comparisons, TPCB concentrations in white croaker range from approximately a factor of one and one-half to three times greater than those in sediment, while TDDT concentrations range from approximately a factor of two to three greater than those in sediment; these ranges overlap the historical fish tissue to sediment concentration ratios of these contaminants computed from Palos Verdes Shelf data (HydroQual 1997; ITSI 2009). The relationship of white croaker tissue to sediment TPCB concentrations from the Palos Verdes from recent data also appears to about a factor of two (Figure 4-9a; segments are shown in Figure 5-13). However, the tissue to sediment TDDT relationship from more recent Palos Verdes Shelf data appears to be lower than those in LA/LB Harbor (Figure 4-9b).

Concentrations of both TPCB and TDDT in white croaker and sediment are correlated with a few exceptions. Croaker TPCB concentrations in Zone 9 (Fish Harbor) are elevated relative to sediment compared with the general relationship of most LA/LB Harbor zones. This elevation may be due to an underestimate of sediment exposure concentrations; cores from Fish Harbor that were excluded from SWAC calculations (due to having surface sample depths greater than 16 cm) have higher concentrations than shallower samples included in the SWAC, suggesting that the actual exposure concentrations may have been underestimated. Another exception for TPCB is Zone 6 (LB Southeast Basin), which could be due to the fact that croaker caught in this sub-area are transitory and thus are being exposed elsewhere. For TDDT, elevated concentrations in white croaker compared with sediment are also found in Zone 2 (part of LA Main Channel) and Zone 5 (LB Inner Harbor). The surface sediment sampling program planned for 2014 will aid in refining these relationships. It is also possible that fish in these areas may be migrating to areas with different sediment concentrations (e.g., Palos Verdes Shelf). Additional fish tracking data will support this evaluation. In addition, model sensitivity analyses will be used to evaluate the impacts of uncertainty in fish movement patterns.

The relationship of TPCB concentrations in queenfish and sediments suggest similar patterns to those for white croaker, although with more variability (Figure 4-7b). The relationship for TDDT, however, is poor. Both TPCB and TDDT concentrations in California halibut do not correlate well with sediment concentrations. One possible explanation of this lack of relationship is a difference in food web structure. Halibut consume small pelagic fish (Plummer et al. 1983), which in turn are probably exposed primarily to TPCB and TDDT in the water column via a phytoplankton-based food web (Melwani et al. 2009). This implies that the halibut food web may differ from that of white croaker insofar as water column sources of these contaminants may be dominant. In addition, they may have home ranges that are larger than the preliminary fish movement zones; movement patterns will be evaluated using the ongoing fish tracking study. Topsmelt TPCB and TDDT concentrations also show no relationship with sediment concentrations, which may be because water column sources are also important for this species or topsmelt receive more localized exposure than the zone average. Extensive movement is not a likely explanation for the lack of fish to sediment TPCB and TDDT concentration relationships for topsmelt, because previous studies of contaminant concentrations and morphology of topsmelt suggest that this species has a limited movement range (Greenfield and Jahn 2010; O'Reilly and Horn 2004).

4.3 TPCB and TDDT Concentrations in Regional Fish Tissue

An understanding of regional background concentrations is important for evaluating the benefits of potential remedial actions within the LA/LB Harbor, because these background concentrations represent the achievable baseline concentrations. Attaining and maintaining remediation target levels below regional background is not feasible, because remediated areas will be subject to recontamination to regional background levels through sediment transport, atmospheric deposition, and/or fish migration. The analysis presented below includes fish tissue data from 1998 through 2012. The regional area around the LA/LB Harbor, northwest to 50 miles west of Santa Barbara, and areas southeast to the border between California and Mexico was chosen as the region of interest and is shown in Figures 4-10 and 4-11 (surface sediment concentrations for TPCB and TDDT, respectively) and Figures 4-12 and 4-13 (white croaker concentrations for TPCB and TDDT, respectively).

White croaker TPCB and TDDT concentrations within the LA/LB Harbor and Eastern San Pedro Bay are compared with regional data shown on these maps and are plotted versus distance along the coastline to demonstrate variability and sample numbers associated with spatial patterns along the coast. For coastline plots, mile-point zero was set to represent the mid-point of Angel's Gate, the first opening in the Federal breakwater to the east of the Palos Verdes Shelf. Each white croaker sampling location was assigned a mile-point to the north and to the south based on the distance to Angel's Gate.

White croaker is the only species for which sufficient fish tissue was available for a regional comparison. Regional TPCB and TDDT concentrations are lowest north of LA and south near San Diego and highest along the Palos Verdes Shelf (Figures 4-14 and 4-15). Considerable overlap does occur between the ranges of concentrations inside of the LA/LB Harbor and concentration nearby outside the breakwater.

4.3.1 Comparison of TPCB and TDDT Concentrations in Harbor Fish with Regional Data

To conduct a more quantitative comparison of TPCB and TDDT concentrations found in LA/LB Harbor fish with those found regionally, regional data were divided into local and regional background. These regions, shown in Figure 4-16, were selected based on spatial distributions of contaminant concentrations in sediment and fish. Many metrics can be used to establish background concentrations. For this analysis, the 95 percent upper confidence limit (UCL) of local and regional background was selected. The selection of an appropriate metric will be reconsidered during model calibration and the evaluation of future conditions. Fish data within these regions were used to generate the 95 UCL to compare with data in the LA/LB Harbor (Figure 4-17).

Average concentrations of TDDT in white croaker exceed the regional background 95 UCL in all zones, using both wet-weight based and lipid-normalized data (Figure 4-17a). In contrast, average TDDT concentrations in most zones are either less than local background 95 UCL or exhibit error bars that overlap the local 95 UCL, except for Zone 2. The difference in the relationship between LA/LB Harbor data and regional versus local background will be an important consideration in the application of the bioaccumulation model.

For TPCB, average concentrations for all zones exceed the regional 95 UCL on a wet-weight and lipid-normalized basis (Figure 4-17b). Average TPCB concentrations exceed the local 95 UCL, except for Zones 5 and 8 (wet-weight basis) and Zones 11 and 8 (lipid-normalized basis).

5 NATURAL RECOVERY EVALUATION

Monitored natural recovery (MNR) is a remedial alternative under evaluation as part of the TMDL program to determine its potential effectiveness as part of the sediment management approach for the LA/LB Harbor. MNR is often implemented in concurrence with active management strategies to allow for a more rapid reduction of higher-risk sediment or sediment that has a lower potential for natural recovery (USEPA 2005). The potential effectiveness of MNR varies by site and depends on the depositional rate, extent of ongoing source inputs, and other site conditions; consequently, natural recovery must be evaluated on a site-specific basis.

In this report, natural recovery occurring in the LA/LB Harbor was evaluated using existing data to support an evaluation of the appropriateness of MNR as a remedial alternative as well as to identify data gaps associated with assessing temporal trends in sediment and biota TPCB and TDDT concentrations. As described by USEPA (2005), primary lines of evidence recommended for assessing natural recovery include the following:

- Evaluation of temporal trends in sediment and tissue contaminant concentrations over time
- Measurement of sediment deposition rates

Temporal trends in surface sediment, fish tissue, and mussel tissue TPCB and TDDT concentrations were evaluated and are presented below. Statistical trends were not quantified due to data limitations, variations in analytical methods, and variations in sampling designs. As a result, trends are qualitatively identified. In addition, vertical contaminant trends in sediment cores collected from undisturbed (i.e., non-dredged) areas within two localized areas of the LA/LB Harbor were also evaluated to determine if contaminant concentrations in more recent (surface) sediments are lower than sub-surface sediments, which would be evidence of natural recovery by burial.

5.1 Temporal Trend Analyses of TPCB and TDDT Concentrations in Surface Sediment and Biota

Temporal trends for TPCB and TDDT concentrations in sediment, fish, and mussel tissue were evaluated using data collected through the studies described in Section 2 for the LA/LB Harbor as a whole and within the fish movement zones described in Section 3.

5.1.1 Temporal Trends in Sediments

5.1.1.1 Surface Sediments

Annual average TPCB and TDDT concentrations in surface sediments on a dry-weight basis are shown for the individual fish movement zones with sufficient data (Figures 5-1a and 5-3a; Zones 1 through 11 as described in Table 3-1) and from the Palos Verdes Shelf (Figures 5-2a and 5-4a). Palos Verdes Shelf data are plotted at water depths of 30 meters (depths where white croaker are generally found) and at 61 meters where the White Point outfall diffusers discharge (ITSI 2013). TDDT concentrations appear to be declining in the LA/LB Harbor zones, with the most consistent declines in Zone 1 (Cabrillo Marina, Cabrillo Beach, Cabrillo Pier, and adjacent area; Figure 5-1a). Surface sediment TDDT concentrations on an OC-normalized basis were similar to those observed for dry-weight data (Figure 5-1b). In Palos Verdes Shelf sediment, TDDT concentrations declined historically through the mid-2000s at 30 meters (Figures 5-2a and b); patterns in more recent years are not clear. Recent TDDT concentrations also do not show a decline in sediment collected from 61 meters and, specifically, at the location closest to the outfall location (Location 8C) (Figure 5-2a and 5-2b). A recent analysis of Palos Verdes Shelf data collected by the USEPA (ITSI 2013) led to the conclusion that TDDT concentrations are trending downward on the shelf, based on a comparison of geostatistical models of data collected from 2002/2004 and 2009. The trends presented above are not inconsistent with the USEPA's analysis. While declines in recent data have slowed, TDDT concentrations do appear to be lower in 2009 compared with 2002/2004 at 30 meters (Figure 5-2b). While the concentrations near the outfall (61 meters and 8C) are similar in 2009 compared with 2002/2004 (Figure 5-2b), the downward trend noted by USEPA was based on a spatially weighted average of data collected from the entire Palos Verdes Shelf and thus represents an integration of results from all depths.

Average annual TPCB concentrations in surface sediment on a dry-weight basis from the LA/LB Harbor zones are more variable than those of TDDT (Figures 5-3a); recent levels are lower than historical levels, but declines appear to be slower. In Palos Verdes Shelf sediment, OC-normalized TPCB concentrations show consistent declines at 30 meters, historical declines at 61 meters, and no decline at Station 8C (Figure 5-4b). Note that older data were Aroclor-based, while newer data were congener-based, which could confound the interpretation of trends, and therefore, conclusions should be considered tentative.

Most sediment data collected in the LA/LB Harbor were based on a targeted placement of sampling locations. Specific locations were not collected as part of a random sampling program, which can lead to sampling bias. Additionally, trends discussed above are based on arithmetic averages of sediment data within LA/LB Harbor zones. To evaluate whether these potential biases might have affected LA/LB Harbor sediment temporal trends presented above, trends based on annual SWACs of PCB and DDT data available from programs that employed random sampling methods were evaluated in zones with sufficient data (i.e., Zone 7 [LB Outer Harbor area] and Zone 11 [Eastern San Pedro Bay]). The only program with sufficient data that employed random sampling was Bight conducted in 1998, 2003, 2008, and 2013. Data from 2013 are preliminary and have not been included at this time; however, upon validation of the Bight 2013 dataset, the trends based on SWACs of PCBs and DDTs will be re-evaluated. SWACs were calculated using Inverse Distance Weighted interpolation in GIS software. Concentrations measured in these programs were generally less than concentrations measured in other targeted sampling programs; therefore, the resulting annual SWACs for Zone 7 are lower than those based on all data combined (compare Table 5-1 with Figures 5-1a and 5-3a). In Zone 11, most data were collected as part of the Bight program; therefore, SWAC concentrations are comparable to the arithmetic averages (compare Table 5-1 with Figures 5-1a and 5-3a). Regardless of concentration, the trend suggested by these SWACs of the limited randomly sampled data available for these zones is similar to that presented above for Zones 7 and 11, providing support for the trends presented above.

5.1.2 Vertical Contaminant Trend Analyses

The distribution of contaminants with depth in undisturbed; depositional sediment areas provide a means of assessing whether surface sediment concentrations are declining. Contaminant concentrations were measured in sediment cores collected from Consolidated Slip; core locations are shown in Figure 5-5 (AMEC 2003). Consolidated Slip was last dredged in the 1930s, according to U.S. Coast Guard Service charts (Appendix A). Contaminant concentrations from individual core segments were plotted against depth to assess whether there were reductions in concentration over time that indicate an improvement in sediment quality near the surface.

The distribution of TPCB and TDDT concentrations with depth in sediment cores collected from Consolidated Slip are shown in order from upstream to downstream in Figure 5-6a and b, respectively. These contaminant profiles vary with depth. In the upper section of Consolidated Slip (Stations CS-2 to CS-4), TPCB and TDDT concentrations were greater near surface segments (0.5 to 5 feet) and decreased with depth. In some cases (Stations CS-3 and CS-4), the peak is in the second core slice, with somewhat lower concentration in the surface slice. At Station CS-5, the highest concentrations of TPCB were measured in the deepest horizon. In the middle to lower section of the slip (Stations CS-6 to CS-14), peak TPCB and TDDT concentrations in most core samples were found in the middle horizons of the cores (4- to 12-foot depths). TPCB and TDDT concentrations decreased towards the surface (to less than 3 feet below the surface) and with increasing core depth beneath the peak; the lowest concentrations of TPCB and TDDT were typically found in the deepest core sections (greater than 13 feet). Carbon data are not available for some of the surface sections of the cores, and therefore, near-surface vertical trends cannot be determined on an OC-normalized basis for all cores. Where OC data are available, similar contaminant patterns were found when Consolidated Slip sediment contaminant data were evaluated on an OC-normalized basis (Figure 5-7a and b).

In Consolidated Slip, the decline in contaminant concentrations towards the surface in the middle to lower sections of the slip suggests that sediment quality is improving in this area. This pattern is similar to patterns observed on Palos Verdes Shelf (Eganhouse et al. 2000). On Palos Verdes Shelf, peak TDDT concentrations were at 30 to 40 cm in depth, consistent with peak annual mass emissions of effluent solids, PCBs, and DDTs that occurred in 1971 (CH2M Hill 2007).

There are two potential explanations for the lack of contaminant decreases in sediment contaminant profiles from the upper portion of Consolidated Slip (CS-2 to CS-4). Less deposition of sediment may be present in these areas as a result of the original basin design of the slip and the associated bathymetry. As shown in Appendix B, the upper most part of the slip (closest to the Henry Ford Avenue Bridge) was not dredged (POLA 1931) or was dredged to shallower depths (Department of Commerce 1934). If this is the case, the peak may lie within the thickness of the first surface slice (0 to 0.5 foot); it is possible that a peak in contamination was not captured by data presented in Figure 5-7. It is also possible that erosion in this area may have affected the vertical pattern of contamination.

5.1.3 Temporal Trends in Mussels

Figure 5-8 shows temporal trends in TPCB and TDDT concentrations in mussels over time at Cabrillo Pier compared with those from Palos Verdes Shelf. Mussels were collected from other zones of the LA/LB Harbor, and TPCB and TDDT concentrations in mussels from other zones demonstrate downward trends over time through the 1980s and 1990s (not shown). However, recent data are only available for Cabrillo Pier and Palos Verdes Shelf, and it is unclear if the declines seen through the 1980s and 1990s are ongoing in all zones.

TDDT concentrations and decline rates in Cabrillo Pier mussels are similar to those in Palos Verdes Shelf mussels. TPCB concentrations in mussels collected from Cabrillo Pier appear to be slightly higher, and are declining more slowly, than the mussels on Palos Verdes Shelf. Declines in DDTs and PCBs reported here are consistent with decreasing trends for these contaminants in mussels in the harbor and many Southern California sites, as described by the State Water Resources Control Board (Melwani et al. 2013). Specifically, Melwani et al. (2013) measured significant decreases in mussel TPCB and TDDT concentrations near the Palos Verdes Shelf (resident mussels) and at two sites in the harbor (transplanted mussels).

5.1.4 Temporal Trends in White Croaker

Figures 5-9a and b and Figures 5-10a and b show temporal trends in white croaker TDDT concentrations from the LA/LB Harbor and Palos Verdes Shelf; Figures 5-11a and b and Figures 5-12a and b show temporal trends in white croaker TPCB concentrations. The trends are evaluated on a wet-weight (Figures 5-9a, 5-10a, 5-11a, and 5-12a) and lipid-normalized (Figures 5-9b, 5-10b, 5-11b, and 5-12b) basis within individual fish movement zones with sufficient data (samples collected from at least 3 years); Zones 1, 8, 10, 11; Cabrillo Pier; and Palos Verdes Shelf (Segments 9, 10, 11, and 13-14; segments are shown in Figure 5-13).

TPCB concentrations in white croaker demonstrate downward trends over time within Zone 8 (LA Outer Harbor), Zone 10 (Seaplane Lagoon) and Palos Verdes Shelf on both a wet-weight and lipid basis (Figure 5-11a and b). Zone 1 (Cabrillo Marina, Cabrillo Beach, Cabrillo Pier, and adjacent area) shows a decline on a wet-weight (Figure 5-11a) but not a lipid-basis (Figure 5-11b). The PCB trend in white croaker is generally flat in the other zones, Zone 11 (Eastern San Pedro Bay), and Cabrillo Pier; data, however, are limited and may be confounded by the mix of Aroclor- and congener-based TPCB concentrations. Similar to TPCB, TDDT concentrations also show a decline in Zone 8 (part of LA Outer Harbor), Zone 10 (Seaplane Lagoon and adjacent area), and Palos Verdes Shelf on both a wet-weight and lipid basis (Figures 5-9a and b and Figures 5-10a and b, respectively) and at Zone 1 (Cabrillo Marina, Cabrillo Beach, Cabrillo Pier, and adjacent area) on a wet-weight basis only (Figure 5-9a). A downward trend is also suggested for TDDT on a wet-weight basis at Cabrillo Pier, but data do not extend past 2003 (Figure 5-9a). The white croaker TDDT concentration trend in the remaining sub-area, Zone 11 (Eastern San Pedro Bay), is generally flat on both a wet-weight and lipid basis, similar to that of TPCB (Figures 5-9a and b).

The historical decline (from mid-1990s through early 2000s) in both TPCB and TDDT concentrations in white croaker on the Palos Verdes Shelf is clear (Figures 5-10a and b and Figures 5-12a and b; segment 13-14). However since 2006, temporal trends in TPCB and TDDT concentrations are confounded by low sample counts and, for TPCBs, the change in analytical methods, from Aroclor- to congener-based methods. Limited available data suggest that TPCB and TDDT declines in recent years are not as strong as in the past.

5.1.5 *Evidence for Natural Recovery*

Based on trends in sediments and mussels, natural recovery in the LA/LB Harbor is evident. However, mussels have substantial variability and slow declines, particularly for TPCB concentrations. White croaker tissue TPCB and TDDT concentrations show clear historical declines in Zone 8, but recent declines are unclear, similar to white croaker concentration trends on the Palos Verdes Shelf. Evidence for white croaker recovery in the other zones is intermittent. Additional data are needed to evaluate trends.

5.2 Natural Recovery Data Gaps

Results of this natural recovery evaluation provide some evidence of recovery of sediment quality in the LA/LB Harbor.

This recovery is likely the result of both natural and anthropogenic effects. Natural recovery in the LA/LB Harbor may be occurring due to the deposition of less contaminated sediments from industrial, stormwater, and wastewater sources over the past few decades and associated reductions in surface sediment deposits of DDTs and PCBs in the LA/LB Harbor. Dredging of sediments over the past 20 years may also be a contributing factor.

To better understand the potential effectiveness for MNR as a remedial alternative in the LA/LB Harbor, a more accurate understanding of natural recovery that may be occurring due to the deposition of cleaner sediments is needed. To fill this information gap, an investigation is recommended in which high-resolution geochronology and analytical chemistry cores are synoptically collected and analyzed. Geochronology cores will allow for the determination of sedimentation rates by measuring the age of sediments at various depths in cores taken from sampling locations throughout the LA/LB Harbor and will provide a key line of evidence in the evaluation of natural recovery in the study area. The synoptic analysis of chemicals at different depths within cores will be used to quantify temporal trends in contaminant concentrations in sediments and will allow for calculation of a rate of recovery in conjunction with dating information provided by geochronology data.

Additional mussel data can also provide an important line of evidence regarding natural recovery. In addition to mussel data collection at Cabrillo Pier and the adjacent area, data are needed at other targeted locations within the LA/LB Harbor to determine whether historical declines are continuing. Moreover, additional data are needed for white croaker in targeted zones. Additional data for California halibut and shiner surfperch (*Cymatogaster aggregata*) will also be useful in understanding trends; however, because data are limited for these species, several additional years of data would likely be required to evaluate trends in these species.

6 CONCEPTUAL SITE MODEL OVERVIEW AND BIOACCUMULATION MODEL PARAMETERS

This section provides an overview of the fish species selected to represent the receptors identified in the CSM for the LA/LB Harbor, including growth information, diet, and relevant bioenergetics parameters that will be used to parameterize the bioaccumulation model. Additionally, a discussion of sources and pathways of PCBs and DDTs to the harbor is presented.

6.1 Harbor Food Web and Bioaccumulation

The CSM identified fish species that are commonly caught in the LA/LB Harbor as receptors of interest for the indirect effects Tier III assessment. To represent the harbor food web, the bioaccumulation model will include a bottom-feeding predator, a sport fish that feeds in the water column, and a prey fish. As shown in Figure 6-1, this representative food web will enable exposure to the water column and sediment sources of PCBs and DDTs simultaneously. Species chosen to represent the harbor food web will include the sport fish California halibut, white croaker, and the prey fish shiner surfperch for reasons discussed below.

6.1.1 Food Web Structure

6.1.1.1 California Halibut

California halibut was selected as a representative sport fish, because halibut are commonly caught and consumed by anglers in the LA/LB Harbor in the Cabrillo Pier area (SCCWRP and MBC 1994). In addition, the State of California Office of Environmental Health Hazard Assessment (OEHHA) recommends reduced servings of halibut caught in the LA/LB Harbor region, because concentrations of TPCB and TDDT have been elevated in some halibut caught within the harbor (OEHHA 2009). Abundance in the harbor has been demonstrated as part of biological baseline studies in 2000 and 2008 (MEC 2002; SAIC 2010). In addition, the use of this species in the bioaccumulation model will be informed by a fish tracking study currently underway to evaluate the movement of California halibut within the harbor.

6.1.1.2 White Croaker

White croaker was selected as a representative species in support of the Harbor Toxics TMDL, as Section 7.6.2 of the TMDL requires compliance monitoring of this species (RWQCB and USEPA 2011). In addition, this species is representative of benthic-feeding fish, is abundant in the harbor (MEC 1988, 2002; SAIC 2010), and is commonly caught and consumed by local anglers in the Cabrillo Pier area (SCCWRP and MBC 1994). The health advisory and safe eating guidelines developed by OEHHA (2009) suggests that white croaker caught from Ventura to San Mateo Point should not be eaten (regardless of age or gender) due to elevated TPCB and TDDT concentrations in croaker fillets, which historically exceed fish consumption advisory tissue levels. White croaker are found in nearshore habitats and are a bottom-dwelling species that primarily feed on benthic organisms, including polychaetes and clams. Consequently, it is likely that white croaker are indirectly exposed to sediment contaminants through the consumption of benthic organisms (Moore 1999) and possibly through incidental ingestion of sediment (Ware 1979).

6.1.1.3 Shiner Surfperch

Shiner surfperch was selected as the representative prey species, because they are abundant in the LA/LB Harbor and surrounding waterways (SAIC 2010) and are likely prey for higher trophic level fishes, such as California halibut (CDFG 2001, 2002; Allen et al. 1988; CDFW 2013). Shiner surfperch are also listed in OEHHA (2009) for reduced consumption or no consumption due to elevated TPCB and TDDT concentrations measured in tissue of surfperch from the region. In addition, shiner surfperch are representative of important prey fish, because the diet of this species is similar to other key prey fish in the harbor, such as topsmelt. Both species have been shown to feed on zooplankton, algae, amphipods, polychaetes, and gastropods (Odenweller 1975; Sempier 2013; UC 2013).

6.1.1.4 Invertebrates

The harbor food web is comprised of a variety of organisms that have been described in several biological baseline studies (SAIC 2010; MEC 2002). For the bioaccumulation model, several types of invertebrates have been chosen to represent different trophic levels, benthic or pelagic food webs, and key feeding strategies of harbor invertebrates. Mussels will be used to represent filter feeding organisms; polychaetes will be used to represent deposit-feeders;

and crustaceans, including amphipods, will represent organisms feeding on a mixture of plankton and detritus. Additional groups of organisms, such as scavenging crustaceans, may also be included as part of further model development.

6.1.1.5 Representativeness of Selected Species

To evaluate the degree to which species selected to represent the harbor food web are representative of the TPCB and TDDT concentrations in other species, average concentrations in available fish were compared with those in the target species.

Average TPCB and TDDT concentrations in sport fish are compared with those in California halibut from the harbor area in Figures 6-2a and b, respectively. As shown, average TDDT concentrations in halibut are generally within a factor of two and thus are representative of those in sport fish available for comparison (Figure 6-2a). Average TPCB concentrations in halibut are generally biased high when compared with TPCB concentrations in other sport fish, thereby providing a conservative comparison (Figure 6-2b).

Average TPCB and TDDT concentrations in queenfish and yellowfin croaker (*Umbrina roncador*) are compared with those in white croaker in Figures 6-2a and b, respectively. The average TPCB and TDDT concentrations in white croaker exceed those in queenfish and yellowfin croaker everywhere except for Zone 1, in which concentrations of these species lie within a factor of two. Thus, white croaker provides a conservative representation of queenfish in these sub-areas.

Shiner surfperch and other prey fish data are limited in the harbor and thus are not available for comparison. This data gap has been identified in Section 7 and will be addressed with TMDL compliance and harbor food web sampling programs.

6.1.2 Diet Parameterization

Tables 6-1, 6-2, and 6-3 illustrate several initial dietary scenarios for each of the target species. These scenarios summarize the diet for each species, based on literature studies described in more detail below, and assume a simplified harbor food web using representative prey items with different feeding strategies. Diets of the target species will be developed based both on this dietary information as well as stable isotope data that will be collected as part of the data gaps sampling program.

6.1.2.1 California Halibut

Diets of California halibut described in literature are summarized in Table 6-1. California halibut primarily consume scavengers such as crustaceans, worms and other deposit feeders, and fish; however, the proportion varies by age. Juvenile California halibut (less than 20 mm) from Alamitos Bay were found to have a similar diet to slightly larger juvenile halibut (20 to 80 mm), except the slightly larger juvenile halibut also consume small fish such as anchovies in the 20 to 80 mm size class (Allen 1988). Plummer et al. (1983) found that larger halibut (124 to 476 mm) off the coast of Northern San Diego County primarily consume fish. Similar findings were reported by Haaker (1975) for California halibut from Anaheim Bay.

6.1.2.2 White Croaker

White croaker are benthic foragers whose diets are primarily comprised of polychaetes and crustaceans found within soft sediment habitats (Allen 1982, 1985, 2001; Table 6-2). Younger white croaker from LA Outer Harbor have been shown to incorporate zooplankton into their diet in addition to polychaetes and crustaceans (Ware 1979); zooplankton contributed to the croaker diet until the fish reached a length of approximately 200 mm. White croaker with lengths between 101 to 200 mm have been shown to consume nominal amounts of fish species such as anchovy (Ware 1979). Jahn (2008) and Malins el al. (1987) found that small fish were a component of the white croaker diet.

Malins et al. (1987) also has direct relevance to the bioaccumulation model, because this study assessed the diet of white croaker spatially from the LA/LB Harbor to Dana Point, located approximately 35 miles to the southeast of the LA/LB Harbor. Malins et al. (1987) found that LA/LB Harbor white croaker consumed more polychaetes and crustaceans, whereas Dana Point white croaker consumed more mussels and filter feeders. As shown in Table 6-2, the diet of LA/LB Harbor white croaker in Malins et al. (1987) and Ware (1979) are similar.

6.1.2.3 Shiner Surfperch

Diets for shiner surfperch reported in literature are summarized in Table 6-3. Most studies on shiner surfperch have demonstrated that their diet is largely comprised of zooplankton and/or crustaceans such as shrimp, amphipods, and isopods (Odenweller 1975; Bane and Robinson 1970; Jahn 2008; Woods 2010). Shiner surfperch have also been shown to consume some detritus, phytoplankton, mussels and other filter feeders, and worms and other deposit feeders. The shiner surfperch feeding mode is described as "picker" (Barry and Calliet 1981). Differences in shiner surfperch diets described in the literature are likely related to age, location, and season. Odenweller (1975) found that shiner surfperch from Anaheim Bay switch their diet between seasons and consume more zooplankton and less sediment and detritus-dwelling organisms in summer and fall than in winter and spring.

In a bioaccumulation model developed for San Francisco Bay, shiner surfperch diets were primarily based on crustaceans and plankton (Gobas and Arnot 2010). In contrast, juvenile shiner surfperch were assumed to consume a diet primarily comprised of phytoplankton (60 percent) and zooplankton (25 percent) in the Mackintosh et al. (2004) bioaccumulation model of False Creek Harbour near Vancouver, British Columbia.

6.1.3 Invertebrate Diets

Mussels are representative of filter-feeding organisms, including clams, oysters, some amphipods, brachiopods, and other pelagic organisms that are assumed to derive most of their food from the water column particulates. Given that these organisms filter water just above the sediment surface, detritus deriving from the sediment is also ingested incidentally (Mackintosh et al. 2004; Gobas and Arnot 2010).

Worms are representative of deposit-feeding organisms, including polychaete and other annelid worms. These organisms primarily consume detritus. Crustaceans represent scavengers such as amphipods. The crustacean group consumes predominately recently deposited detritus deriving from the water column (Gobas and Arnot 2010).

For the purpose of quantifying PCB and DDT transfer, invertebrates are distinguished by their exposure source (water column via algae or freshly deposited detritus versus sediment via deposit feeding) and degree of bioaccumulation.

Research demonstrates that benthic invertebrate growth and habitat selection are strongly correlated with the availability of fresh organic material (Purinton 2005; Stapleton et al. 2001; Vos et al. 2004; De Haas et al. 2006). For example, Stapleton et al. (2001) used stable isotope ratio analysis to show that the primary source of PCBs to benthic invertebrates in Lake Michigan was from the settling of fresh organic matter rather than PCBs in sediments, and field abundance, habitat selection, and laboratory growth of *detritivorous chironomid* larvae have been found to be positively correlated with variables indicative of fresh organic matter (Vos et al. 2004; De Hass et al. 2006).

The relative proportion of particulate material ingested by the representative invertebrate prey deriving from the water column versus the sediment bed is based on literature and available site-specific data but will be used as a calibration parameter in the model.

6.2 Bioenergetics and Toxicokinetics

6.2.1 Growth Rates

Growth rates for each species are necessary model input parameters. Growth rates are species-specific and affected by numerous factors including age, sex, and temperature. Growth rate estimates for fish are based on length-at-age relationships. Fish otoliths (i.e., the inner ear structure) accumulate daily rings or annuli and thus their measurement can be used to age fish. Growth rate estimates based on length-at-age relationships available from literature will be converted to weight-at-age relationships for use in the model. These relationships are described below for each of the target species. These growth rates may be modified following the collection of additional fish from the LA/LB Harbor as part of compliance monitoring or planned special studies.

6.2.1.1 California Halibut

Most age and growth studies for California halibut have been based on studies of halibut at aquaculture facilities, and consequently, growth rates for raising halibut at varying water velocities, stocking density, salinity, and temperature are available. Monthly growth rates for halibut from Alamitos Bay ranging from 7 to 77 mm grew on average 10.71 mm per month (in 1983) and 29.78 mm per month (in 1985; Allen 1988). Recent length-at-age relationships have been established for both sexes of halibut in Southern California (MacNair et al. 2001) and are listed in Table 6-4 and shown in Figure 6-3.

6.2.1.2 White Croaker

White croaker growth rates used in the bioaccumulation model developed as part of the Montrose NRDA project (HydroQual 1997) relied on length-at-age relationships and weight-at-length relationships developed by Love et al. (1984) and Isaacson (1964), respectively. Length-at-age and weight/length relationships available from Moore (1999) are based on the analyses of white croaker from Palos Verdes Shelf and consistent with those developed by Love et al. (1984) and Isaacson (1964); these relationships are compared in Figures 6-4a and b and detailed in Table 6-5.

6.2.1.3 Shiner Surfperch

Limited growth rate information is available for shiner surfperch. Length-at-age and weight/length relationships from shiner surfperch from Humboldt and Anaheim Bay were determined by Anderson and Bryan (1970) and Eckmayer (1979) and are shown in Figures 6-5a and b, respectively, and listed in Table 6-6. Sex differences for weight/length relationships are provided and differ in magnitude between the two studies. Anderson and Bryan (1970) describe males as increasing in weight relative to length faster than females; whereas Eckmayer (1979) describes females and males having similar weight/length curves. Odenweller (1975), another study from Anaheim Bay, also measured length at age for shiner surfperch; however, data were not included here because this relationship was significantly different than those from Anderson and Bryan (1970) and Eckmayer (1979). These relationships will be used for initial model development and will be modified as appropriate when additional site-specific growth rate data become available.

6.2.2 Respiration

Respiration is calculated in the bioaccumulation model as a function of weight, water temperature, an activity multiplier, and empirical coefficients. The weight of the fish will be specified by growth rates, and the temperature profile will be obtained from conductivity, temperature, and depth monitoring data collected by the Port of LA from three stations throughout the LA Harbor and data collected as part of the ultra-low detection limit water column study of the harbor. For white croaker, the activity multiplier and empirical coefficients used in the Montrose NRDA bioaccumulation model (HydroQual 1997) will be used; the HydroQual (1997) respiration model was based on Hemmingsen (1960). Respiration coefficients for shiner surfperch will be based on respiration rates for surfperch measured by Webb (1975) and Gordon et al. (1989). Similarly, respiration coefficients for California halibut will be based on respiration rates for halibut measured by Merino et al. (2009, 2011).

6.2.3 Lipid Contents

Lipid values for each species will be based on site-specific data. Given that age information is not available for existing fish data, the relationship of lipids with age in the target species cannot be evaluated. Thus, the initial bioaccumulation model will be parameterized with average lipid contents that do not vary by age. Year-to-year variation in lipid contents will be incorporated into the model as determined by site-specific data from existing data or planned special studies. Lipid data from within the LA/LB Harbor are currently not available for shiner surfperch; available lipid data for shiner surfperch caught along the Southern California Bight will be used as a surrogate until shiner surfperch lipid data become available after compliance monitoring and data gaps sampling programs are implemented.

6.2.4 Contaminant Mass Transfer at the Gill

Computation of the gill exchange rate of the contaminant from an organism requires the estimation of the partitioning of contaminants between lipid and aqueous phases; the octanol-water partition coefficient (K_{ow}) is used as an estimate. For the analyte group sums (i.e., TPCBs and TDDTs), the K_{ow} value will reflect the congener or chemical composition in the modeled species. High-resolution PCB and DDT data made available through the harbor food web and compliance monitoring sampling programs will be used to develop site-specific and species-specific K_{ow} values.

The rate of contaminant exchange between water and the organism is also controlled by the efficiency with which the contaminant is absorbed from the water. The chemical uptake efficiency (P-ratio; k_{gl}/k_{glO_2}, where k_{gl} is the chemical mass transfer coefficient and k_{glO_2} is the oxygen mass transfer coefficient) can be approximated by the ratio of contaminant to oxygen exchange efficiency. Connolly et al. (1992) reported P-ratio values between 0.1 to 1.0 for PCBs in walleye (*Sander vitreus*) and brown trout (*Salmo trutta*), as a function of K_{ow}. The chemical uptake efficiency value (expressed as E_w in the Gobas model) can also be obtained as a function of log K_{ow} through the approximation developed by Arnot and Gobas (2004):

$$E_w = \left(1.85 + \left(\frac{1.55}{K_{ow}}\right)\right)^{-1} \quad (1)$$

The ratio of uptake to elimination rate constants control gill exchange. Initially, the bioaccumulation model will be parameterized with the P-ratios specified for the Palos Verdes Shelf (HydroQual 1997). Once the K_{ow} value is supported by site-specific data, the chemical update efficiency rate constant will adjusted, but the final value will be used a calibration parameter.

6.3 Exposure Characterization

Fish can acquire PCBs and DDTs from both water column and residual sediment contamination within the LA/LB Harbor. The chemical fate CSM developed for the harbor waters provides a broad, overall view of the importance of various processes or mechanisms that control the fate and transport of chemicals into and out of LA/LB Harbor (Anchor QEA and Everest 2014). The bioaccumulation model incorporates the CSM for chemical fate as well as fish movement patterns that determine contaminant exposure.

Numerous processes can affect the fate of chemicals within the water column. The following processes were considered during CSM development for the harbor:

- Air components (wet deposition, dry deposition, and gas exchange)
- Watershed components (gaged and nearshore contributions)
- Sediment and water column components (tidal exchange, settling, sediment-water diffusion, groundwater advection, and degradation)

For the CSM, annual loadings of TPCB and TDDT concentrations were estimated for each of the processes indicated above (see Figure 4 in Anchor QEA and Everest 2014). As shown, tidal exchange appears to be an important process; watershed loadings may also be important. As part CSM development for chemical fate, other mechanisms contributing to the gain or loss of PCBs and DDTs to the LA/LB Harbor were shown to be less important; these include wet and dry deposition, groundwater, and chemical degradation in the water column. The fate model, to be incorporated into the WRAP Model, will enable the distinction between ongoing external and residual internal sources to the harbor food web.

The movement of fish controls their exposure. As shown by white croaker movement data (Section 3), fish exhibit a certain degree of site fidelity within the LA/LB Harbor, but exhibit movement within the harbor, between the fish exposure zones described above, and to some degree between the LA/LB Harbor and Palos Verdes Shelf. Movement patterns based on the fish tracking study will be incorporated into the bioaccumulation model.

7 DATA GAPS SUMMARY

This report includes analyses conducted in support of CSM and bioaccumulation model development; the analyses of fish movement patterns, spatial patterns in sediment and fish TPCB and TDDT concentrations, relationships between fish and sediment PCB and DDT concentrations, and temporal trends for evidence of natural recovery; and characterization of regional background concentrations of PCBs and DDTs. Data and information that will be used to parameterize the bioaccumulation model were also presented. Data gaps identified as part of this study and other related studies are summarized below.

7.1 Fish Movement Data Gaps

As described in Section 3, the first phase of the CSULB fish tracking study provided quantitative data on white croaker movements within the LA/LB Harbor as well as to and from Palos Verdes Shelf. However, additional data gaps in white croaker movement patterns remain and are listed in Table 7-1. A second phase of the fish tracking study is currently being implemented by CSULB, focusing on the placement of receivers and targeted capture, tagging, and releasing white croaker in areas with identified data gaps (Section 3.3). While fish movement within LB Outer Harbor and Eastern San Pedro Bay will not be directly assessed during this study due to the inability to place receivers or other project limitations, respectively, the movement of fish into Eastern San Pedro Bay and between LB Outer Harbor and other harbor sub-areas will be determined.

Fish movement data within the LA/LB Harbor are not available for the other target fish species (Table 7-1). Thus, the second phase of the fish tracking study currently underway is addressing California halibut movement data gaps throughout the LA/LB Harbor using the same receivers as those used for white croaker (Figure 3-8). Transmitter locations were selected in LA/LB Harbor areas where size-appropriate halibut were caught and tagged. Additional transmitters were placed at Pier J and Cabrillo Pier, because these are well-known fishing piers in the harbor area; understanding the movement of fish in these areas will provide information on the movement and sediment exposure patterns for fish most likely to be caught and consumed. Shiner surfperch movement data gaps cannot be addressed by the fish tracking study, because these fish are too small for transmitter installation. Movement of shiner surfperch in the bioaccumulation model will be based on fish contaminant data and movement information acquired from literature. The fish movement study will fill data gaps to provide the information necessary to revise preliminary fish movement zones.

7.2 Biota and Sediment PCB and DDT Data Gaps

Spatial and temporal analyses presented in Sections 4 and 5 reveal several biota and sediment PCB and DDT data gaps. These data gaps, as well as plans for addressing these gaps, are discussed below.

7.2.1 Biota

The analysis of spatial trends presented in Section 4 reveals that white croaker, California halibut, and shiner surfperch PCB and DDT data are needed in areas listed in Table 7-1. Data are needed to better understand spatial patterns, fish and sediment PCB and DDT relationships, and temporal trends. Existing California halibut TPCB and TDDT concentrations did not show a clear relationship with sediment concentrations; Section 5 reveals temporal and spatial data gaps for white croaker.

White croaker tissue TPCB and TDDT concentrations showed clear historical declines in Zone 8 but declines in other preliminary fish movement zones were less clear. Temporal patterns in mussel TPCB and TDDT concentrations also demonstrated declines at Cabrillo Pier. Declining concentrations were also observed in other areas of the harbor; however, recent data were only available for Cabrillo Pier, and therefore, it is unclear if declines seen through the 1980s and 1990s are ongoing in all zones. Thus, additional white croaker and mussel PCB and DDT tissue data are needed to determine whether historical declines in TPCB and TDDT concentrations are continuing and to provide additional data that can improve the analysis of temporal trends (Table 7-1).

Existing California halibut TPCB and TDDT concentrations did not show a clear spatial pattern or relationship with sediment concentrations, but additional data in all LA/LB Harbor areas are needed to better understand movement patterns for the evaluation of temporal trends. For shiner surfperch, data are needed in all LA/LB Harbor areas to understand spatial trends and initiate the determination of temporal trends (Table 7-1).

Except for Southeast Basin, white croaker PCB and DDT spatial data gaps in all areas outlined in Table 7-1 will be filled through the implementation of the food web sampling and compliance monitoring programs targeted for 2014. The white croaker data gap in Southeast Basin will be addressed through modification of the preliminary fish movement zones. Specifically, Southeast Basin and LB Outer Harbor fish movement zones will likely be combined, because these adjacent zones demonstrate similar sediment contaminant concentrations and physical characteristics. Targeted sampling areas for the fulfillment of white croaker data gaps are shown in Figure 7-1.

All halibut PCB and DDT spatial data gaps identified in Table 7-1 will be filled through the implementation of the food web sampling and compliance monitoring programs. Temporal data gaps will also be filled in all areas identified, except for LA Inner Harbor. Targeted sampling areas for the fulfillment of halibut data gaps are shown in Figure 7-2. For shiner surfperch, most spatial data gaps in surfperch TPCB and TDDT concentrations will be filled through upcoming sampling programs. Similar to halibut, data collected through the food web sampling and compliance monitoring programs will provide a baseline from which temporal trends can be evaluated after future monitoring events. Targeted sampling areas for the fulfillment of shiner surfperch data gaps are shown in Figure 7-3.

Contaminant data in other biota (i.e., polychaetes and mussels) that will serve as representative prey for the representative fish species in the bioaccumulation model are also a goal of the program. Additional mussel data are needed in several areas of the LA/LB Harbor (Table 7-1). Given the lack of recent contaminant data for polychaetes, data for these organisms are needed throughout the LA/LB Harbor.

Polychaete PCB and DDT spatial data gaps identified in Table 7-1 will be filled by implementing the food web sampling program, which will target collection of polychaetes at 10 to 11 stations throughout the harbor, as shown in Figure 7-4. Eastern San Pedro Bay is currently not targeted for polychaete collection in this program. The concurrent collection of sediment and polychaete data from 10 to 11 stations within the LA/LB Harbor, where a wide range of sediment PCB and DDT concentrations have previously been measured, will enable the establishment of relationships between sediment and polychaete TPCB and TDDT concentrations. From these relationships, concentrations in worms from Eastern San Pedro Bay can be reasonably predicted.

All mussel PCB and DDT spatial and temporal data gaps identified in Table 7-1 will be filled through the implementation of the food web sampling program. This program targets the collection of five composite samples from four areas of the LA/LB Harbor (i.e., Consolidated Slip, LA Inner Harbor Main Channel, Cabrillo Pier, and LB Inner Harbor), in which resident mussels have been previously collected during numerous years over the past 20 years. Targeted stations for the fulfillment of mussel data gaps are shown in Figure 7-5.

As more data are collected, the biota dataset discussed in Section 2 may be refined. For example, because temporal comparability of fish data is confounded by differences in analytical methodologies over time (Table 7-2), characterization of temporal trends will be quantified using solely congener data in the future.

7.2.2 Sediment

Surface sediment data gaps exist due to spatial gaps in a few areas; in other areas data are limited to older samples that potentially do not represent current sediment quality conditions or surface samples that include greater depths and do not closely represent the bioactive surface layer (approximately 10 cm depth).

As additional data are collected, received, and incorporated into the Ports' databases, the constraints (e.g., retaining sediment and fish data from 1998 and later for evaluation) discussed in Section 2.1.3 may be further refined. The objectives of the refinement are to characterize contaminant concentrations so that they are comparable spatially and temporally to describe current conditions. Refinements related to the selection of the starting year and to differences in laboratory analytical methodologies among studies have been recently explored.

The use of older sediment data compromises the characterization of current conditions, because older data generally exhibit higher concentrations due to natural recovery (see Figures 5-3a and b), are more often Aroclor-only (Table 7-3), and congeners often have 25 or fewer congeners quantified (Figure 7-6). In contrast, nearly all PCB data from 2003 to present are congener-based with greater than or equal to 40 congeners quantified (Figure 7-6). Because historical programs used different analytical methodologies, which are laboratory- and method-specific (Figure 7-7), development of a coherent dataset is difficult.[4] Moreover, Aroclor-only data with limited documentation cannot be confidently combined with congener data. In the future, recommendations for characterizing current sediment concentrations will likely be the use of data from 2003 to present, data quantified using congener methods only, and data from only programs with greater than or equal to 40 congeners measured. The chemical fate model will be calibrated using this optimized dataset.

The additional constraints discussed above introduce surface sediment data gaps, in addition to those identified in Sections 4 and 5. These data gaps are detailed in Table 7-1. These data gaps will be addressed through the implementation of a surface sediment data gaps sampling program that targets data collection in areas shown in Figure 7-8.

The temporal trend analyses discussed in Section 4 provided some evidence of recovery in LA/LB Harbor sediment quality; however, trends in surface sediment concentrations are confounded by the redistribution of sediments through physical processes. This sediment movement cannot be assessed with existing sediment core profile data, which are limited to undated cores in Consolidated Slip and LB Inner Harbor West Basin areas. Consequently, additional data are needed to improve the understanding of natural recovery throughout the entire harbor (Table 7-1). To fill this information gap, the Ports have recently funded a high-resolution geochronology and analytical chemistry coring program to more accurately determine sedimentation rates and to quantify historical changes in TPCB and TDDT concentrations. To maximize the usability of core data, sampling locations have been placed in depositional environments with the least probability of disturbance.

7.3 Food Web Structure

An additional data gap identified as part of this study is the establishment of the food web structure for organisms in the harbor food web. To address this data gap, stable isotope

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[4] As described in Section 2.1.3, data analyses presented earlier in this report distinguish Aroclor and congener data using different symbols or only uses congener data for samples where both were measured.

analyses are also planned as part of the food web sampling program to determine the approximate trophic position ($\delta^{15}N$ stable isotope analysis) and dietary sources ($\delta^{13}C$ stable isotope analysis) of the representative fish species and their prey in the bioaccumulation model.

7.4 Other Data Gaps

Additional data gaps have been identified in other previously completed studies and are briefly summarized below.

Stormwater and water column TPCB and TDDT concentrations are data gaps that were identified as part of the *Draft Comprehensive Data Review for the TMDL Program Memorandum (*Anchor QEA and Everest 2013b) and were determined to be important as described as part of the development of a chemical fate CSM for the LA/LB Harbor (Anchor QEA and Everest 2014). Results of this study demonstrated that watershed loadings may be important not only as direct sources of chemicals to the water column of the harbor but also as sources of contaminated particles settling on the harbor sediment bed.

The Ports have funded a stormwater monitoring program for purposes of collecting additional stormwater PCBs and DDTs and particulates from key upstream sources (i.e., LA River, Dominguez Channel [and Torrance Lateral], and Machado Lake), using high resolution methods. This study is currently underway and will fill key data gaps on stormwater sources of PCBs and DDTs and improve the understanding the watershed loadings to the harbor.

It was also previously determined that additional information on water column TPCB and TDDT concentrations throughout the harbor will be necessary for an accurate assessment of all sources of these contaminants to fish receptors (Anchor QEA and Everest 2013b). Previous studies conducted in the harbor demonstrated primarily non-detect results, and detected results were sporadic and were not representative of annual concentrations in the harbor. In addition, the chemical fate CSM study further discussed the potential importance of determining water column TPCB and TDDT concentrations; these data are used in the calculation of various processes including settling, tidal exchange, and sediment-water fluxes (Anchor QEA and Everest 2014). To address this data gap, the Ports have funded the first phase of a low detection limit method development study to determine the most appropriate method for the collection of water column TPCB and TDDT concentrations; the second phase of this study will assess the spatial differences in water column PCB and DDT concentrations throughout the harbor, between dry and wet events and among various water column depths, using the most appropriate method. Results of this study will support the development of the WRAP and bioaccumulation models.

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TABLES

Table 2-1
Summary of Additional Ports of Long Beach and Los Angeles Sediment Chemical and Physical Datasets

Study	Reference	Start Year	End Year	General Location	Description of Stations	Number of Stations	Multiple Depths (Y/N)	Depth Interval(s)	Analytes	Quantitative QA/QC (Y/N)
PV SHELF	LACSD 2013a-c	1998	2001	Southern California Bight	Northern extents of Southern California Bight, Palos Verdes Shelf	44	N	0-8 cm	Grain size, PCB congeners, PCB Aroclors, organochlorine pesticides, conventional parameters	N
Weston	Weston 2013	2012	2012	LA/LB Harbor	LA Outer Harbor, Consolidated Slip	12	N	0-5 cm	PCB congeners, organochlorine pesticides, conventional parameters	Y
SG River	ABC 2013a-b	2007	2012	San Gabriel River	San Pedro Bay	4	N	0-5 cm	Metals, PAHs, PCB congeners, organochlorine pesticides, conventional parameters	Y
POLAPOLB-2006	Weston 2007	2006	2006	LA/LB Harbor, San Pedro Bay	LB Inner Harbor, LB Outer Harbor, LA Inner Harbor, LA Outer Harbor, Cabrillo Marina, Inner Cabrillo Beach Area, San Pedro Bay	59	N	0-1 ft	Grain size [1]	N

Notes:
1 The sediment data compilation from April 2013 already contained data for other parameters for this study.
cm = centimeters
ft = feet
LA = Los Angeles
LB = Long Beach
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
QA/QC = quality assurance/quality control

Table 2-2
Summary of Additional Ports of Long Beach and Los Angeles Fish Tissue Chemistry Datasets

Study	Reference	Year	General Location	Station Description	Species	Number of Samples/ Species	Composite (Y/N)	Number in Composite	Tissue Sample Type	Analytes	Quantitative QA/QC (Y/ N)
Weston	Weston 2013	2012	LA Inner and Outer Harbors	Consolidated Slip, LA Outer Harbor 1a	Queenfish, White Croaker	1-12	Y	NA	Fish gut	PCB Congeners, DDTs, lipid	Y
Weston	Weston 2013	2012	LA Inner and Outer Harbors	Consolidated Slip, LA Outer Harbor 1a	California Halibut, Queenfish, White Croaker	1-26	N	NA	Fillet without skin	PCB Congeners, DDTs, lipid	Y
Weston	Weston 2013	2012	LA Inner and Outer Harbors	Consolidated Slip	Queenfish	1	N	NA	Fish gut	PCB Congeners, DDTs, lipid	Y
Weston	Weston 2013	2012	LA Inner and Outer Harbors	Consolidated Slip	Topsmelt	7-14	N	NA	Whole fish	PCB Congeners, DDTs, lipid	Y
LACSD	LACSD 2013d	1990	Palos Verdes Shelf	Zone 1 (outfall zone) and 3 (distant zone)	Dover Sole, Kelp Bass, White Croaker	5-14	Y	10	Skin-off fillet	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1990	Palos Verdes Shelf	Zone 1 (outfall zone) and 3 (distant zone)	Red Urchin	8-12	N	10	Gonad	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1990	Palos Verdes Shelf	Zone 2 (distant zone)	Kelp Bass	12	Y	1-5	Liver	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1991	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Dover Sole	6-10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1992	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass, White Croaker	10-12	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1992	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Red Urchin	10	N	NA	Gonad	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1992	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Dover Sole	1	Y	6-10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1993	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Dover Sole	1	Y	7-10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1994	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1994	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Red Urchin	10	N	NA	Gonad	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1995	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass, White Croaker	10-12	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1995	Palos Verdes Shelf	Zone 1 (outfall zone) and 3 (distant zone)	Dover Sole	1-2	Y	10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1996	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass, White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1996	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Red Urchin	10	N	NA	Gonad	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1996	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Dover Sole	1-2	Y	10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1996	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass	2	N	NA	Liver	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1997	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1999	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	1999	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Dover Sole	1	Y	10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y

Table 2-2
Summary of Additional Ports of Long Beach and Los Angeles Fish Tissue Chemistry Datasets

Study	Reference	Year	General Location	Station Description	Species	Number of Samples/ Species	Composite (Y/N)	Number in Composite	Tissue Sample Type	Analytes	Quantitative QA/QC (Y/ N)
LACSD	LACSD 2013d	2000	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass, White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2000	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Red Urchin	10	N	NA	Gonad	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2000	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Dover Sole	1-2	Y	5-10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2000	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass	2	Y	5	Liver	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2001	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2001	Palos Verdes Shelf	Zone 1 (outfall zone)	Dover Sole	2	Y	10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2002	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass, White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2002	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Red Urchin	10	N	NA	Gonad	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2002	Palos Verdes Shelf	Zone 2 (distant zone)	Dover Sole	1	Y	5-10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2002	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass	2	Y	5	Liver	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2004	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass, White Croaker	10	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2004	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Red Urchin	10	N	NA	Gonad	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2004	Palos Verdes Shelf	Zone 1 (outfall zone)	Dover Sole	1	Y	5-10	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2004	Palos Verdes Shelf	Zone 1 (outfall zone), Zones 2 and 3 (distant zone)	Kelp Bass	2	Y	5	Liver	PCB Aroclors, DDTs, lipid	Y
LACSD	LACSD 2013d	2005	Palos Verdes Shelf	Zone 1 (outfall zone)	White Croaker	30	N	NA	Fillet without skin	PCB Aroclors, DDTs, lipid	Y
San Gabriel River Regional Monitoring Program	ABC 2013a,c	2006	San Gabriel River	San Gabriel River Estuary - Upper	Striped Mullet	1	Y	2	Fillet	PCB Congeners, DDTs, lipid	Y
San Gabriel River Regional Monitoring Program	ABC 2013a,c	2007	San Gabriel River	San Gabriel River Estuary - Upper and Lower	Carp, Striped Mullet, Tilapia	1	Y	6-7	Fillet	PCB Congeners, DDTs, lipid	Y
San Gabriel River Regional Monitoring Program	ABC 2013a,c	2008	San Gabriel River	San Gabriel River Estuary - Upper	Carp, Striped Mullet, Tilapia	1	Y	3-8	Fillet	PCB Congeners, DDTs, lipid	Y
San Gabriel River Regional Monitoring Program	ABC 2013a,c	2009	San Gabriel River	San Gabriel River Estuary - Upper	Striped Mullet	2	Y	6	Fillet	PCB Congeners, DDTs, lipid	Y

Notes:
DDT = dichlorodiphenyltrichloroethane
LA = Los Angeles
LACSD = LA County Sanitation District
NA = not applicable

Table 2-3
Sediment Data Counts per TMDL Waterbody and Other Areas

TMDL Waterbody or Other Area	DDT	Aroclor PCB	Congener PCB	TOC	% Fines
Cabrillo Marina	4	2	4	9	4
Consolidated Slip	25	17	10	19	6
Dominguez Channel Estuary	66	61	23	23	23
Fish Harbor	6	4	6	11	3
Inner Cabrillo Beach Area	2	2	2	5	2
LB Inner Harbor	30	8	22	43	46
LB Outer Harbor	33	0	33	48	40
LA Inner Harbor	50	26	49	65	38
LA Outer Harbor	19	0	19	20	18
San Pedro Bay	68	0	68	68	44
Palos Verdes Shelf	294	195	160	575	15
Total	597	315	396	886	239

Notes:
Counts are limited to data collected between 1998 and 2012. Data collected prior to 1998 were used only as part of the natural recovery assessment (described in Section 5).
Counts focused on the top 1 foot for percent fines and top 16 centimeters for all other parameters.
For cores, only one interval was counted per location.
LA = Los Angeles
LB = Long Beach
DDT = dichlorodiphenyltrichloroethane
PCB = polychlorinated biphenyl
TOC = total organic carbon

Table 2-4
Fish Data Counts per TMDL Waterbody and Other Areas

Parameter	TMDL Waterbody or Other Area	Barred Sand Bass	Black Perch	Brown Smooth-hound Shark	California Corbina	California Halibut	California Scorpionfish	California Tonguefish	Chub Mackerel	Diamond Turbot	Jack Smelt	Queenfish	Shiner Surfperch	Spiny Dogfish	Spotted Turbot	Topsmelt	White Croaker	White Surfperch	Yellowfin Croaker
DDT	Cabrillo Marina	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-
	Consolidated Slip	-	-	-	-	1	-	-	-	-	-	10	-	-	-	9	14	-	-
	Dominguez Channel Estuary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fish Harbor	-	-	-	-	1	-	-	-	-	-	7	-	-	-	-	7	-	-
	Inner Cabrillo Beach Area	-	-	-	-	3	-	-	-	-	-	14	-	-	-	7	14	-	-
	LB Inner Harbor	-	-	-	-	4	-	-	-	-	-	16	-	-	-	13	21	-	-
	LB Outer Harbor	2	-	-	-	8	-	1	-	-	-	11	-	-	-	19	22	-	-
	LA Inner Harbor	-	-	-	-	8	-	-	-	-	-	16	-	-	-	11	23	-	-
	LA Outer Harbor	4	1	-	-	11	10	-	-	-	10	27	1	1	-	5	79	10	-
	San Pedro Bay	3	-	1	3	11	1	-	1	1	-	1	-	-	2	1	38	-	3
	Palos Verdes Shelf	22	7	-	-	-	22	-	1	-	-	-	-	-	-	-	153	-	-
Aroclor PCB	Cabrillo Marina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Consolidated Slip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Dominguez Channel Estuary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fish Harbor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Inner Cabrillo Beach Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LB Inner Harbor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LB Outer Harbor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LA Inner Harbor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	LA Outer Harbor	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	56	9	-
	San Pedro Bay	-	-	-	3	-	-	-	-	-	-	1	-	-	2	-	6	-	2
	Palos Verdes Shelf	6	6	-	-	-	4	-	-	-	-	-	-	-	-	-	136	-	-
Congener PCB	Cabrillo Marina	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-
	Consolidated Slip	-	-	-	-	1	-	-	-	-	-	15	-	-	-	16	20	-	-
	Dominguez Channel Estuary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fish Harbor	-	-	-	-	1	-	-	-	-	-	7	-	-	-	-	7	-	-
	Inner Cabrillo Beach Area	-	-	-	-	3	-	-	-	-	-	14	-	-	-	7	14	-	-
	LB Inner Harbor	-	-	-	-	4	-	-	-	-	-	16	-	-	-	13	21	-	-
	LB Outer Harbor	2	-	-	-	8	-	1	-	-	-	11	-	-	-	18	22	-	-
	LA Inner Harbor	-	-	-	-	8	-	-	-	-	-	16	-	-	-	11	23	-	-
	LA Outer Harbor	4	1	-	-	11	10	-	-	-	10	7	1	1	-	5	20	2	-
	San Pedro Bay	3	-	1	3	11	1	-	1	1	-	-	-	-	1	1	33	-	1
	Palos Verdes Shelf	22	7	-	-	-	22	-	1	-	-	-	-	-	-	-	23	-	-
% Lipid	Cabrillo Marina	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-
	Consolidated Slip	-	-	-	-	1	-	-	-	-	-	10	-	-	-	9	14	-	-
	Dominguez Channel Estuary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fish Harbor	-	-	-	-	1	-	-	-	-	-	7	-	-	-	-	7	-	-
	Inner Cabrillo Beach Area	-	-	-	-	3	-	-	-	-	-	14	-	-	-	7	14	-	-
	LB Inner Harbor	-	-	-	-	4	-	-	-	-	-	16	-	-	-	13	21	-	-
	LB Outer Harbor	2	-	-	-	8	-	1	-	-	-	11	-	-	-	18	22	-	-
	LA Inner Harbor	-	-	-	-	8	-	-	-	-	-	16	-	-	-	11	23	-	-
	LA Outer Harbor	4	1	-	-	11	10	-	-	-	10	27	1	1	-	5	80	11	-
	San Pedro Bay	3	-	1	4	11	1	-	1	1	-	1	-	-	2	1	39	-	3
	Palos Verdes Shelf	22	7	-	-	-	22	-	1	-	-	-	-	-	-	-	153	-	-

Table 2-4
Fish Data Counts per TMDL Waterbody and Other Areas

Parameter	TMDL Waterbody or Other Area	Barred Sand Bass	Black Perch	Brown Smooth-hound Shark	California Corbina	California Halibut	California Scorpionfish	California Tonguefish	Chub Mackerel	Diamond Turbot	Jack Smelt	Queenfish	Shiner Surfperch	Spiny Dogfish	Spotted Turbot	Topsmelt	White Croaker	White Surfperch	Yellowfin Croaker
Length	Cabrillo Marina	1	-	-	-	-	-	-	-	-	-	2	-	-	-	7	7	-	-
	Consolidated Slip	-	-	-	-	1	-	-	-	-	-	10	-	-	-	9	14	-	-
	Dominguez Channel Estuary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fish Harbor	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	7	-	-
	Inner Cabrillo Beach Area	-	-	-	-	3	-	-	-	-	-	7	-	-	-	7	7	-	-
	LB Inner Harbor	-	-	-	-	4	-	-	-	-	-	16	-	-	-	13	21	-	-
	LB Outer Harbor	2	-	-	-	6	-	-	-	-	-	11	-	-	-	18	21	-	-
	LA Inner Harbor	-	-	-	-	7	-	-	-	-	-	16	-	-	-	-	21	-	-
	LA Outer Harbor	4	1	-	-	11	10	-	-	-	10	7	1	2	-	5	18	2	-
	San Pedro Bay	3	-	1	-	9	1	-	1	-	-	-	-	-	-	2	29	-	1
	Palos Verdes Shelf	22	8	-	-	-	18	-	1	-	-	-	-	-	-	-	23	-	-
Weight	Cabrillo Marina	-	-	-	-	-	-	-	-	-	-	2	-	-	-	7	7	-	-
	Consolidated Slip	-	-	-	-	-	-	-	-	-	-	10	-	-	-	2	14	-	-
	Dominguez Channel Estuary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fish Harbor	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	7	-	-
	Inner Cabrillo Beach Area	-	-	-	-	3	-	-	-	-	-	7	-	-	-	7	7	-	-
	LB Inner Harbor	-	-	-	-	4	-	-	-	-	-	16	-	-	-	13	21	-	-
	LB Outer Harbor	-	-	-	-	6	-	-	-	-	-	11	-	-	-	18	21	-	-
	LA Inner Harbor	-	-	-	-	7	-	-	-	-	-	16	-	-	-	-	21	-	-
	LA Outer Harbor	1	1	-	-	5	-	-	-	-	-	7	-	2	-	5	7	2	-
	San Pedro Bay	2	-	1	-	2	-	-	1	-	-	-	-	-	-	2	1	-	-
	Palos Verdes Shelf	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

Notes:
Counts are limited to data collected between 1998 and 2012. Data collected prior to 1998 were used only as part of the natural recovery assessment (described in Section 5).
Counts only include fillets and whole body preparations. Body part preparations (e.g., liver) were not counted.
DDT = dichlorodiphenyltrichloroethane
LA = Los Angeles
LB = Long Beach
PCB = polychlorinated biphenyl

Table 2-5
Mussel Data Counts per TMDL Waterbody and Other Areas

TMDL Waterbody or Other Area	DDT	Aroclor PCB	Congener PCB	% Lipid Dry Weight
Cabrillo Marina	-	-	-	-
Consolidated Slip	2	2	-	-
Dominguez Channel Estuary	-	-	-	-
Fish Harbor	-	-	-	-
Inner Cabrillo Beach Area	-	-	-	-
LB Inner Harbor	7	7	-	-
LB Outer Harbor	1	1	-	-
LA Inner Harbor	5	5	1	-
LA Outer Harbor	21	21	-	36
San Pedro Bay	7	7	-	32
Palos Verdes Shelf	25	25	3	33

Notes:
Counts are limited to data collected between 1977 and 2008.
Data with Species Codes of SED, TFC, TCM, and TCM-a (sediment samples, transplanted freshwater clam, and transplanted California mussels) are not included in the counts.
DDT = dichlorodiphenyltrichloroethane
LA = Los Angeles
LB = Long Beach
PCB = polychlorinated biphenyl

Table 3-1
Narrative Description of Preliminary Fish Movement Zones

Preliminary Fish Movement Zone	Description of Zone[1]
Zone 1	Cabrillo Marina, Cabrillo Beach, Cabrillo Pier, [2] and a portion of LA Outer Harbor
Zone 2	A portion of the LA Main Channel and LA West Basin
Zone 3	LA East Basin
Zone 4	Consolidated Slip
Zone 5	Cerritos Channel, LB Inner Harbor, Back Channel, Middle Harbor, East Basin, and LB West Basin
Zone 6	LB Southeast Basin
Zone 7	LB Outer Harbor
Zone 8	Part of LA Outer Harbor
Zone 9	Fish Harbor
Zone 10	Seaplane Lagoon, the area adjacent to Seaplane Lagoon and Pier 300, and the channel between Piers 300 and 400
Zone 11	Eastern San Pedro Bay

Notes:

1 Zones shown here are based on fish movement data and are not related to the TMDL waterbodies specified by RWQCB and USEPA (2011).

2 The Cabrillo Pier area is located within Zone 1. Data from this area, however, were separated in data analyses for purposes of understanding the fish movement and contaminants in fish most likely to be caught off the Cabrillo Pier and consumed.

LA = Los Angeles

LB = Long Beach

Table 5-1
Surface Weighted Average TPCB and TDDT Concentrations for Zones 7 and 11

Year	SWAC (µg/kg dry)				Sample Counts			
	TPCB		TDDT		TPCB		TDDT	
	Zone 7	Zone 11	Zone 7	Zone 11	Zone 7	Zone 11	Zone 7	Zone 11
1998	7.0	31.0	41.9	32.0	14	15	14	15
2003	2.3	13.5	37.1	30.7	6	5	6	5
2008	14.5	21.9	37.3	24.3	10	11	10	11

Notes:
TPCB includes congeners and Aroclors (if not also measured for congeners)
Surface sediment (0-16 cm)
SWACs were calculated using Inverse Distance Weighted interpolation in GIS, with only data that fall within the zones. A handful of outside points may influence the zones.
SWAC = surface weighted average concentration
TDDT = total dichlorodiphenyltrichloroethane
TPCB = total polychlorinated biphenyl
Zone 7 = LB Outer Harbor
Zone 11 = Eastern San Pedro Bay

Table 6-1
California Halibut Food Web

Species	Sediment/ Detritus	Phytoplankton (including algae)	Zooplankton	Mussels/ Filter Feeders	Crustaceans/ Scavengers	Worms/ Deposit Feeder	Fish 1: Shiner Perch	Fish 2: White Croaker	Fish 3: California Halibut	Sum	Source
California Halibut SL< 20 mm	0	0	0	0	0.8	0.2	0	0	0	1	Allen 1988
California Halibut 20 mm < SL < 80 mm	0	0	0	0	0.35	0.05	0.3	0.3	0	1	Allen 1988
California Halibut 124-476 mm SL	0	0	0	0.02	0.08	0	0.74	0.16	0	1	Plummer et al. 1983
California Halibut 12-510 mm	0	0	0	0.02	0.3	0	0.45	0.23	0	1	Haaker 1975

Notes:
mm = millimeters
SL = standard length

Table 6-2
White Croaker Food Web

Species	Sediment/ Detritus	Phytoplankton (including algae)	Zooplankton	Mussels/ Filter Feeders	Crustaceans/ Scavengers	Worms/ Deposit Feeder	Fish 1: Shiner Perch	Fish 2: White Croaker	Fish 3: California Halibut	Sum	Source
White Croaker age 0	0.05	0.05	0.2	0.1	0.3	0.3	0	0	0	1	Gobas and Arnot 2010
White Croaker age > 0	0.05	0	0	0	0.55	0.4	0	0	0	1	Gobas and Arnot 2010
White Croaker	0	0.03	0.01	0.2	0.39	0.07	0.3	0	0	1	Jahn 2008
White Croaker LA/LB	0	0	0	0.04	0.28	0.61	0.07	0	0	1	Malins et al. 1987
White Croaker Dana Point	0	0	0	0.36	0.12	0.47	0.05	0	0	1	Malins et al. 1987
White Croaker 18-50 mm	0.05	0	0.54	0	0.24	0.17	0	0	0	1	Ware 1979
White Croaker 51-100 mm	0.05	0	0.12	0	0.76	0.07	0	0	0	1	Ware 1979
White Croaker 101-150 mm	0.05	0	0.12	0	0.66	0.17	0	0	0	1	Ware 1979
White Croaker 151-200 mm	0.05	0	0.01	0	0.35	0.59	0	0	0	1	Ware 1979
White Croaker 201-250 mm	0.05	0	0	0	0.73	0.22	0	0	0	1	Ware 1979
White Croaker 251-300 mm	0.05	0	0	0	0.475	0.475	0	0	0	1	Ware 1979

Notes:
mm = millimeters
LA/LB = Los Angeles/Long Beach

Table 6-3
Shiner Surfperch Food Web

Species	Sediment/ Detritus	Phytoplankton (including algae)	Zooplankton	Mussels/ Filter Feeders	Crustaceans/ Scavengers	Worms/ Deposit Feeder	Fish 1: Shiner Perch	Fish 2: White Croaker	Fish 3: California Halibut	Sum	Source
Shiner Perch Summer/Fall	0.18	0.08	0.66	0	0.06	0.02	0	0	0	1	Odenweller 1975
Shiner Perch Winter/Spring	0.31	0.11	0.37	0.04	0.11	0.06	0	0	0	1	Odenweller 1975
Shiner Perch	0.25	0.3	0.03	0.05	0.22	0.15	0	0	0	1	Bane and Robinson 1970
Shiner Perch	0	0.1	0.1	0.1	0.43	0.27	0	0	0	1	Jahn 2008
Shiner Perch	0	0.15	0.1	0.1	0.5	0.15	0	0	0	1	Woods 2010
Shiner Perch	0	0.15	0.58	0.15	0	0.12	0	0	0	1	Mackintosh et al. 2004 *Table 2.3-2
Shiner Perch age 0	0.05	0.1	0.2	0	0.55	0.1	0	0	0	1	Gobas and Arnot 2010
Shiner Perch age > 0	0.05	0.1	0.1	0	0.55	0.2	0	0	0	1	Gobas and Arnot 2010

Table 6-4
California Halibut Growth Rate Equations

Species	Age/Length Relationship	Length/Weight Relationship	Other Relationship	Fish Gender	Location	Reference
California Halibut (juveniles and adults)	NA	$W = 9.39(10^{-4})SL^{3.088}$	NA	Not specified	Anaheim Bay	Haaker 1975
California Halibut 7 -77 mm	$Y = 0.45x-2.7$	NA	10.71 mm/month[1] 29.78 mm/month[2]	Not specified	Alamitos Bay	Allen 1988
California Halibut	$L_t=1367.7(1-e^{-0.08(t+1.2)})$	NA	NA	Female	Southern California	MacNair et al. 2001
California Halibut	$L_t=925.3(1-e^{-0.08(t+2.2)})$	NA	NA	Male	Southern California	MacNair et al. 2001

Notes:
1 Growth rate in 1983
2 Growth rate in 1985
L = length
mm = millimeters
NA = not applicable
SL = standard length (mm)
t = time
w = weight
x = number of growth rings on otoliths
y = standard length (mm)

Table 6-5
White Croaker Growth Rate Equations

Species	Age/Length Relationship	Length/Weight Relationship	Other Relationships	Fish Gender	Location	Reference	Notes
White Croaker	L_∞ = 60.7, k = 0.04, t_o = -7.6	$W = aL^b$	NA	Female	Palos Verdes to Huntington Beach	Love et al. 1984	Von bertallanfy growth equation ($L_t = L_\infty$ [1 - exp - k (t -t_o)], where L_t = predicted length at time *Used in hydroQual 1997
White Croaker	L_∞ = 59.2, k = 0.03, t_o = -8.7	$W = aL^b$	NA	Male	Palos Verdes to Huntington Beach	Love et al. 1984	
White Croaker	$L_t=607.71[1-e^{-0.03(t+8.54))}]$	$W = 0.000007L^{3.11}$	SL=-4.06 +0.86TL	Female	Palos Verdes	Moore 1999	Body weight(g) does not include gonad weight Length is total length (mm) Other formula is conversion from standard length to total length (mm)
White Croaker	$L_t=558.62[1-e^{-0.03(t+7.78)}]$	$W = 0.000007L^{3.11}$	SL=-4.06 +0.86TL	Male	Palos Verdes	Moore 1999	Body weight does not include gonad weight Length is total length
White Croaker	L = -0.833 + 0.242A	NA	NA	Not specified	Huntington Beach	Miller et al. 2011a Miller et al. 2011b	*Growth rate for larvae Age(A) is in days Length(L) is mm and is either notochord length or standard length
White Croaker	NA	$W = 0.0550\ SL^{2.700}$	NA	Not specified	Eastern N. Pacific Ocean	Harvey et al. 2000	
White Croaker	NA	logW=-4.48142 + 2.80355 log L	NA	Not specified	Southern California	Isaacson 1964	*Used in hydroQual 1997

Notes:
cm = centimeters
k = instantaneous growth rate
L = length in mm
L∞= theoretical maximum length
mm = millimeters
NA = not applicable
SL = standard length in cm
t_o = length at which the fish would theoretically have been at age 0
w = weigth in grams

Table 6-6
Shiner Surfperch Growth Rate Equations

Species	Age/Length Relationship	Length/Weight Relationship	Other Relationship	Fish Gender	Location	Reference	Notes
Shiner Surfperch (first or prenatal growth)	NA	NA	y= 1.09 + 0.334x	Not specified	Newport Bay	Bane and Robinson 1970	
Shiner Surfperch (juveniles)	NA	NA	y= 0.229 + 0.700x	Not specified	Newport Bay	Bane and Robinson 1970	
Shiner Surfperch (adults)	NA	NA	y= 10.52 – 0.091x	Not specified	Newport Bay	Bane and Robinson 1970	
Shiner Surfperch	$L_t = 128.7(1-e^{-0.063(t+0.045)})$	$W = 1.58 * 10^{-5} L^{3.111}$	TL=1.245 SL + 1.771	Male	Anaheim Bay	Eckmayer 1975, 1979	Total length to standard length equation provided
Shiner Surfperch	$L_t = 128.7(1-e^{-0.063(t+0.045)})$	$W = 9.697 * 10^{-6} L^{3.212}$	NA	Female	Anaheim Bay	Eckmayer 1975, 1979	
Shiner Surfperch	NA	$W = 4.91 * 10^{-4} SL^{3.05}$	Log SL = 8.82 Log T-Log17.14 (T in years)[1] SL = 5.12T + 33.98 (T in months)[2] g = Ln(Wt/Wo)[3]	Not specified	Anaheim Bay	Odenweller 1975	* Inconsistent with other studies, was excluded from analysis
Shiner Surfperch	NA	$WT = 0.0100 SL^{3.515}$	NA	Not specified	Eastern N. Pacific Ocean	Harvey et al. 2000	
Shiner Surfperch	NA	$W = 1.17 * 10^{-5} L^{3.19885}$	NA	Female	Arcata Bay	Anderson and Bryan 1970	
Shiner Surfperch	NA	$W = 5.54 * 10^{-6} L^{3.38776}$	NA	Male	Arcata Bay	Anderson and Bryan 1970	
Shiner Surfperch	NA	$W = 1.06 * 10^{-5} L^{3.29807}$	NA	Both	Arcata Bay	Anderson and Bryan 1970	

Notes:

1 First year growth rate SL = standard length (mm), t = years

2 Mean size per month T = months

3 Instantaneous growth calculation g = instantaneous growth rate, W_o = weight at start time, Wt = weight at end time

L = standard length in millimeters

NA = not applicable

SL= standard length in centimeters

x = time (in months i.e., April = 4)

y = standard length centimeters

w = weight in grams

Table 7-1
Data Gaps

Fish Movement Data	
White Croaker	• Movement and exposure of white croaker in the following areas: 1) Cabrillo Pier and Cabrillo Beach area, 2) Pier J fishing pier area, 3) Fish Harbor, 4) Seaplane Lagoon, 5) LB Outer Harbor, and 6) Eastern San Pedro Bay • Movement of white croaker between subareas of the Harbor including the following: 1) Outer LB Harbor and Pier J/Eastern San Pedro Bay, 2) LA Outer Harbor and LB Outer Harbor, 3) LB Outer Harbor and LB Inner Harbor, 4) Cabrillo Pier/ LA Outer Harbor/ LB Outer Harbor and Palos Verdes Shelf.
California Halibut	• Movement and exposure of California halibut in all subareas of the Harbor
Shiner Perch	• Movement and exposure of Shiner Perch in all subareas of the Harbor
Biota PCBs and DDTs and Food Web Structure	
White Croaker PCBs and DDTs	• White croaker DDT/PCB in Southeast Basin, LB Outer Harbor, and Fish Harbor, to fill fish chemistry data gaps and to better understand sediment–fish linkages for PCBs and DDTs. • White croaker DDT/PCB data in the Cabrillo Pier area, LA Outer Harbor, Seaplane Lagoon, and Eastern San Pedro Bay for further evaluation and continuation of temporal trends.
California Halibut PCBs and DDTs	• California halibut DDT/PCB data in Consolidated Slip, Cabrillo Pier area, LB Inner Harbor, due to limited data and the need for improved sediment - fish linkages. • Halibut DDT/PCB data are also needed in the Cabrillo Pier area, LB Inner Harbor, LB Outer Harbor, LA Inner Harbor, LB Outer Harbor, and Eastern San Pedro Bay for further evaluation and continuation of temporal trends.
Shiner Surfperch PCBs and DDTs	• Shiner surfperch DDT/PCB data in Consolidated Slip, LA Inner Harbor, LB Inner Harbor, Cabrillo Pier, LA Outer Harbor, LB Outer Harbor, Eastern San Pedro Bay due to limited data (n=1) in the harbor for this species. • Baseline shiner surfperch data are needed throughout LA/LB Harbor for future temporal trend analyses. •
Polychaete Worm PCBs and DDTs	• Polychaete worm DDT and PCB data needed throughout the Harbor (i.e., Consolidated Slip, LA Inner Harbor, LB Inner Harbor, Cabrillo Pier, LA Outer Harbor, LB Outer Harbor, Eastern San Pedro Bay) to fill data gaps for deposit-feeders preyed upon by the representative fish species.
Mussels PCBs and DDTs	• Mussel DDT and PCB data needed in Consolidated Slip, LA Main Channel, Cabrillo Pier, and LB Inner Harbor to fill data gaps for representative filter-feeders preyed upon by representative fish species and for continuation of temporal trend analysis/resolution.
Food Web Structure	• Need to determine the trophic position (15N stable isotope analysis) and dietary sources (13C stable isotope analysis) for representative species (white croaker, shiner perch, and California halibut) and their representative prey in the bioaccumulation model

Table 7-1
Data Gaps

Sediment PCBs and DDTs	
Surface Sediment PCBs and DDTs	• LB Inner Harbor (Channels 2 and 3, West Basin, Southeast Basin) due to spatially-limited data, need to replace older (pre-2003) data and data with depth >16 cm, and need for improved understanding of sediment-fish linkage • LB Outer Harbor due to need to delineate concentration gradients and need to replace older (pre-2003) data • LA Inner Harbor (West Basin, mid-main channel, mouth of Main Channel, Cerritos Channel) due to spatially-limited data, need to replace older (pre-2003) data, and need for improved understanding of sediment-fish linkage • Consolidated Slip due to need to replace older (pre-2003) data. • Fish Harbor due to need to replace older (pre-2003), deeper (>16 cm) data, and Aroclor-based data; and need for improved understanding of sediment-fish linkage • LA Outer Harbor (near TIWRP outfall, near Angels Gate, in Shallow Water Habitat mitigation area near Cabrillo Pier/Beach) due to limited data and need to replace older (pre-2003) data • Eastern San Pedro Bay primarily due to older (pre-2003) data and need to delineate concentration gradients • Data from all areas to support continued evaluation of natural recovery of sediments
High Resolution Geochronology Core/Analytical Chemistry Data	• Data needed in all areas of the Harbor for determination of sedimentation rates and more quantitative natural recovery rate estimate.

Notes:
cm = centimeters
DDT = dichlorodiphenyltrichloroethane
LA = Los Angeles
LB = Long Beach
PCBs = polychlorinated biphenyls
TIWRP = Terminal Island Water Reclamation Plant

Table 7-2
Aroclor-only and Congener TPCB Fish Data Counts per Year

Year	California Halibut		Queenfish		Topsmelt		White Croaker	
	Aroclor Only	Congener	Aroclor Only	Congener	Aroclor Only	Congener	Aroclor Only	Congener
1998	-	5	-	-	-	-	-	-
1999	-	1	-	-	-	-	14	6
2000	-	-	-	-	-	-	5	-
2001	-	-	-	-	-	-	-	2
2002	-	12	-	-	-	-	- [1]	23
2003	-	-	-	-	-	-	-	1
2004	-	-	-	-	-	-	5	-
2005	-	-	10	-	-	-	10	-
2006	-	-	-	-	-	-	10	-
2007	-	-	10	-	-	-	9	-
2008	-	-	-	-	-	-	-	-
2009	-	1	-	-	-	1	-	2
2010	-	-	-	-	-	-	-	-
2011	-	27	-	74	-	63	-	98
2012	-	1	-	9	-	7	-	14

Notes:
Data from Harbor area and Eastern San Pedro Bay
Aroclors counted only when congeners not measured
Tissue types excluded liver and fish gut
1 Non-detect Aroclor samples from LATIWRP 2002 with detection limits of 1,000 micrograms per kilogram were excluded.
TPCB = total polychlorinated biphenyl

Table 7-3
Aroclor-only and Congener TPCB Surface Sediment Data Counts per Year

Year	Aroclor Only	Congener
1998	6	42
1999	-	5
2002	16	-
2003	-	26
2004	-	-
2005	-	3
2006	-	-
2007	-	-
2008	-	93
2009	-	-
2010	2	-
2011	-	3
2012	-	12
2013	-	26

Notes:
Sediment from 0 to 16 centimeters
Data from Harbor area and Eastern San Pedro Bay
Aroclors counted only when congeners not measured
TPCB = total polychlorinated biphenyl

FIGURES

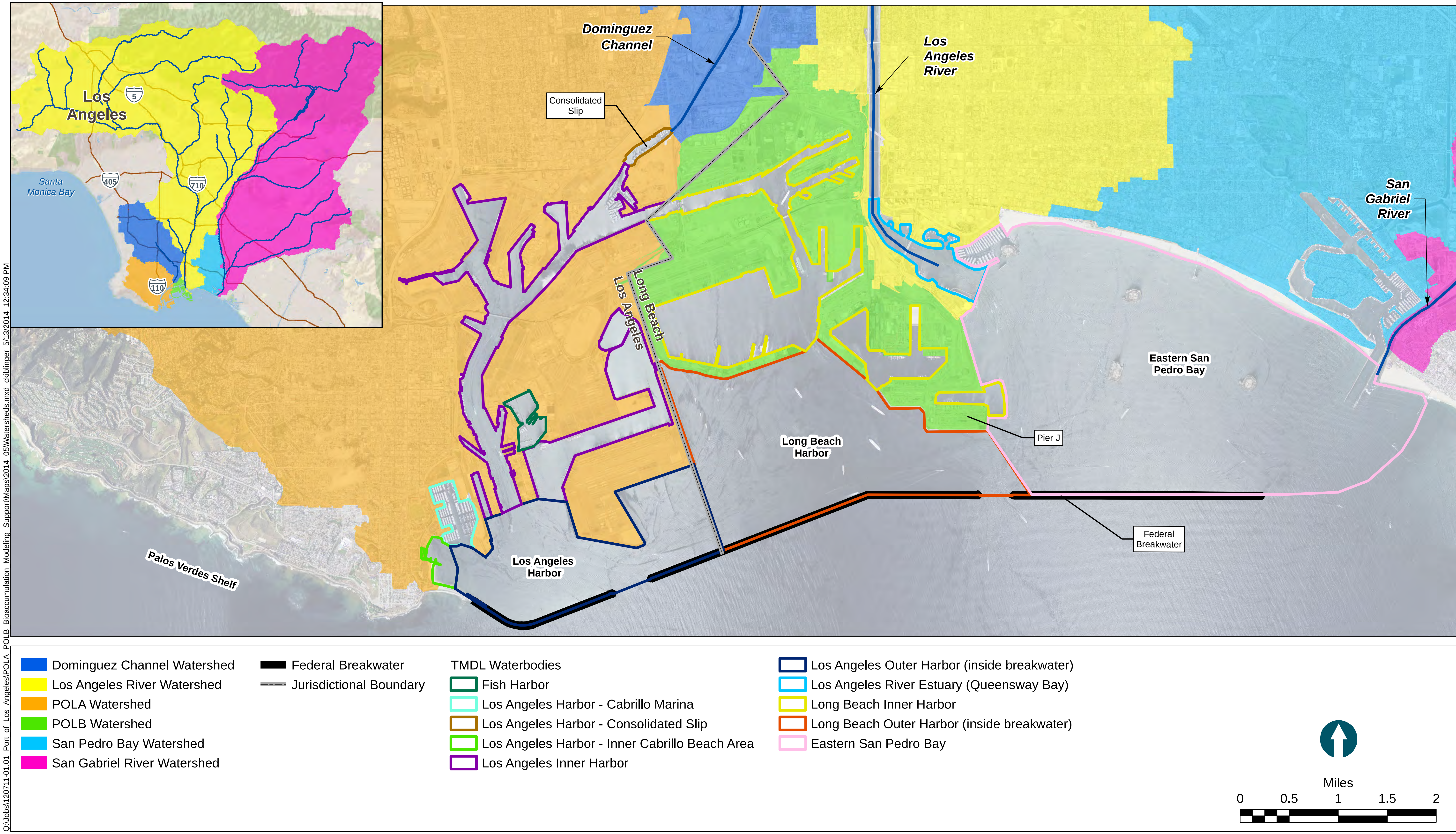

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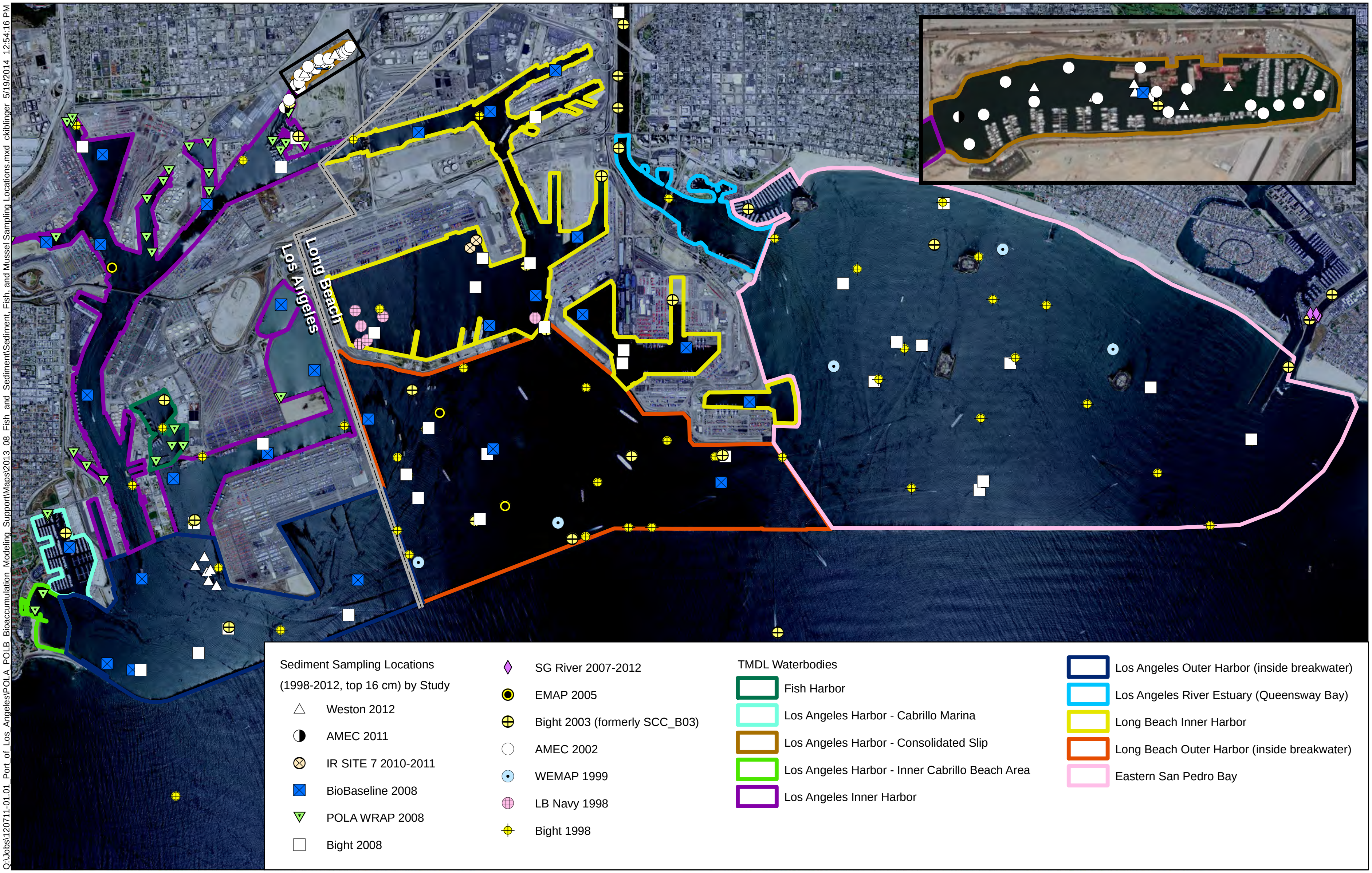
Figure 1-1
Study Area
Greater Los Angeles and Long Beach Harbor Waters



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Miles

0 0.5 1

NOTES:
1. Database: Sed_DBcomb_NDhalfMDL_*_20130722.xlsx
2. For study details, see Table 2-1 and Anchor QEA 2013b.

Figure 2-1
Sediment Sampling Locations (1998-2012; top 16 cm)
Greater Los Angeles and Long Beach Harbor Waters

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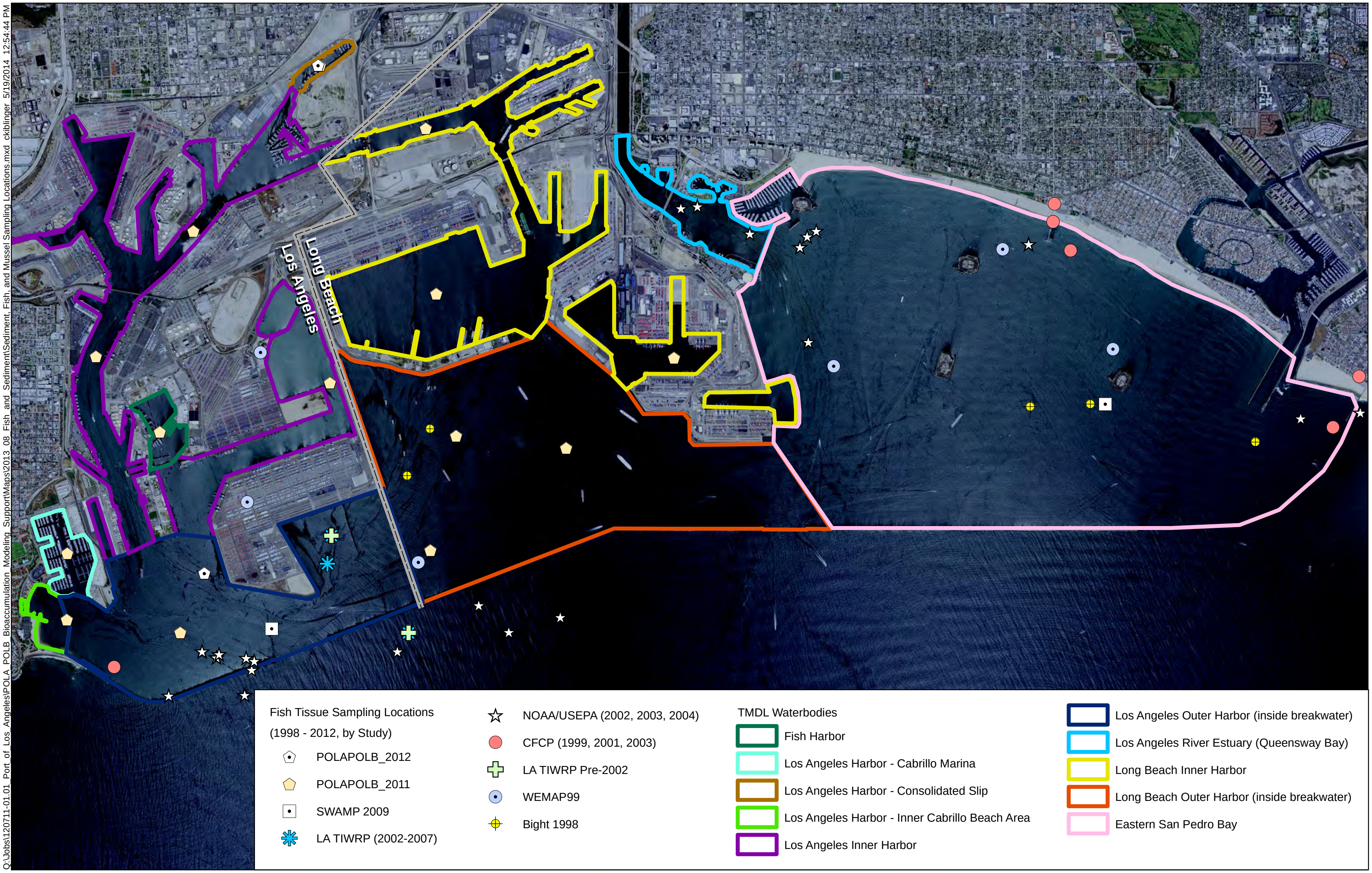

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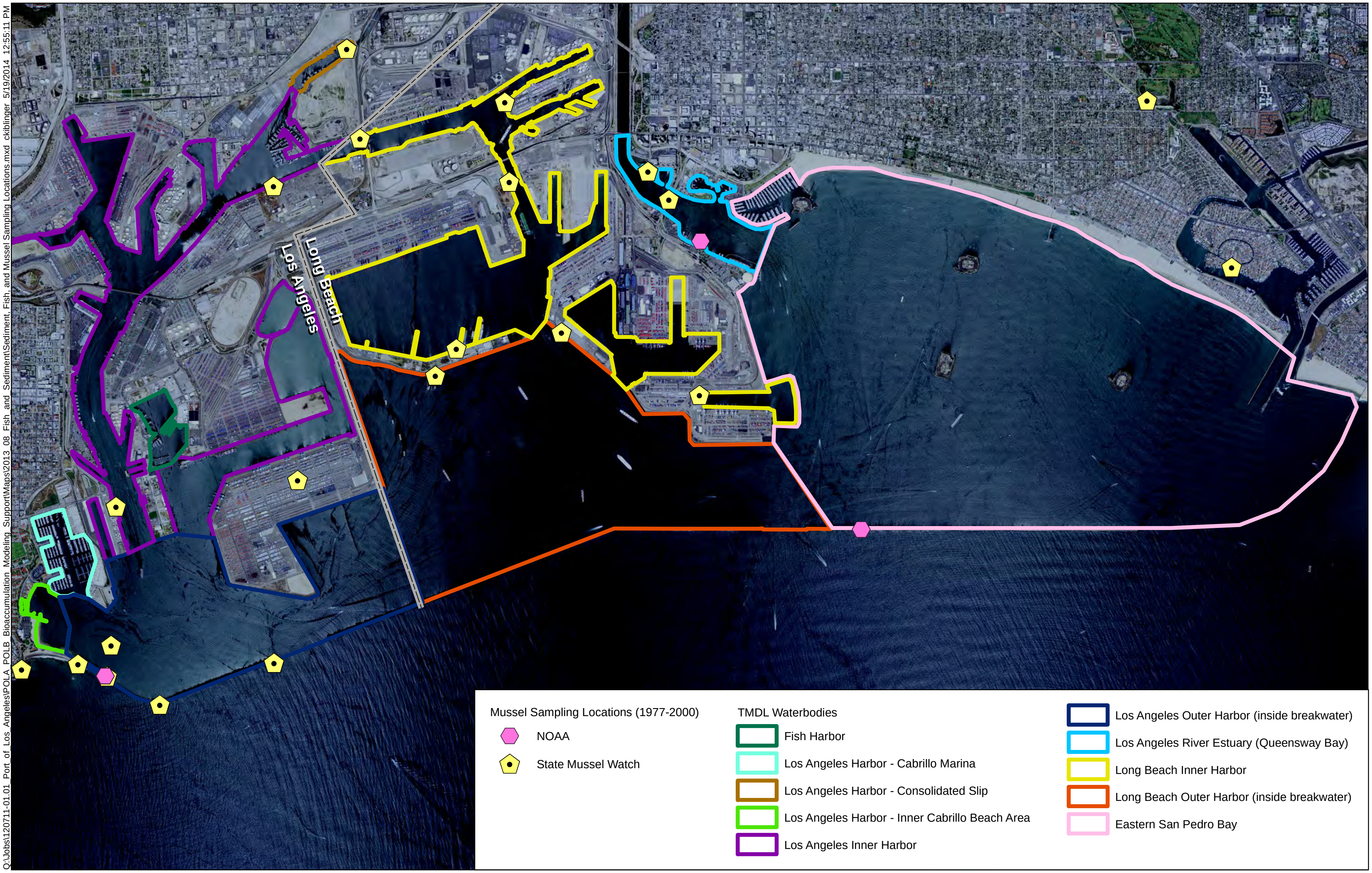
ANCHOR QEA

Miles

0 0.5 1

NOTES:
1. Database: fishData_processed_20130801.csv (based on AllFishData_Compile_130731).
2. For study details, see Table 2-2 and Anchor QEA 2013b.

Figure 2-2
Fish Tissue Sampling Locations (1998-2012)
Greater Los Angeles and Long Beach Harbor Waters



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Miles
0 0.5 1

NOTES:
1. Database: POLA_POLB_Mussel_Dataset_130711.xlsx
2. For study details, see Anchor QEA 2013b.

Figure 2-3
Mussel Tissue Sampling Locations (1977-2009)
Greater Los Angeles and Long Beach Harbor Waters

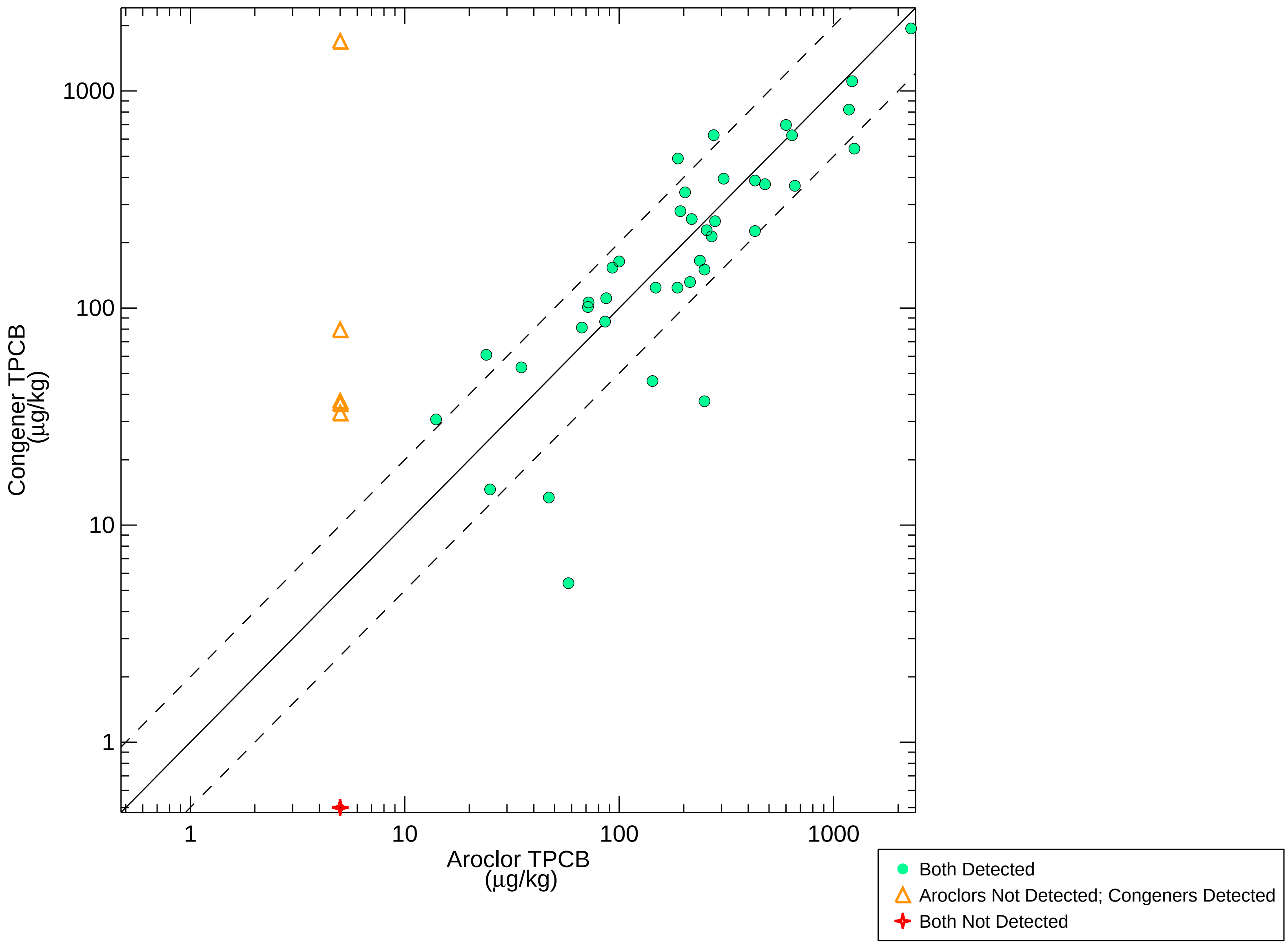

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Figure 2−4

Comparison Between Congener and Aroclor TPCB in Surface Sediment

Only samples in the top 16 cm from 1998 to 2012 are shown. Solid line is the 1:1 line; dashed lines are 2:1 and 1:2 lines.
Totals were calculated as the sum of detected components, or if all components were non−detects, half of the highest method detection limit was used as the total and shown as open symbols. Data from LA/LB Harbor and Dominguez Channel.
Database: Sed_DB_comb_ND_half_MDL__totals_20140229.bin

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BG − \\socal2\Disneyland\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_crossplot_TPCBC_vs_TPCBA.pro Mon May 19 12:26:30 2014

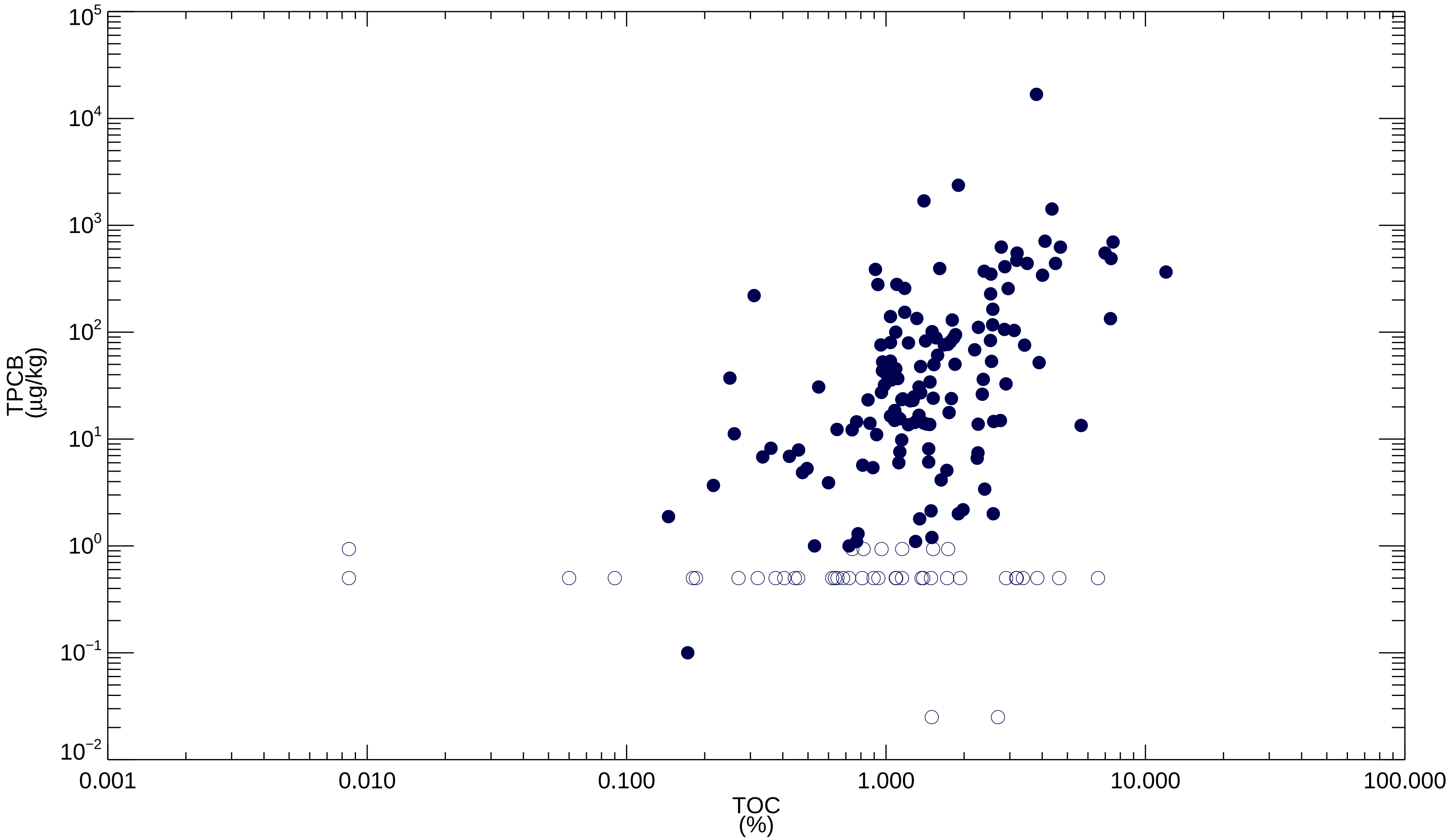

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Figure 2−5a

TPCB versus TOC in Surface Sediment

Aroclor data are shown only when congeners were not measured. Data collected between 1998 and 2012. Totals were calculated as the sum of detected components or half highest method detection limit. Surface sediment samples (0−16cm) shown. Non−detects shown as open symbols.
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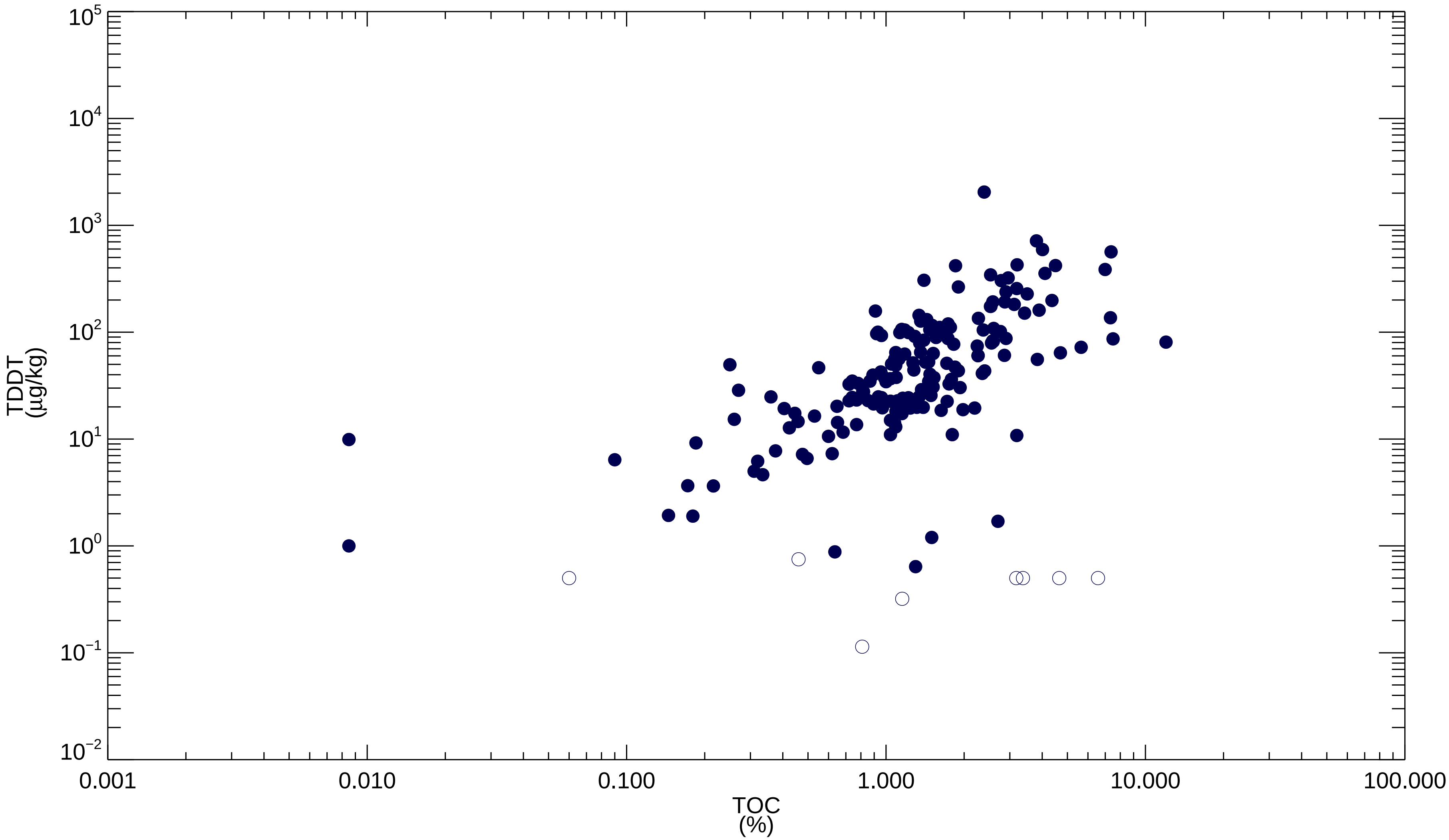

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Figure 2−5b

TDDT versus TOC in Surface Sediment

Aroclor data are shown only when congeners were not measured. Data collected between 1998 and 2012. Totals were calculated as the sum of detected components or half highest method detection limit. Surface sediment samples (0−16cm) shown. Non−detects shown as open symbols. Database: Sed_DBcomb_NDhalfMDL_tot_20140229_alignTOC_20140430

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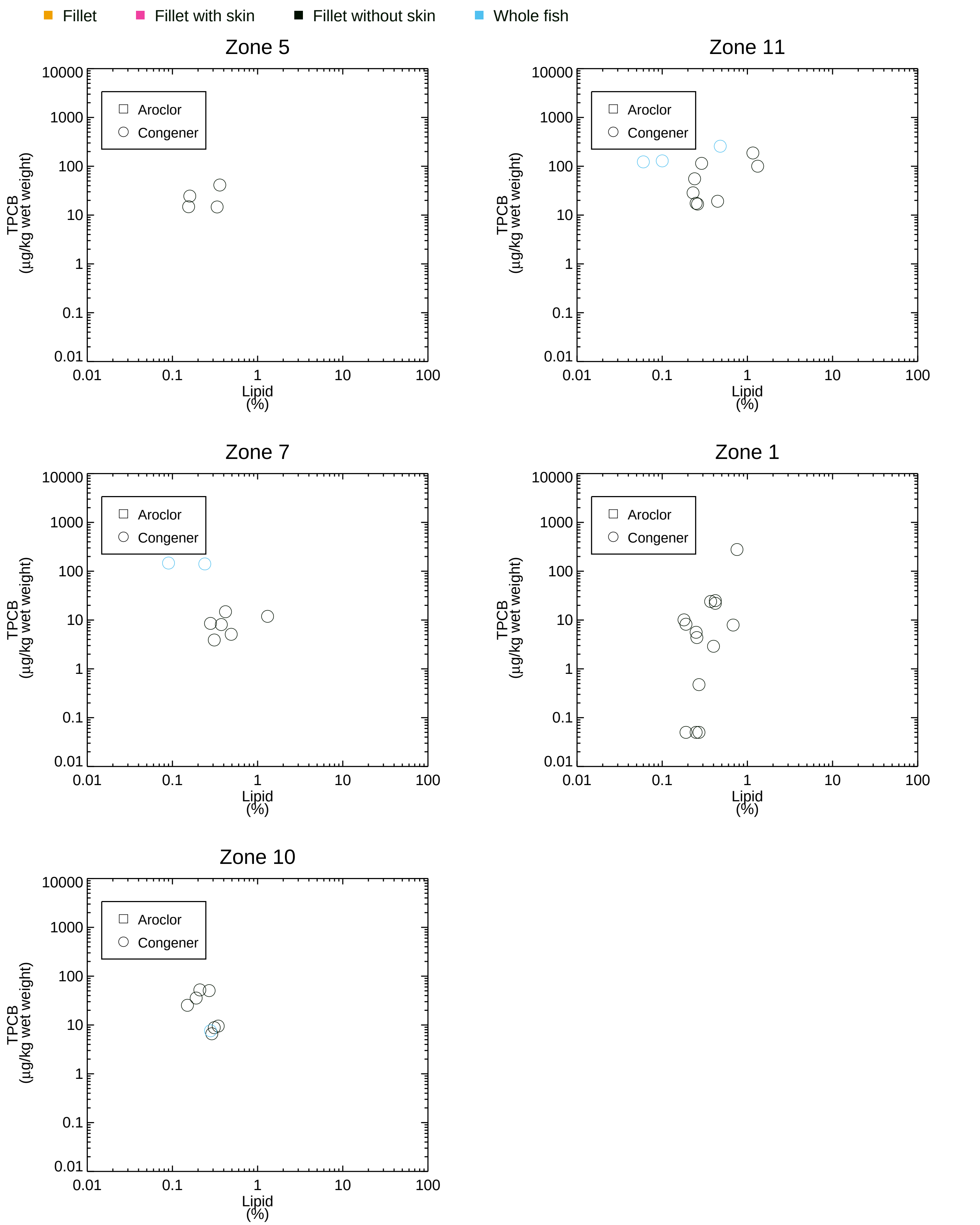

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Figure 2-6a

TPCB Concentration versus Percent Lipid in California Halibut

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

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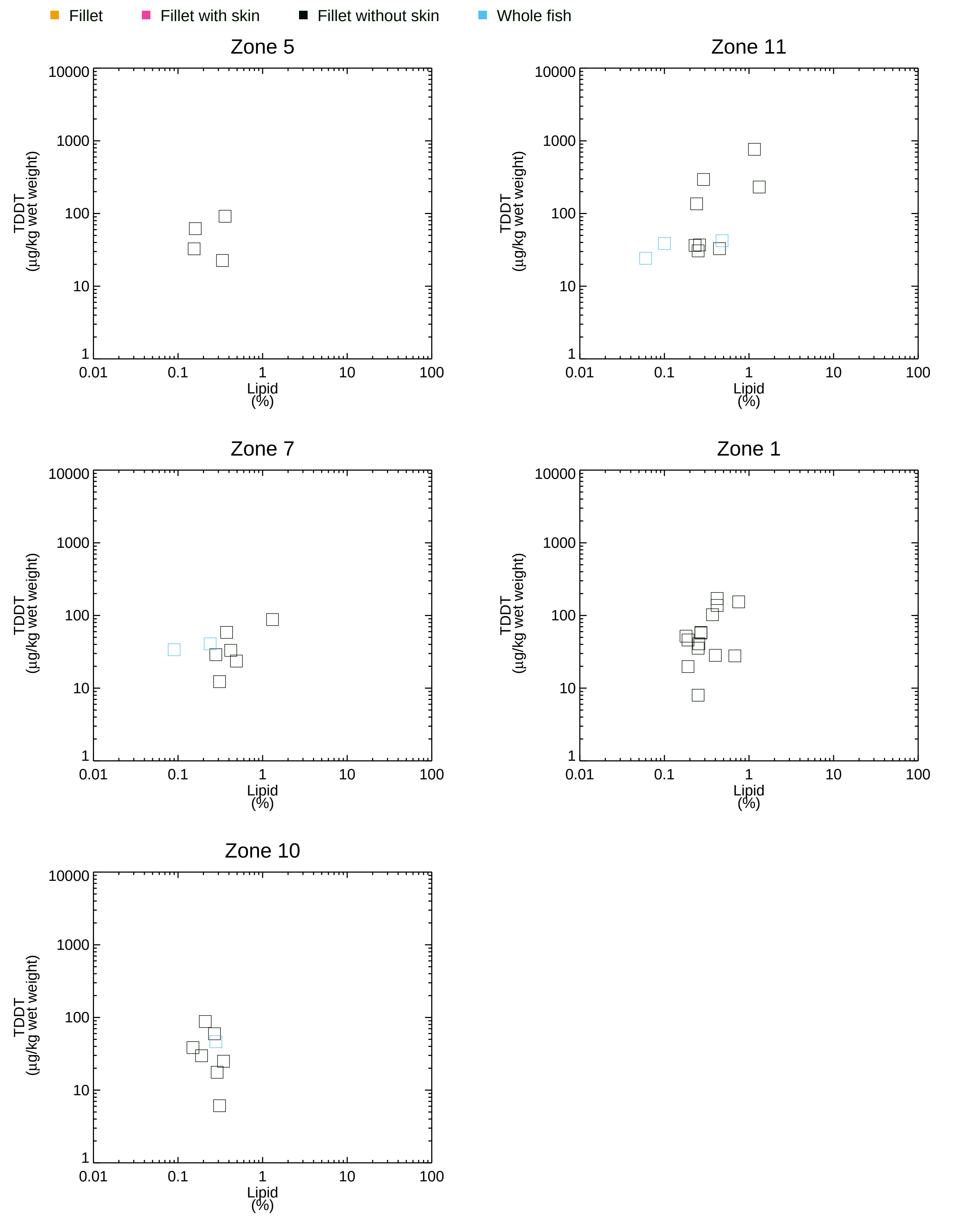

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Figure 2-6b

TDDT Concentration versus Percent Lipid in California Halibut

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
Database: AllFishData_Compile_130731.xlsx.

Fillet Fillet with skin Fillet without skin Whole fish

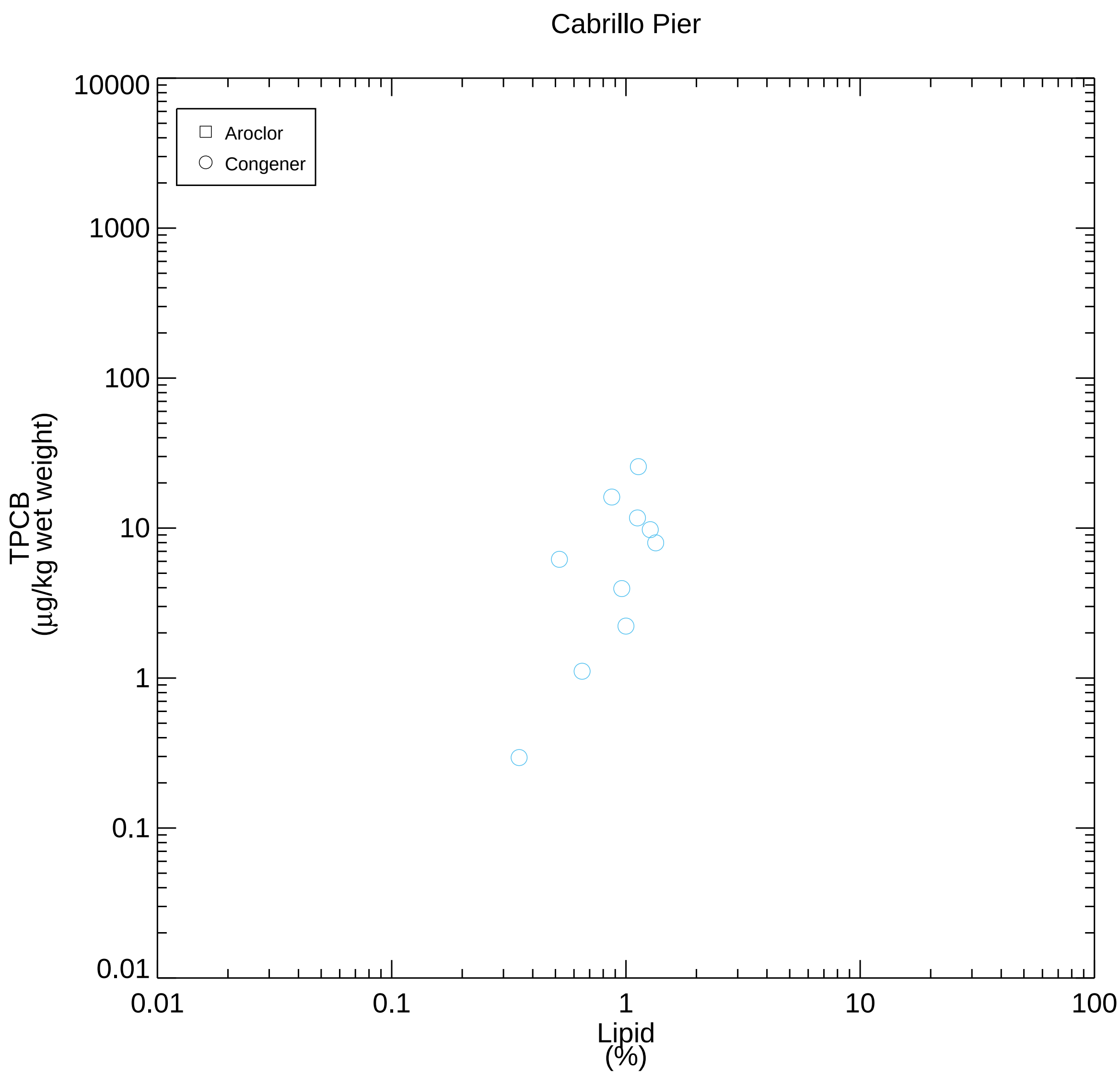

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Figure 2-6c

TPCB Concentration versus Percent Lipid in Jack Smelt

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

Fillet   Fillet with skin   Fillet without skin   Whole fish

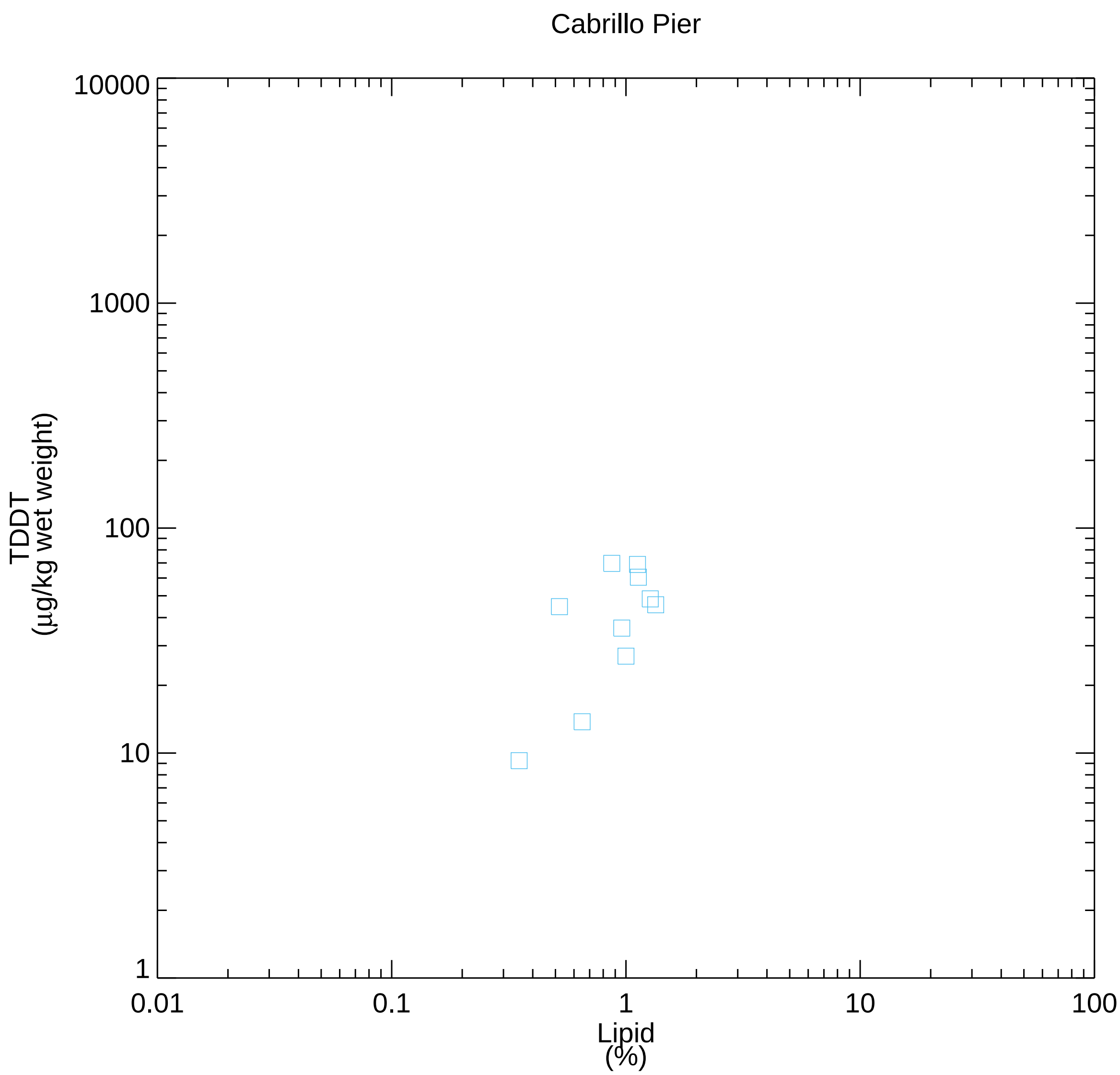

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Figure 2-6d

TDDT Concentration versus Percent Lipid in Jack Smelt

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
Database: AllFishData_Compile_130731.xlsx.

ANCHOR QEA

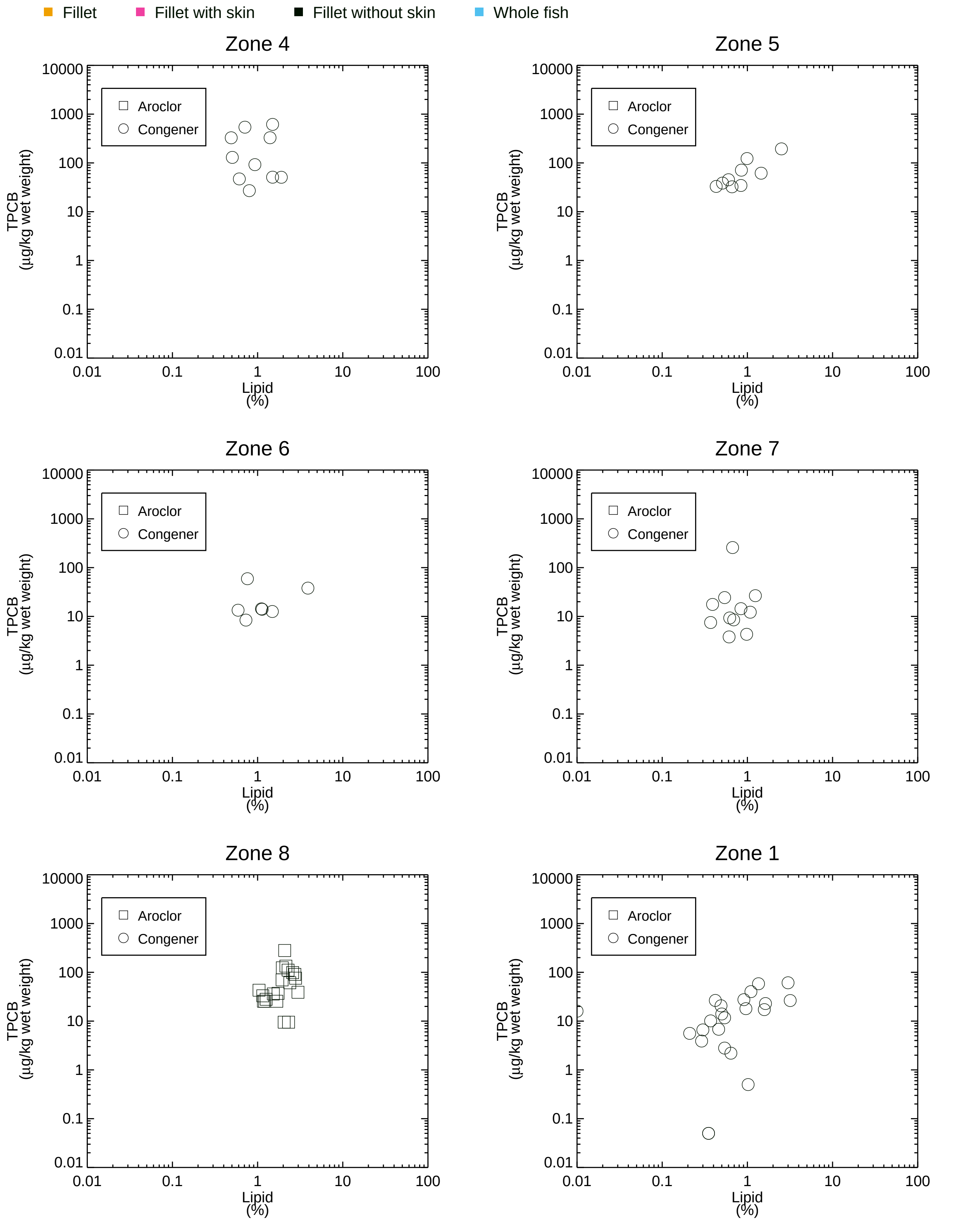

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Figure 2-6e

TPCB Concentration versus Percent Lipid in Queenfish

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

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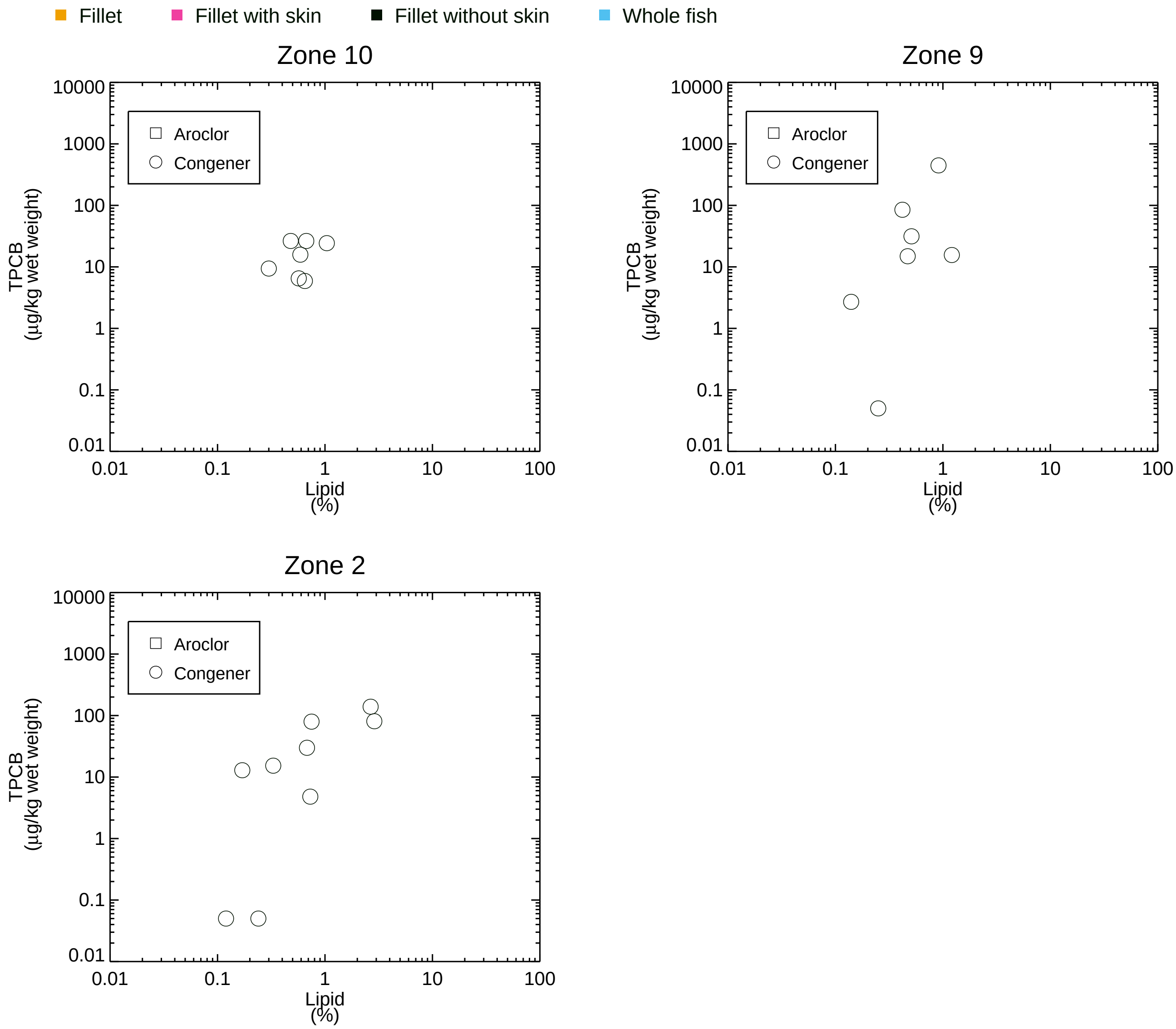

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Figure 2-6e

TPCB Concentration versus Percent Lipid in Queenfish

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

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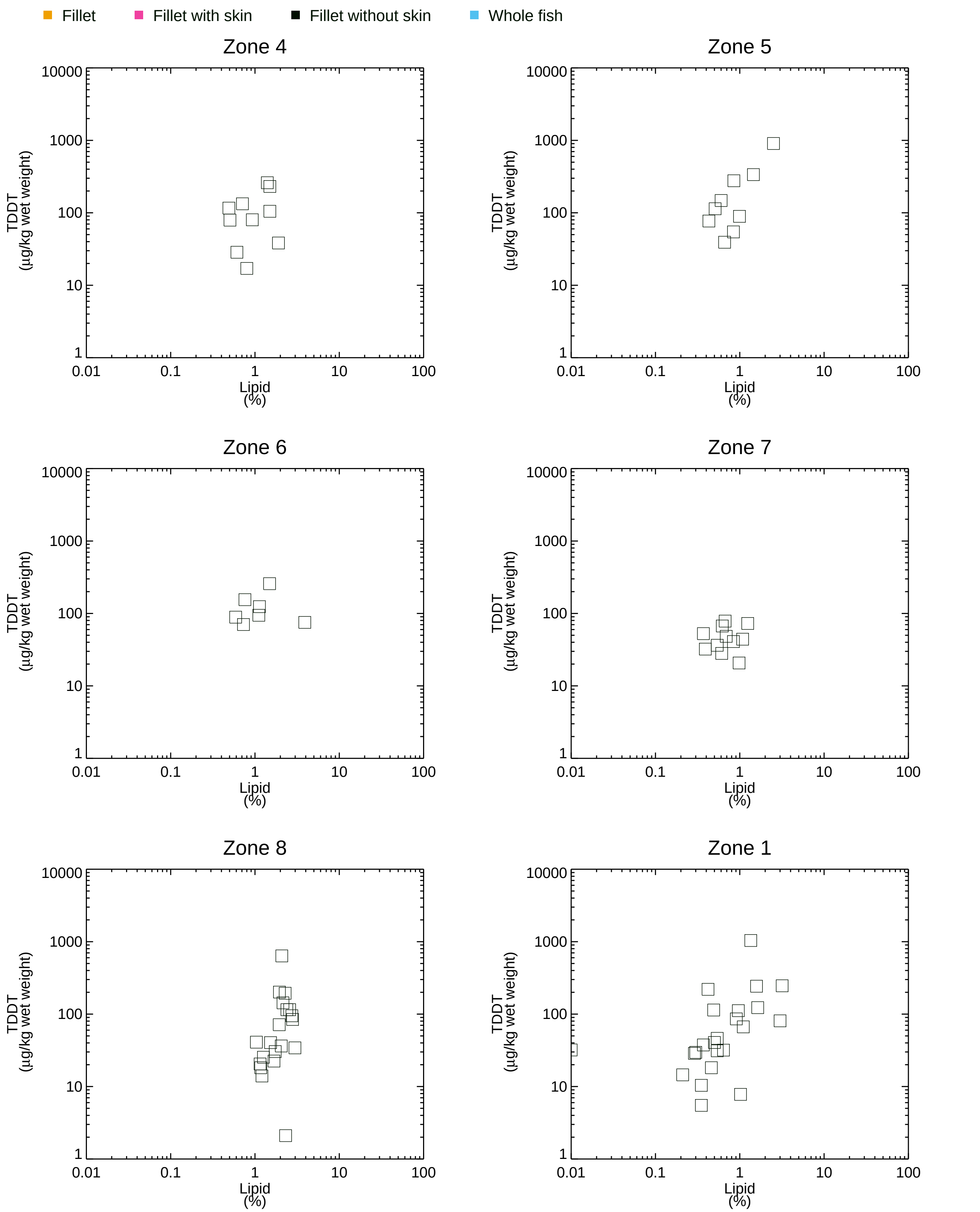

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Figure 2-6f

TDDT Concentration versus Percent Lipid in Queenfish

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
Database: AllFishData_Compile_130731.xlsx.

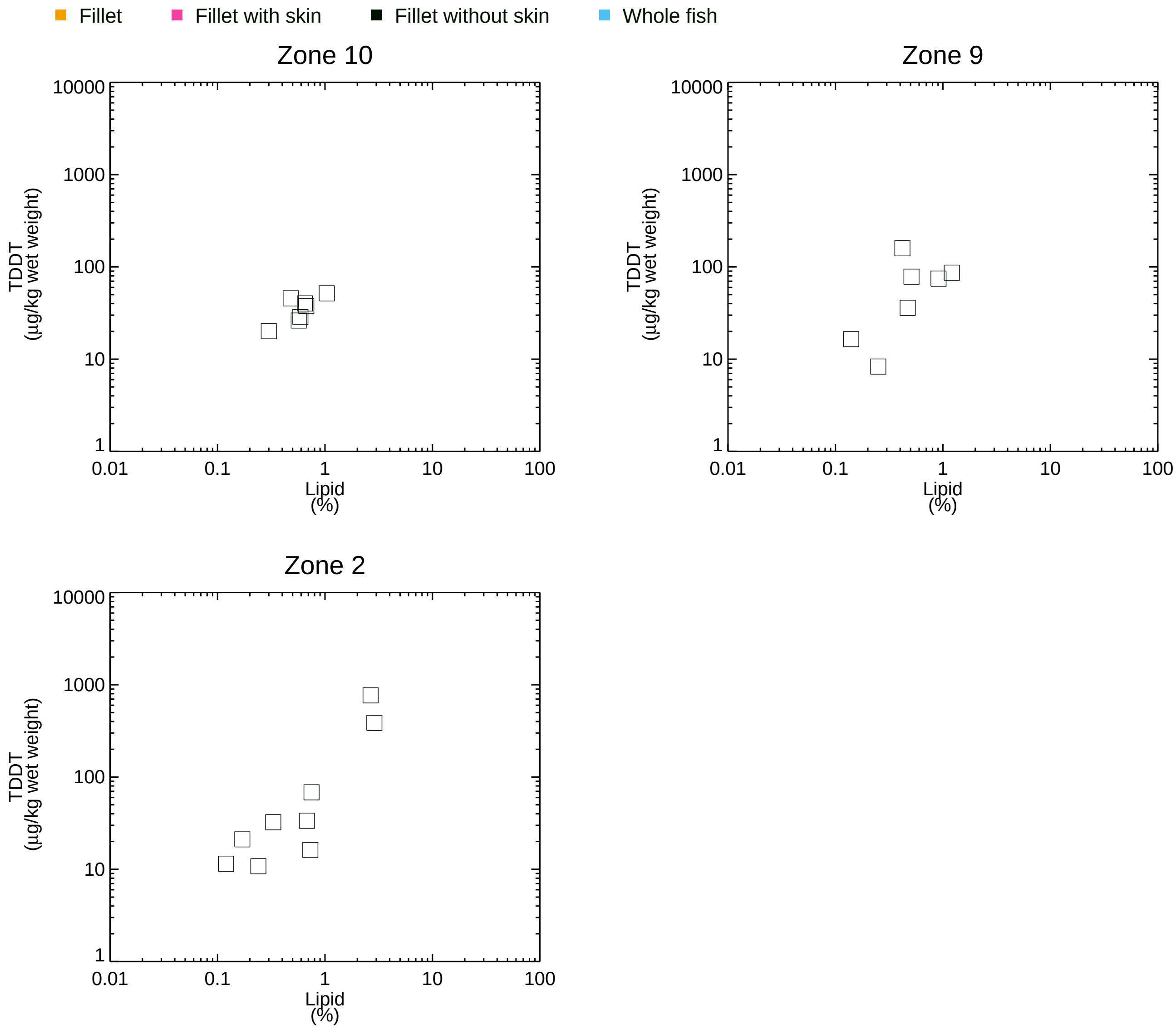

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Figure 2-6f

TDDT Concentration versus Percent Lipid in Queenfish

Zones delineated based on fish movement. Data included years from 1990 to 2012. Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample. Database: AllFishData_Compile_130731.xlsx.

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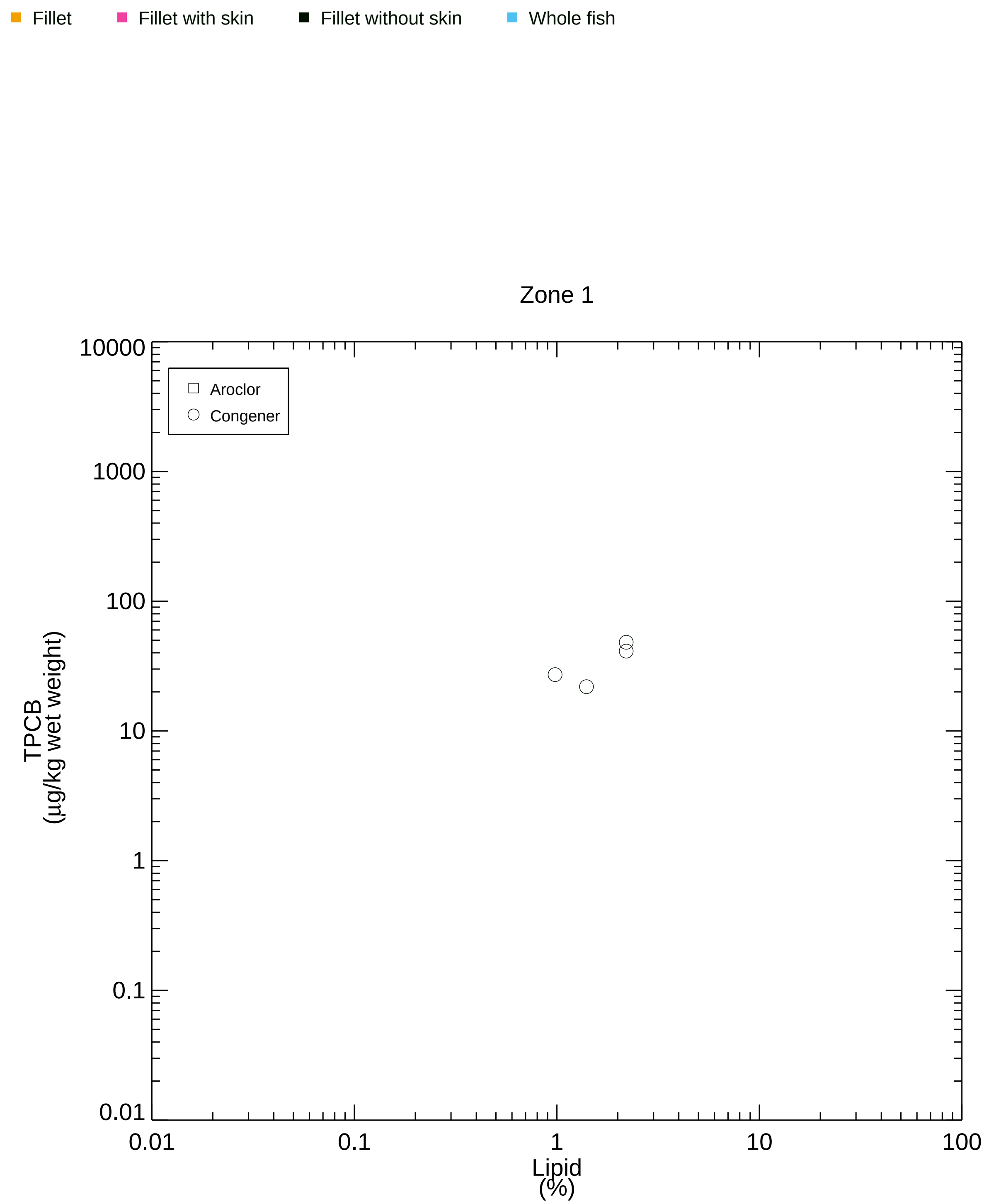

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Figure 2-6g

TPCB Concentration versus Percent Lipid in Sand Bass

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

Fillet   Fillet with skin   Fillet without skin   Whole fish

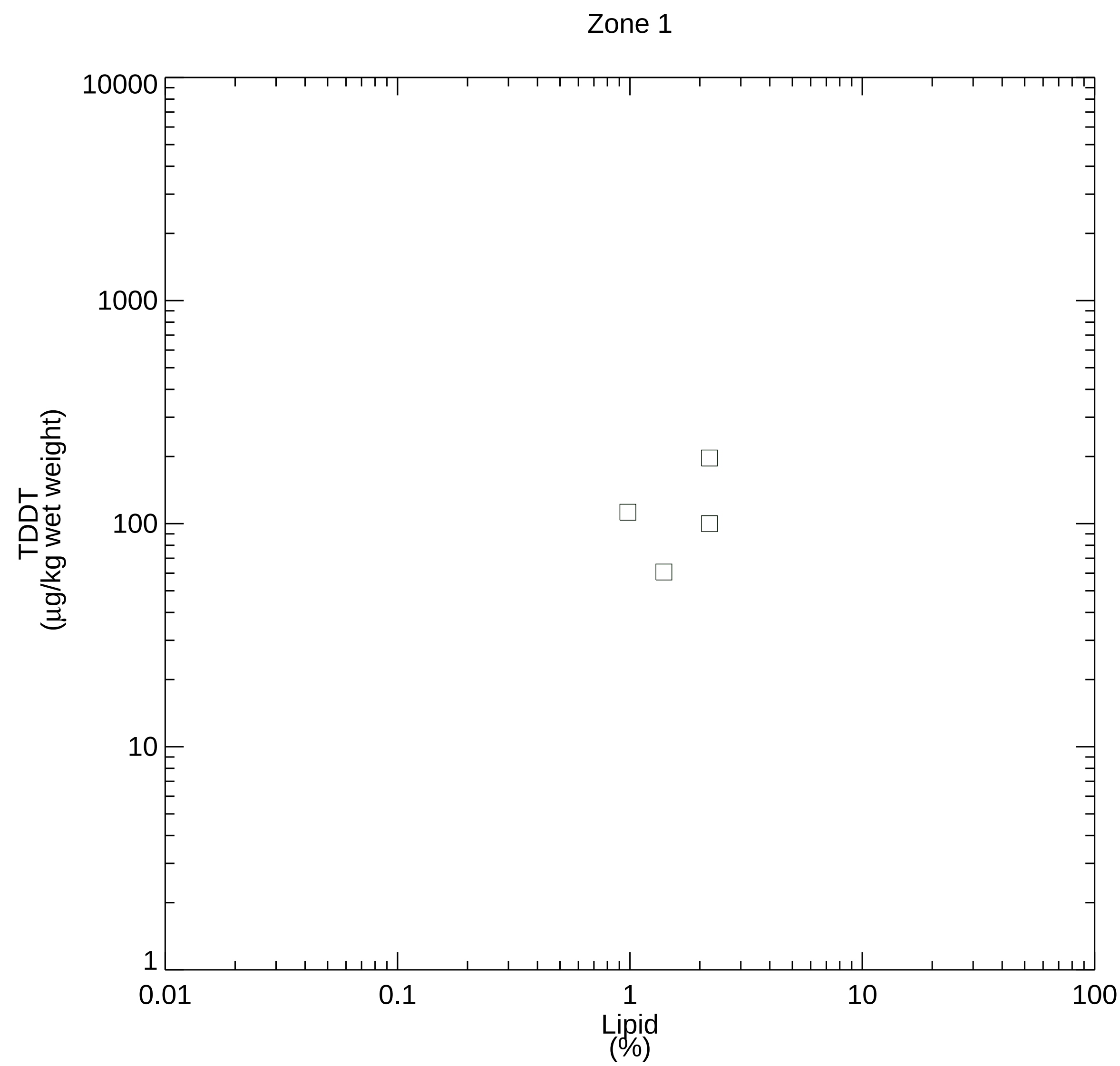

Figure 2-6h

TDDT Concentration versus Percent Lipid in Sand Bass

Zones delineated based on fish movement. Data included years from 1990 to 2012. Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample. Database: AllFishData_Compile_130731.xlsx.

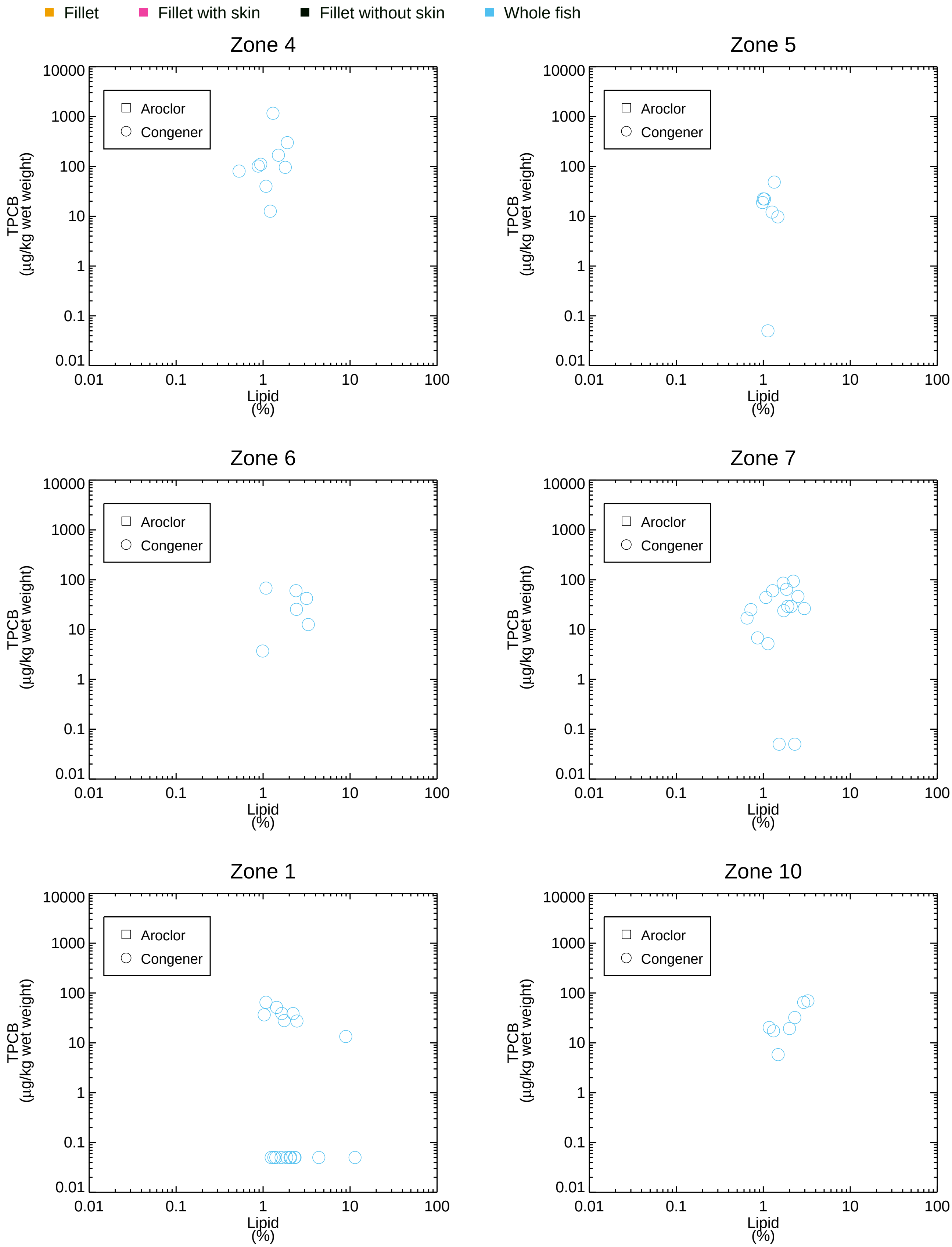

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Figure 2-6i

TPCB Concentration versus Percent Lipid in Topsmelt

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Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
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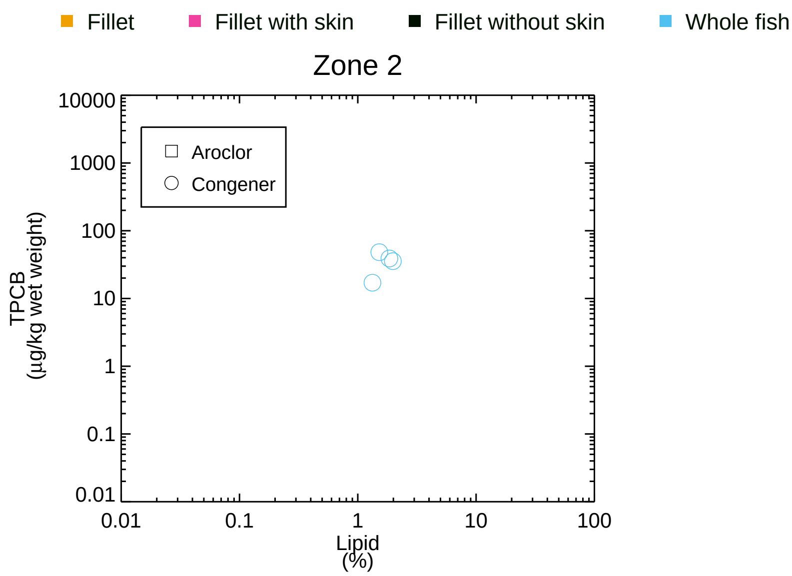

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Figure 2-6i

TPCB Concentration versus Percent Lipid in Topsmelt

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

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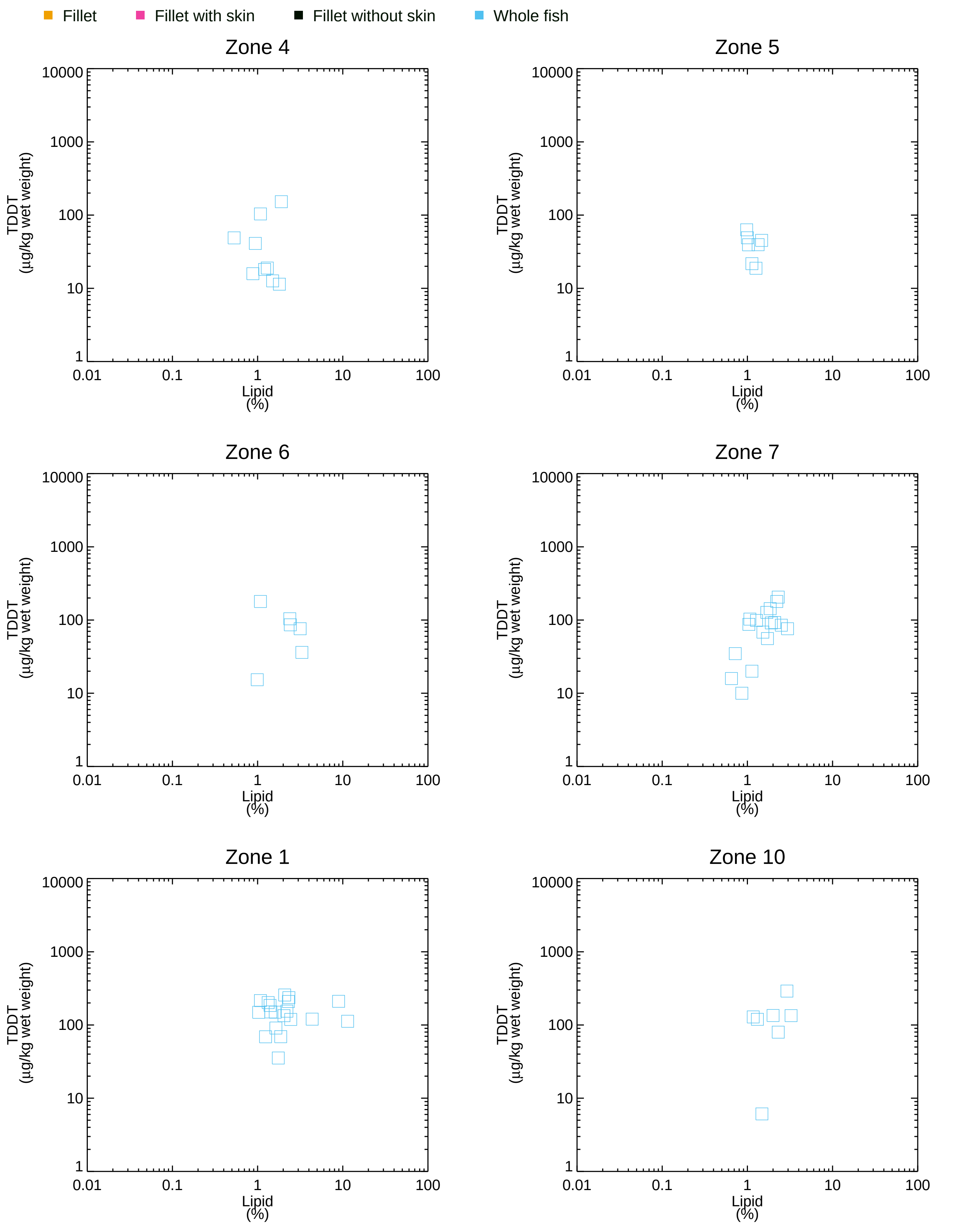

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Figure 2-6j

TDDT Concentration versus Percent Lipid in Topsmelt

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
Database: AllFishData_Compile_130731.xlsx.

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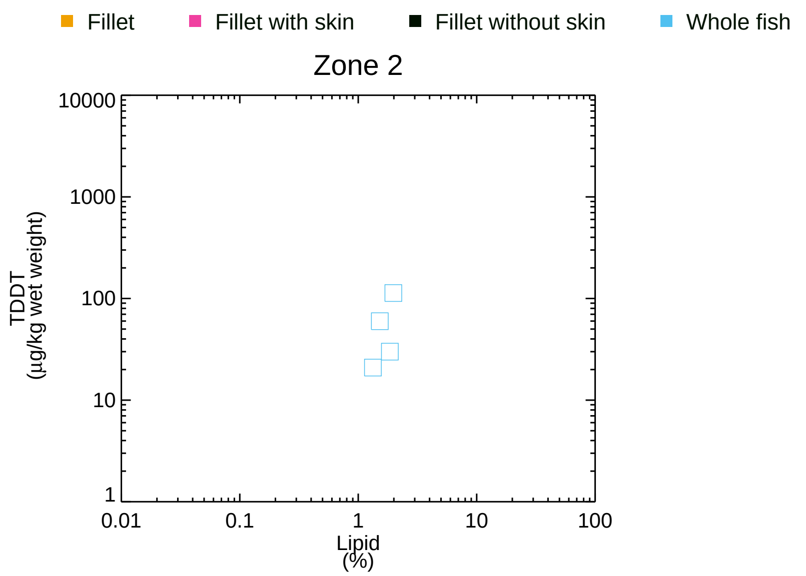

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Figure 2-6j

TDDT Concentration versus Percent Lipid in Topsmelt

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
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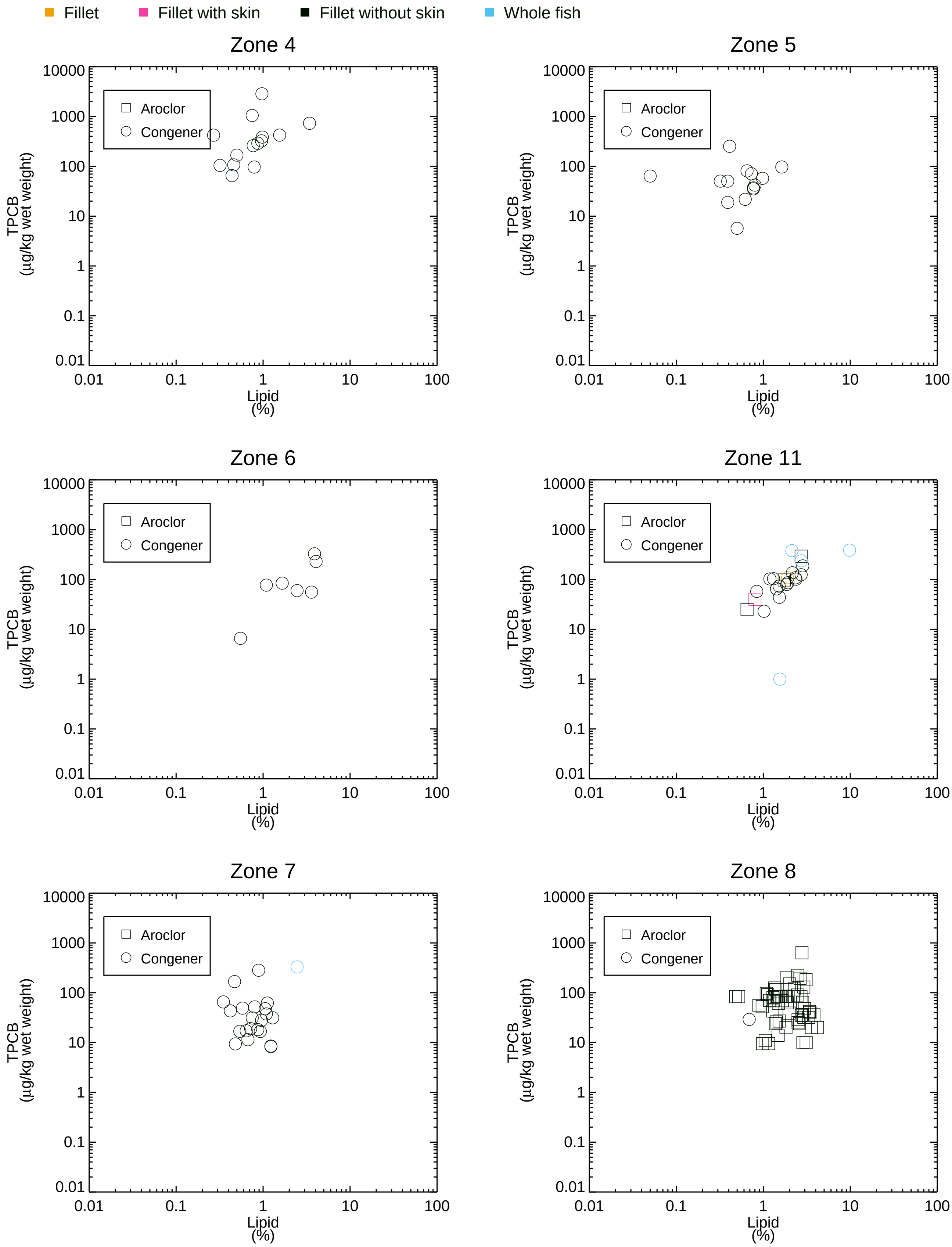

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Figure 2-6k

TPCB Concentration versus Percent Lipid in White Croaker

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

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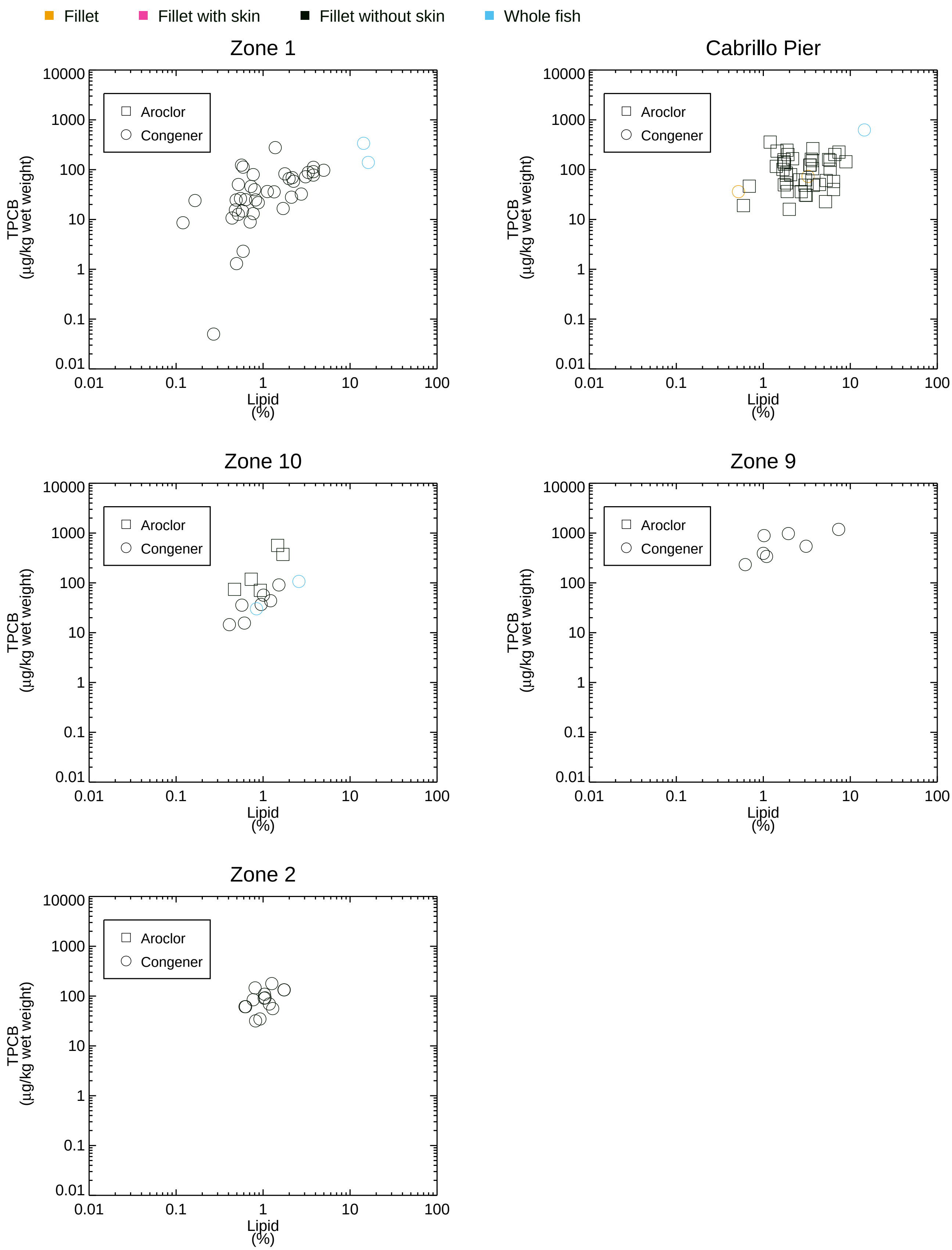

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Figure 2-6k

TPCB Concentration versus Percent Lipid in White Croaker

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

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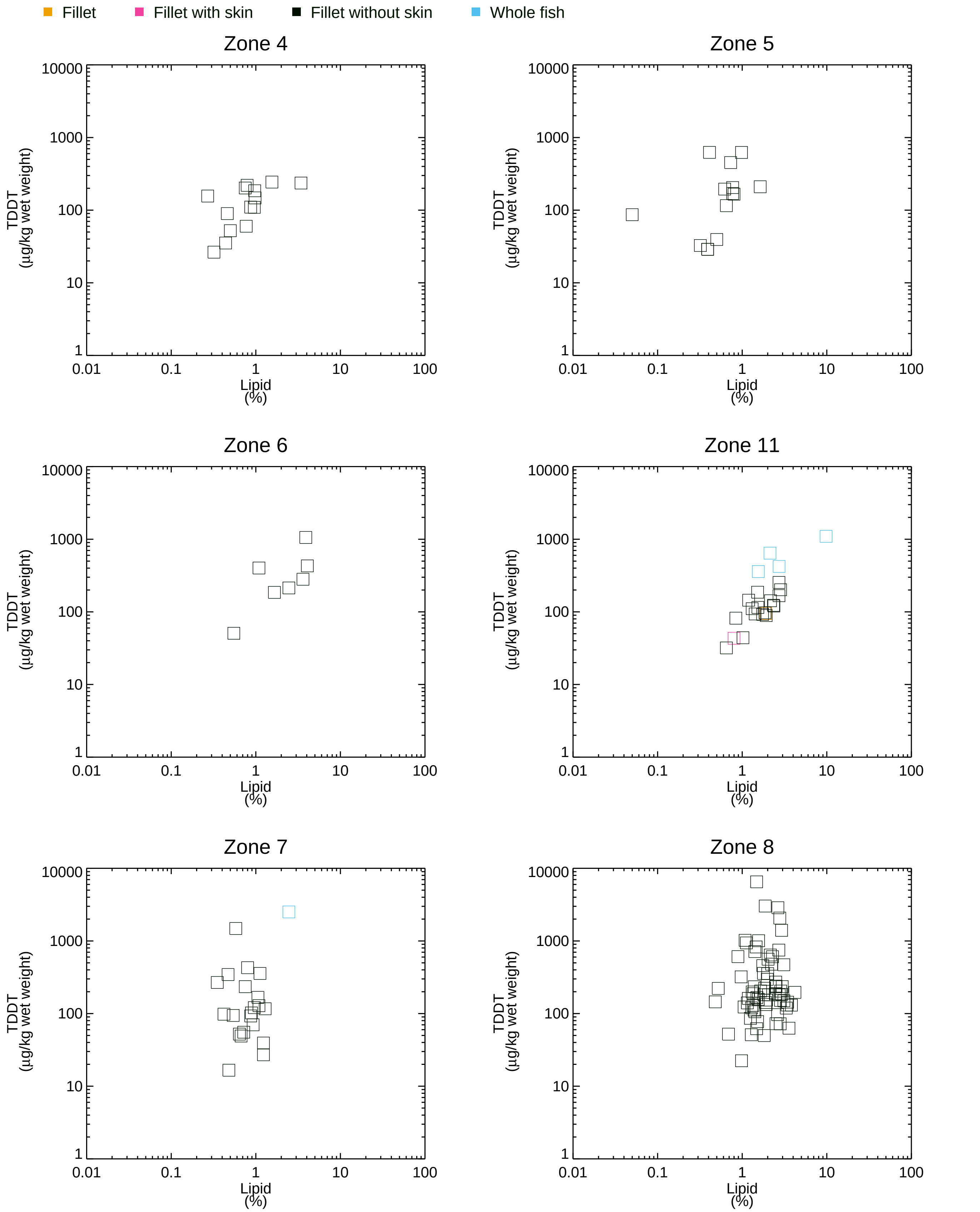

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Figure 2-6l

TDDT Concentration versus Percent Lipid in White Croaker

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
Database: AllFishData_Compile_130731.xlsx.

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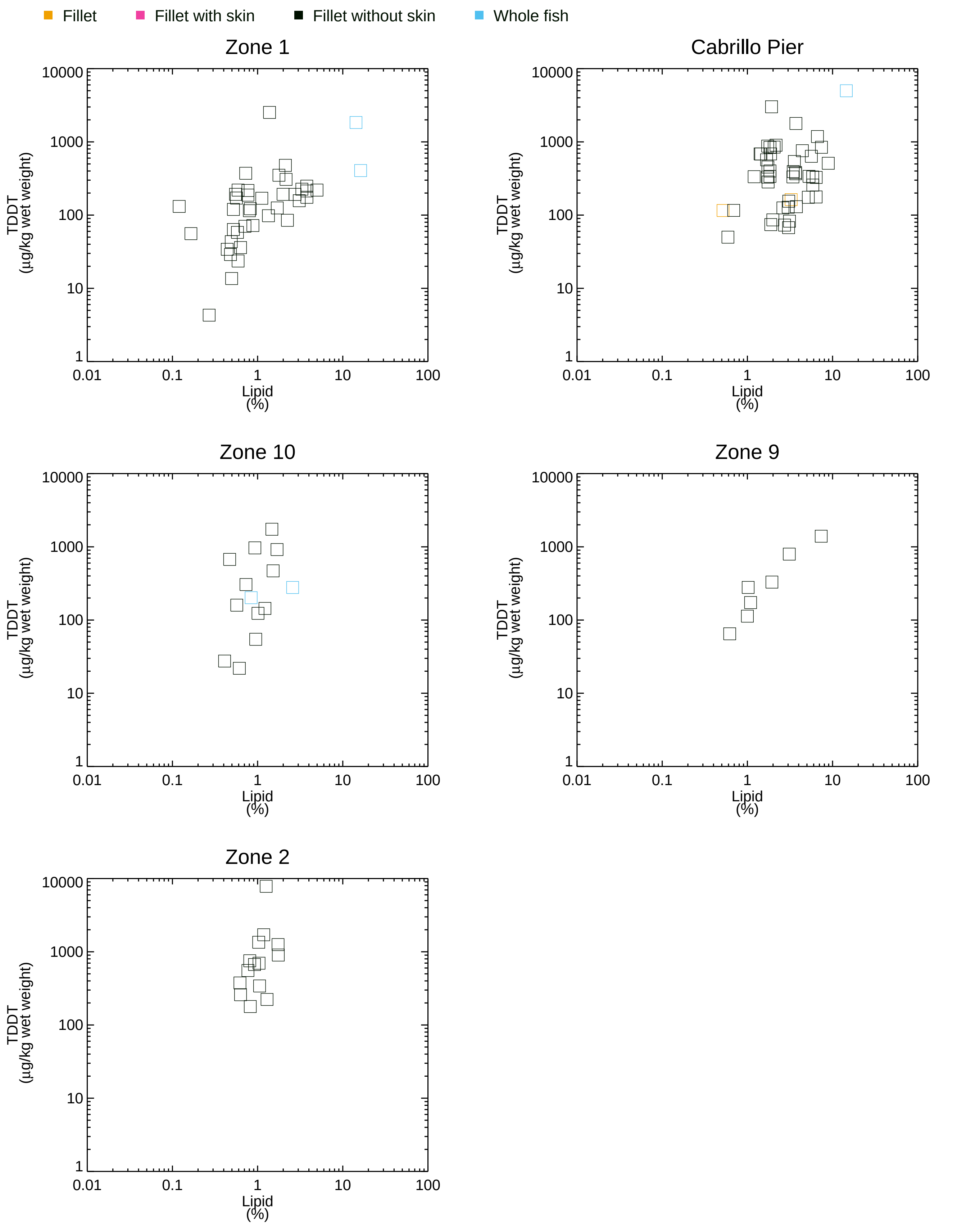

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Figure 2-6l

TDDT Concentration versus Percent Lipid in White Croaker

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
Database: AllFishData_Compile_130731.xlsx.

Fillet · Fillet with skin · Fillet without skin · Whole fish

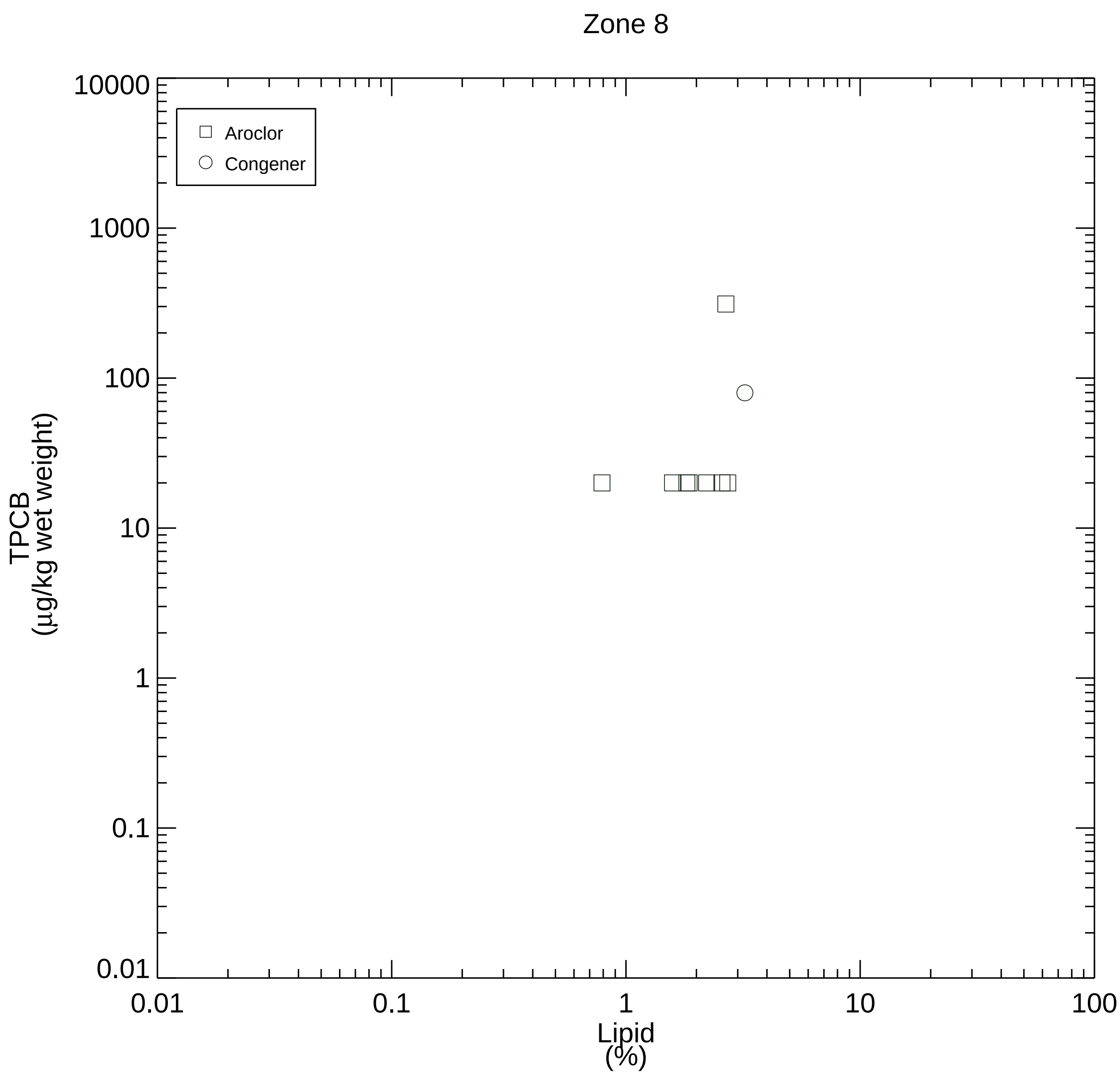

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Figure 2-6m

TPCB Concentration versus Percent Lipid in White Surfperch

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis.
Database: AllFishData_Compile_130731.xlsx.

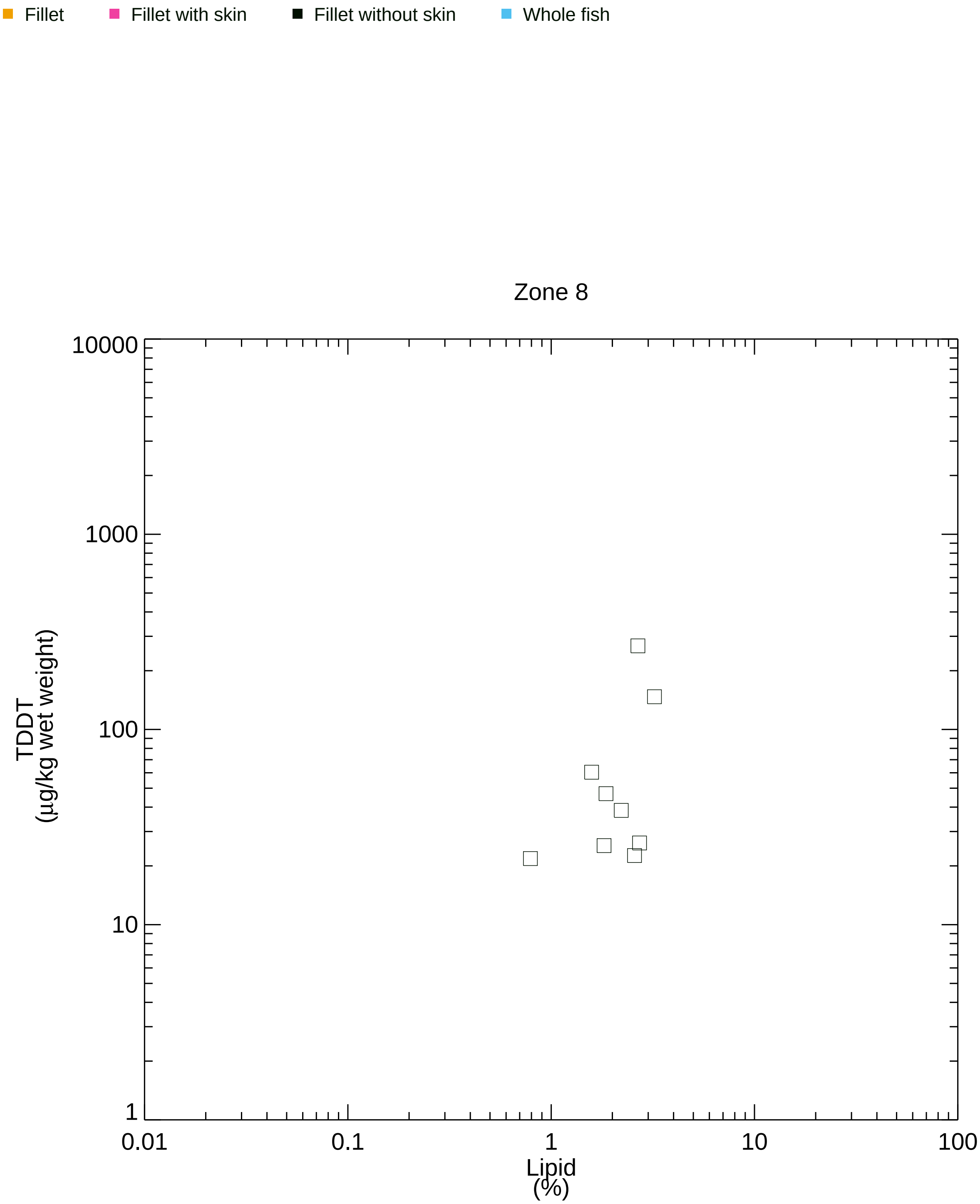

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Figure 2-6n

TDDT Concentration versus Percent Lipid in White Surfperch

Zones delineated based on fish movement. Data included years from 1990 to 2012.
Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. Congener data are used when both Aroclor and Congener data exist for the same sample.
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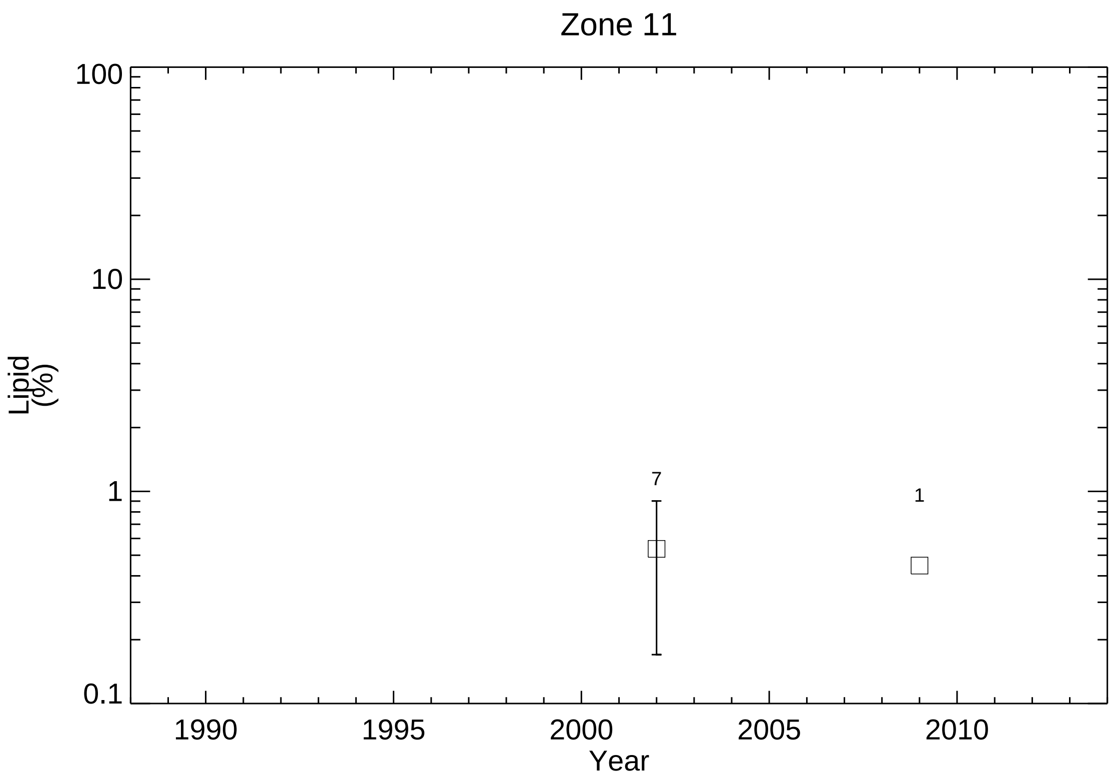

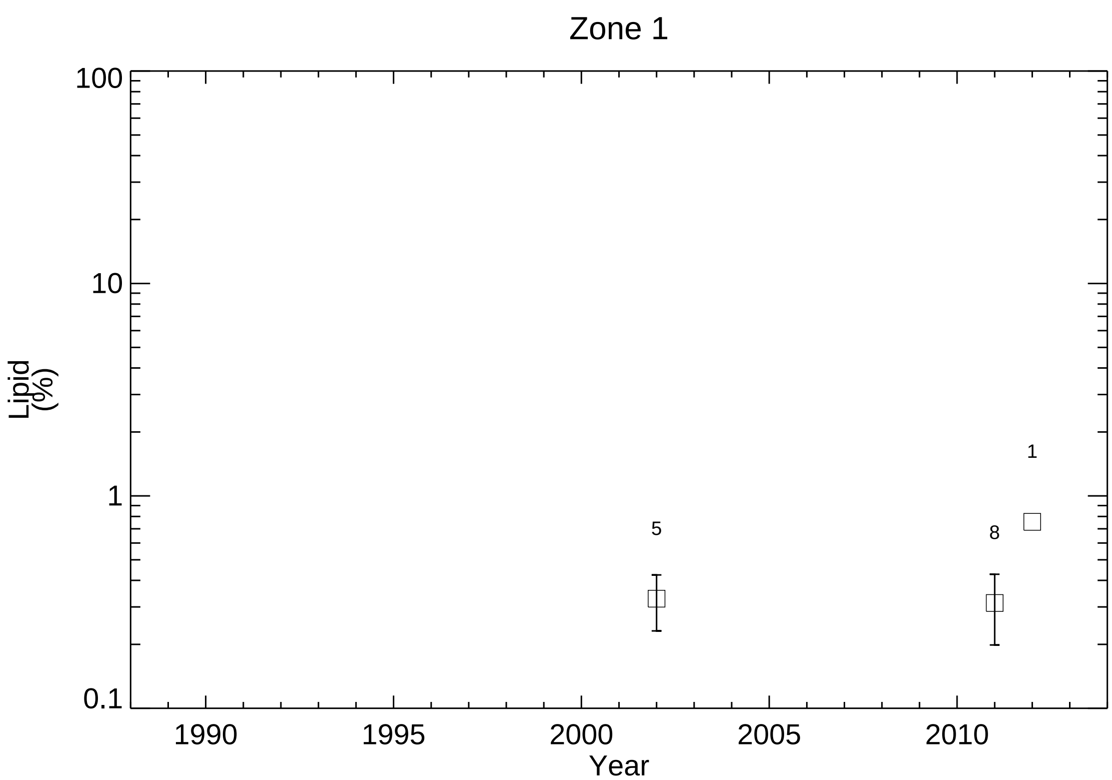

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Figure 2-7a

Temporals of Percent Lipid in California Halibut

Points are means +/- two standard errors. Data count is posted above each symbol. Data shown include: fillet, fillet with skin, fillet without skin, and skin on scales off whole without head tail and guts. Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately. Database: AllFishData_Compile_130731.xlsx.

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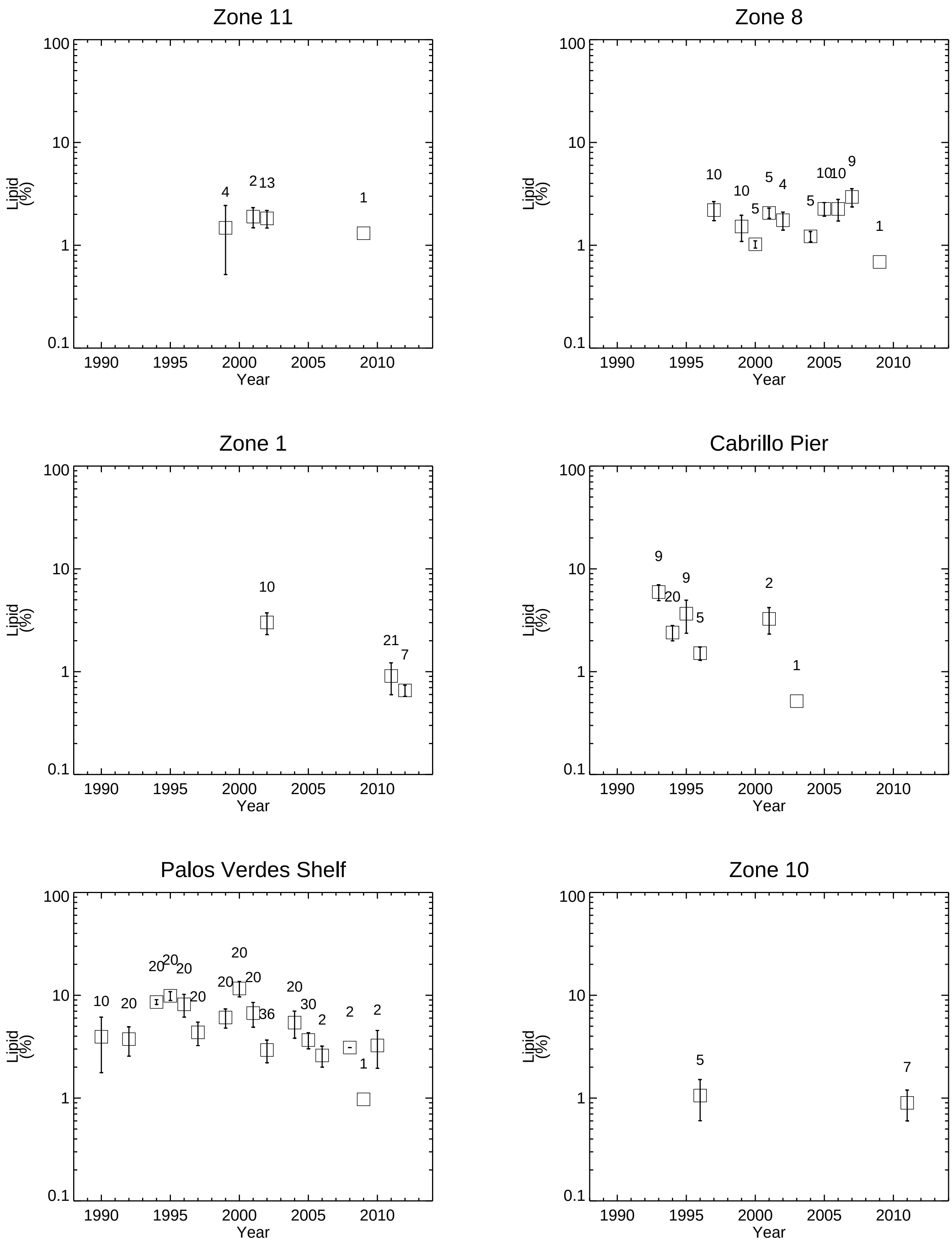

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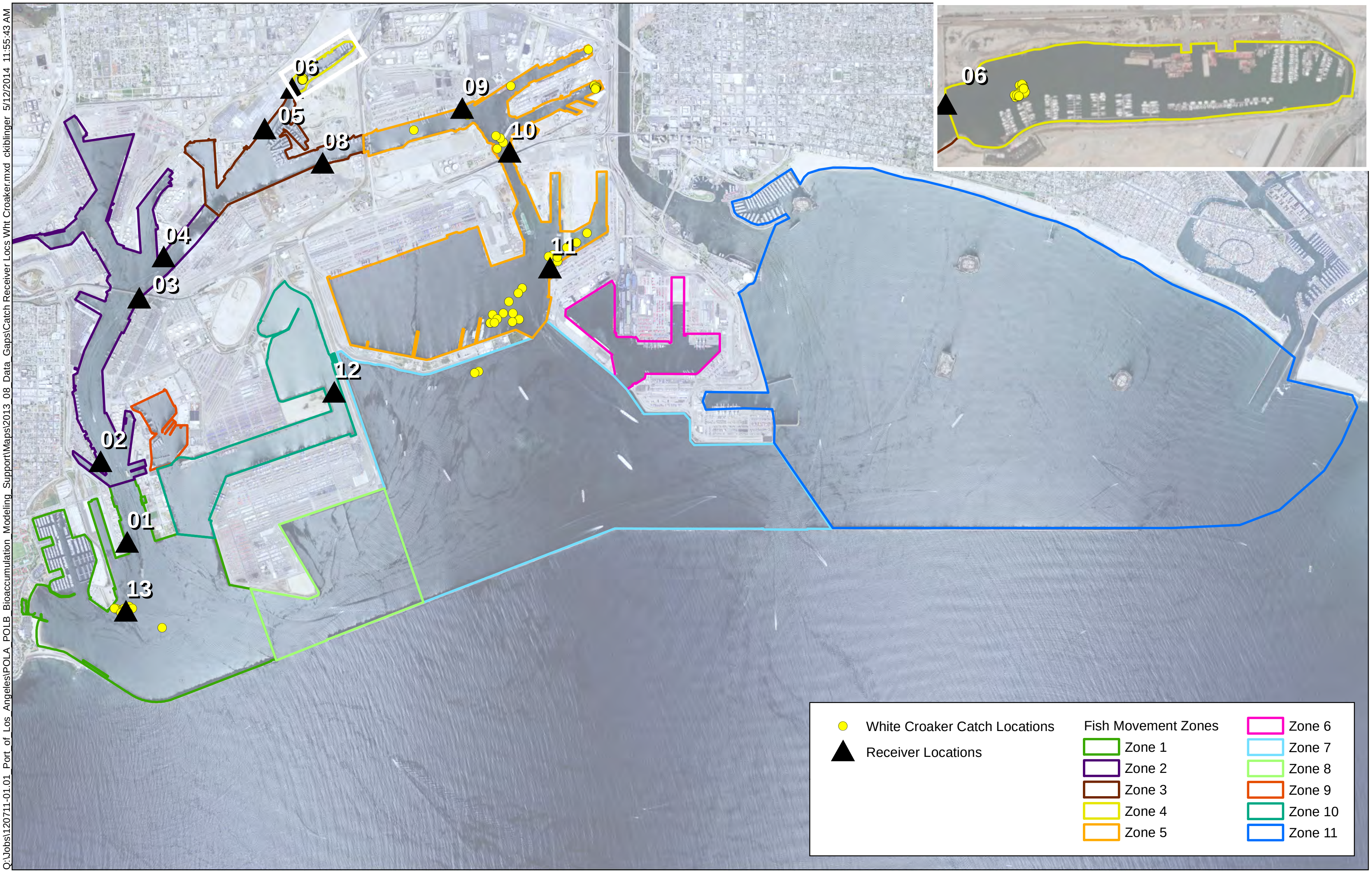
Figure 2-7b

Temporals of Percent Lipid in White Croaker

Points are means +/- two standard errors. Data count is posted above each symbol. Data shown include: fillet, fillet with skin, fillet without skin, and skin on scales off whole without head tail and guts. Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately. Database: AllFishData_Compile_130731.xlsx.



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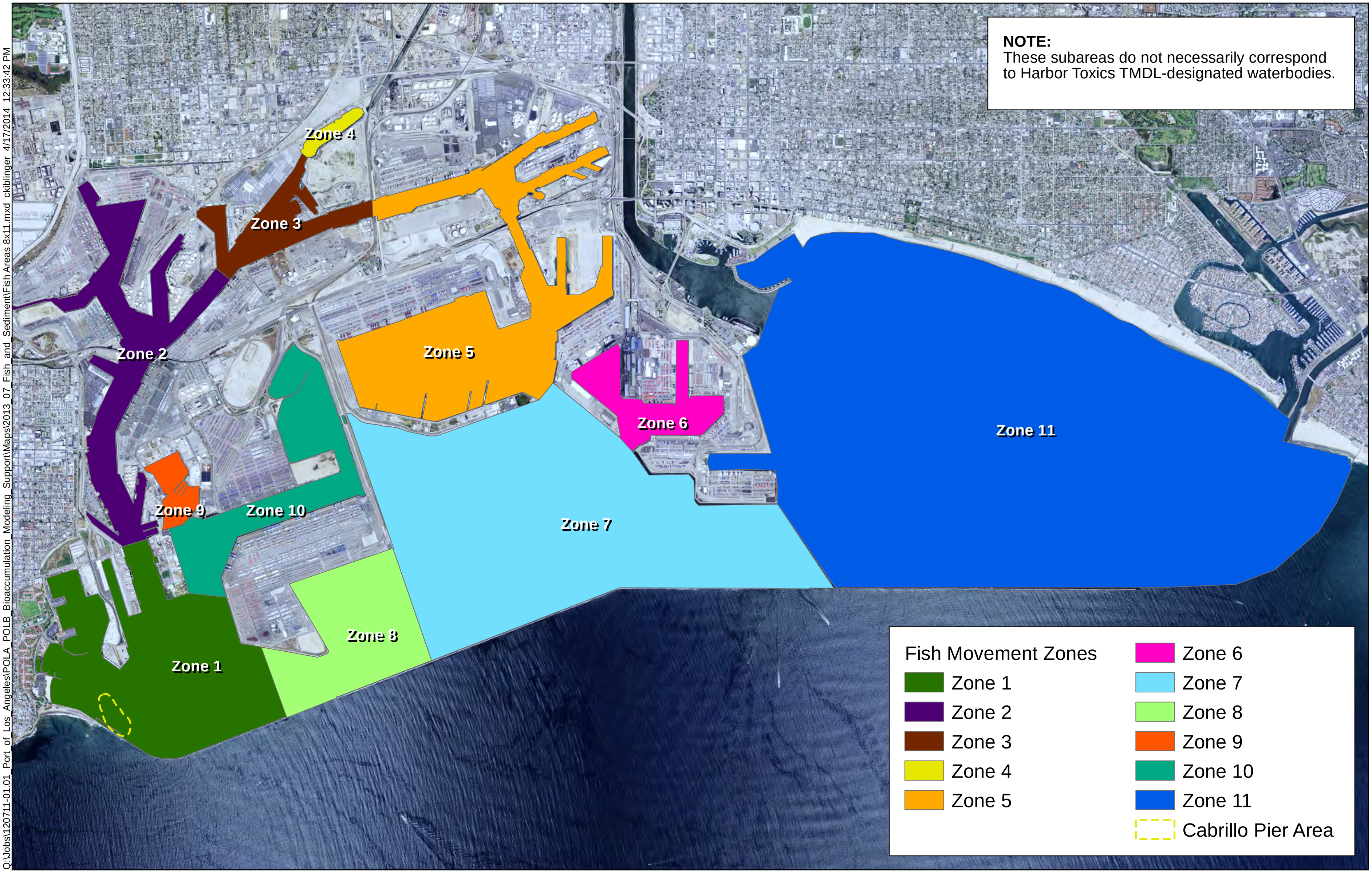
Miles
0 0.5 1

Figure 2-8
White Croaker Catch and Receiver Locations
Greater Los Angeles and Long Beach Harbor Waters



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Miles
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Figure 3-1
Preliminary Fish Movement Zones of White Croaker
Greater Los Angeles and Long Beach Harbor Waters

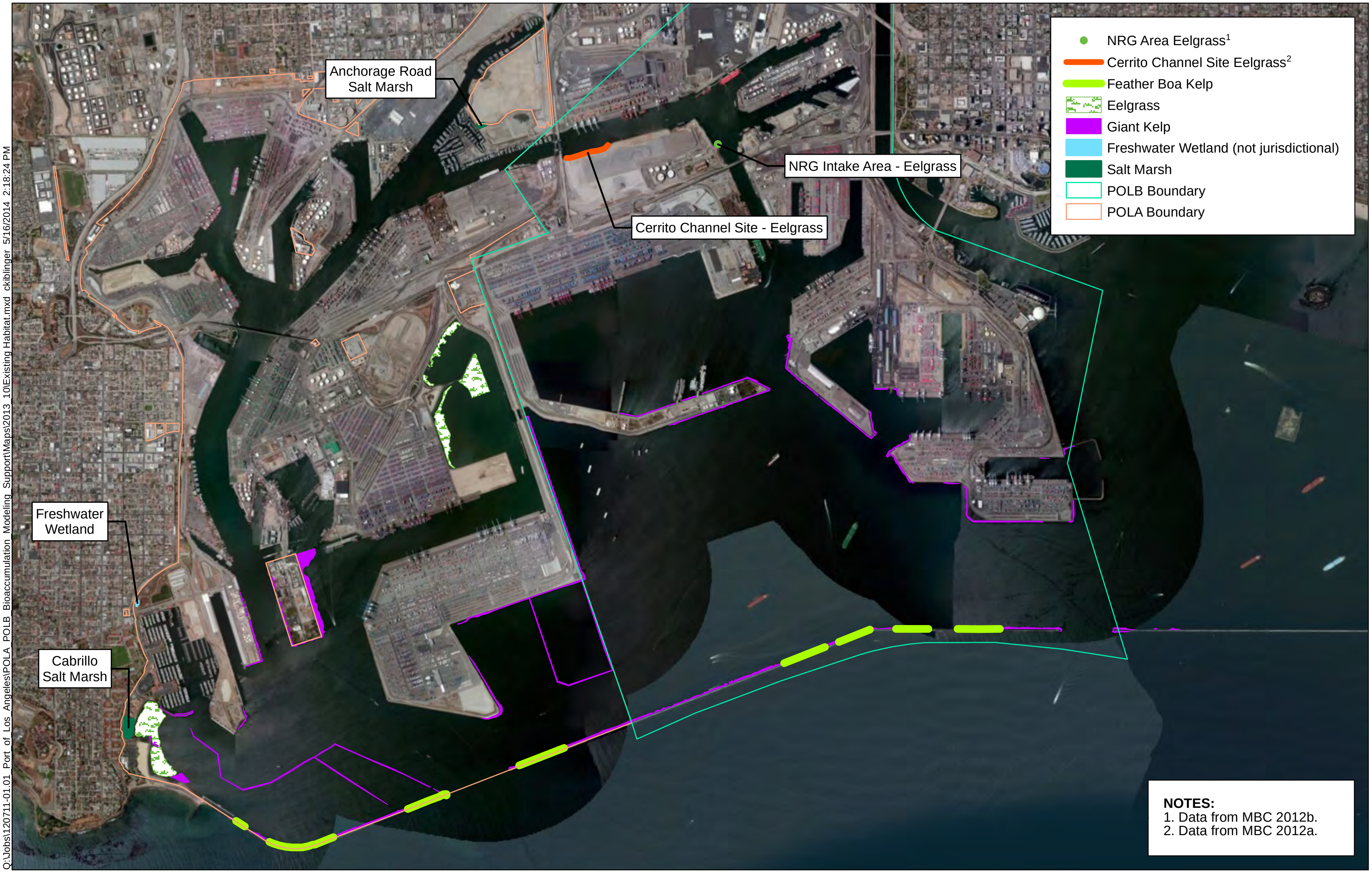

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Figure 3-2
Habitat Areas
Greater Los Angeles and Long Beach Harbor Waters

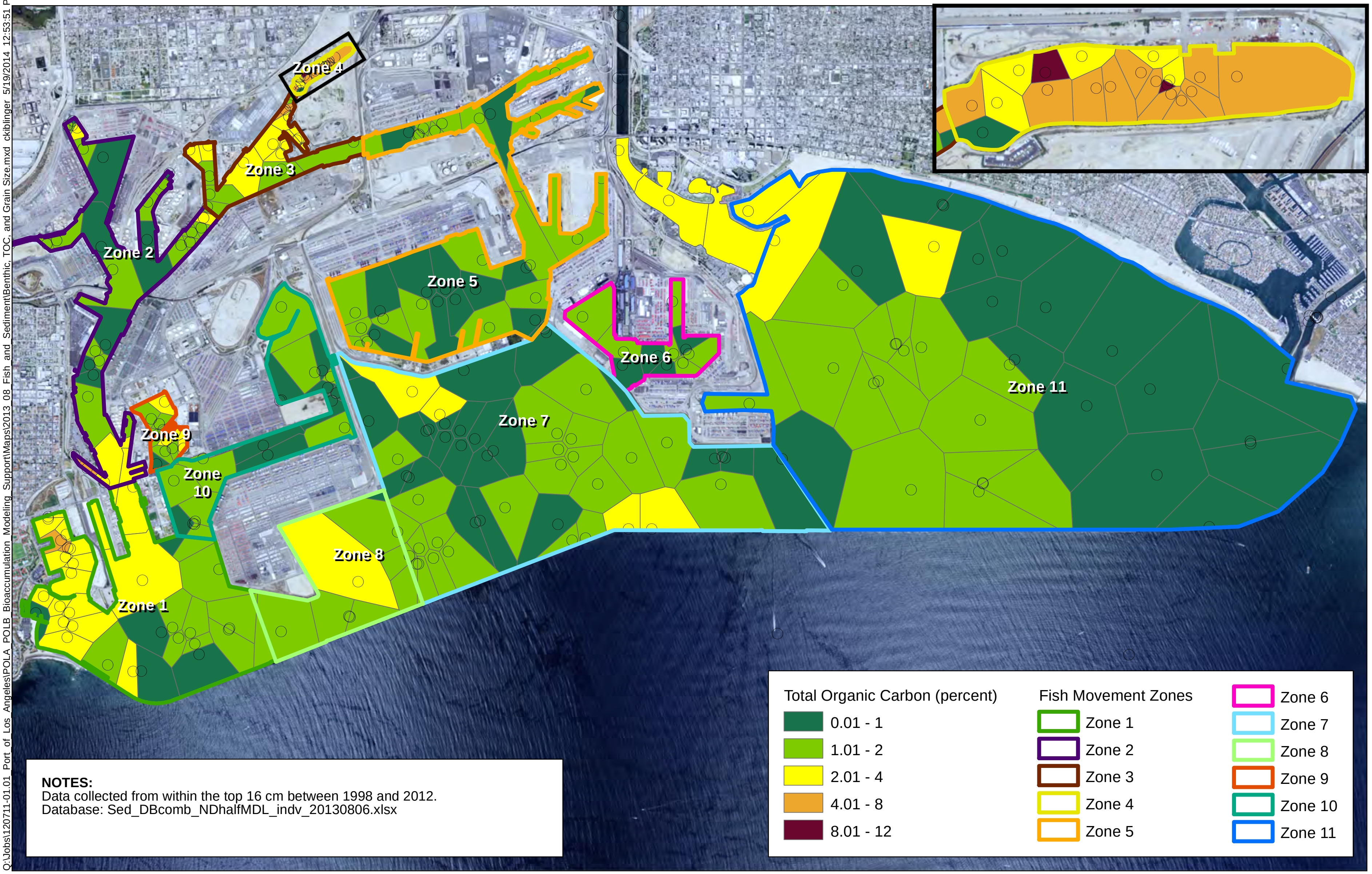

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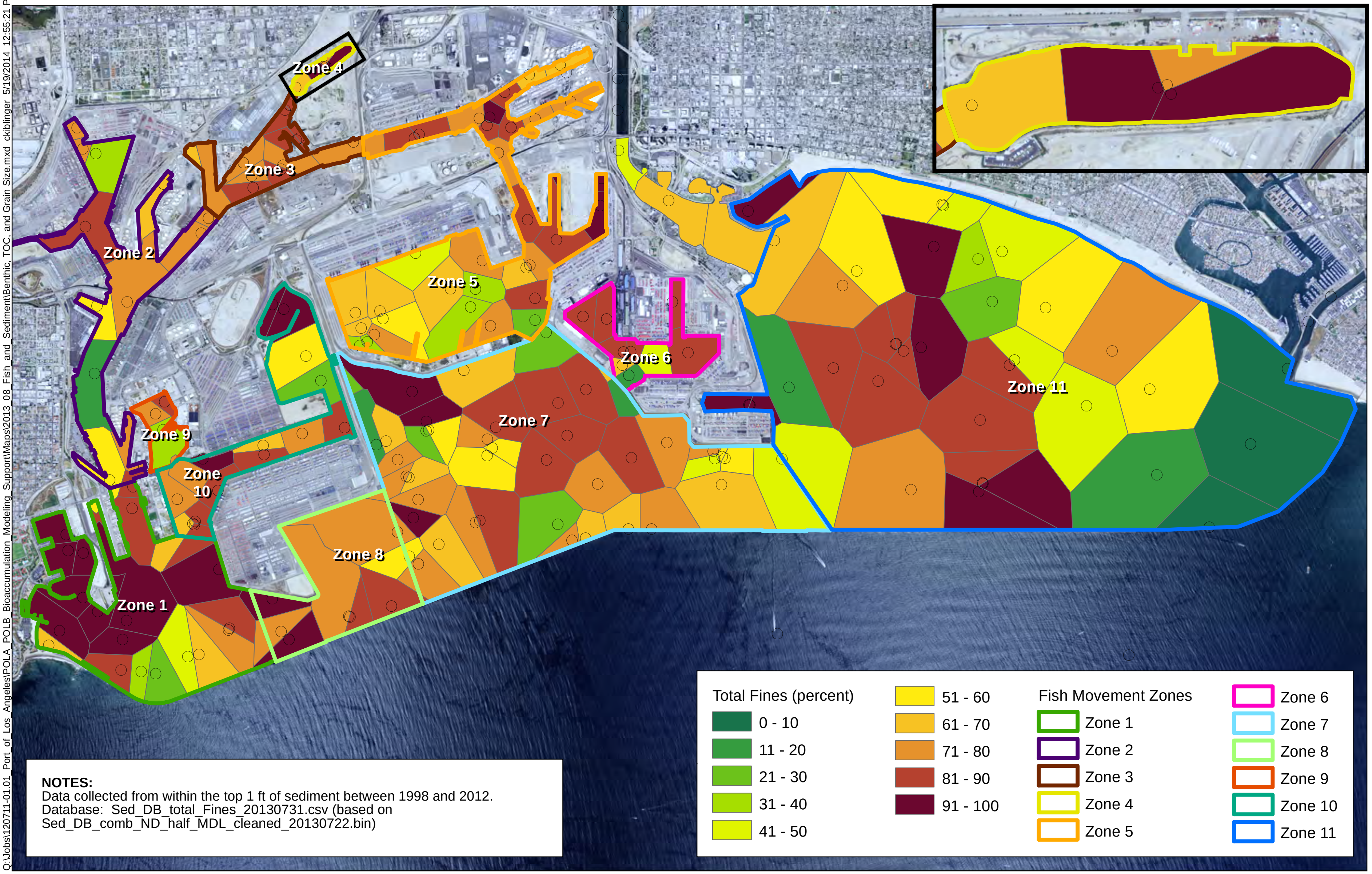
Figure 3-3
Thiessen Polygons Showing Total Organic Carbon in Surface Sediment
Greater Los Angeles and Long Beach Harbor Waters



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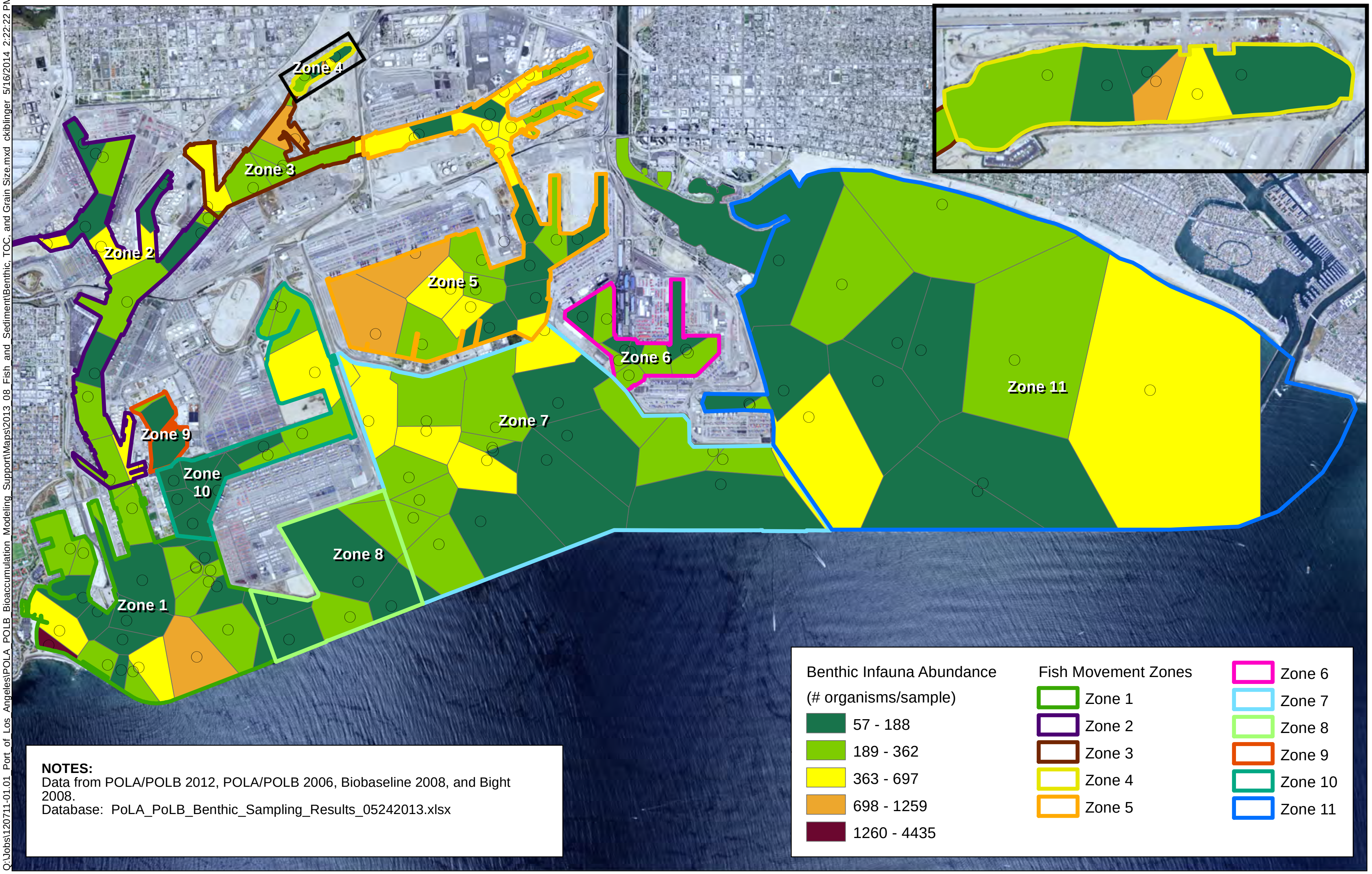
Miles
0 0.5 1

Figure 3-4

Thiessen Polygons Showing Percent Fines in Surface Sediment
Greater Los Angeles and Long Beach Harbor Waters



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Miles
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Figure 3-5
Thiessen Polygons Showing Benthic Infauna Abundance
Greater Los Angeles and Long Beach Harbor Waters

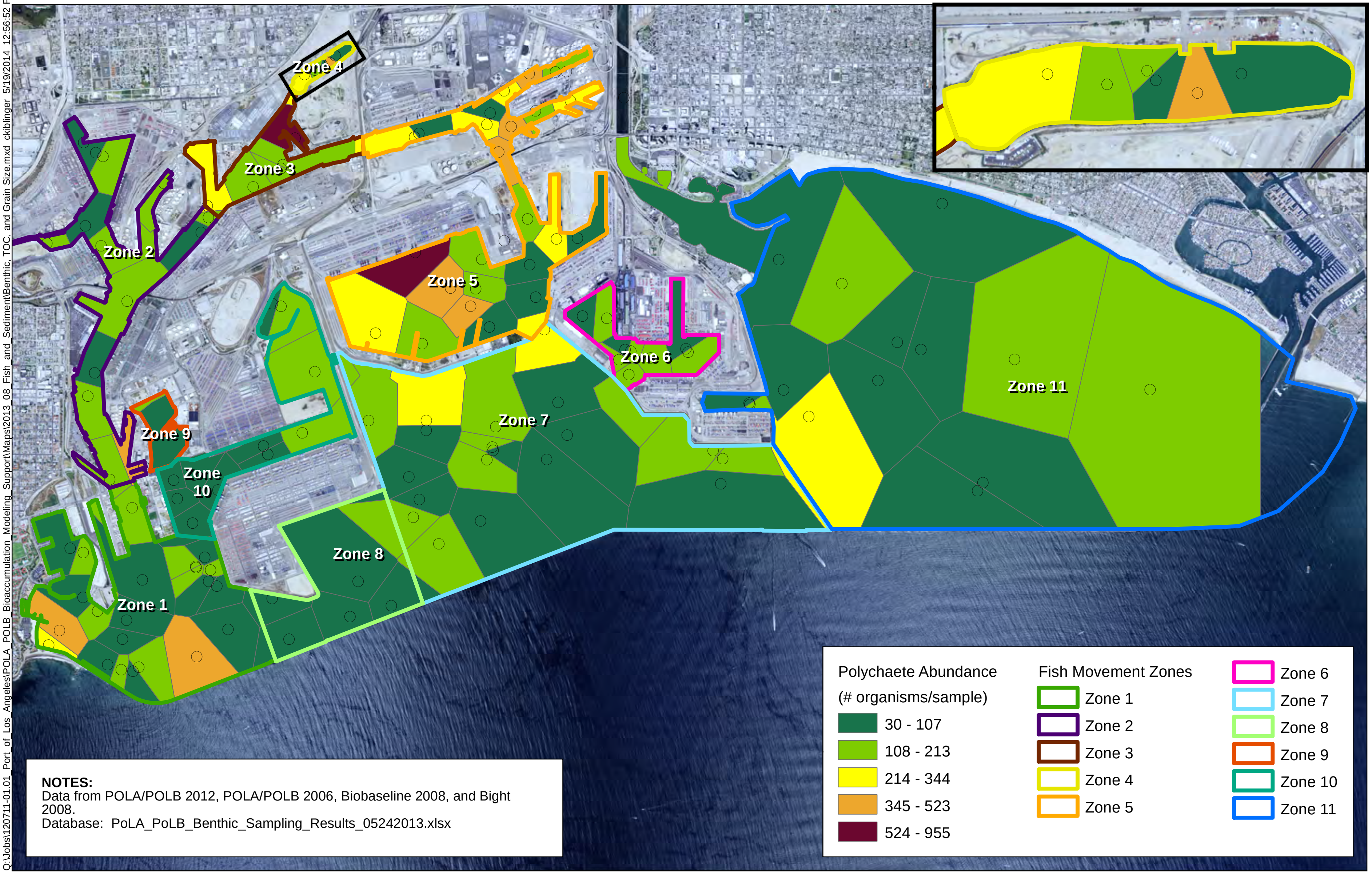

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Figure 3-6
Thiessen Polygons Showing Polychaete Abundance
Greater Los Angeles and Long Beach Harbor Waters

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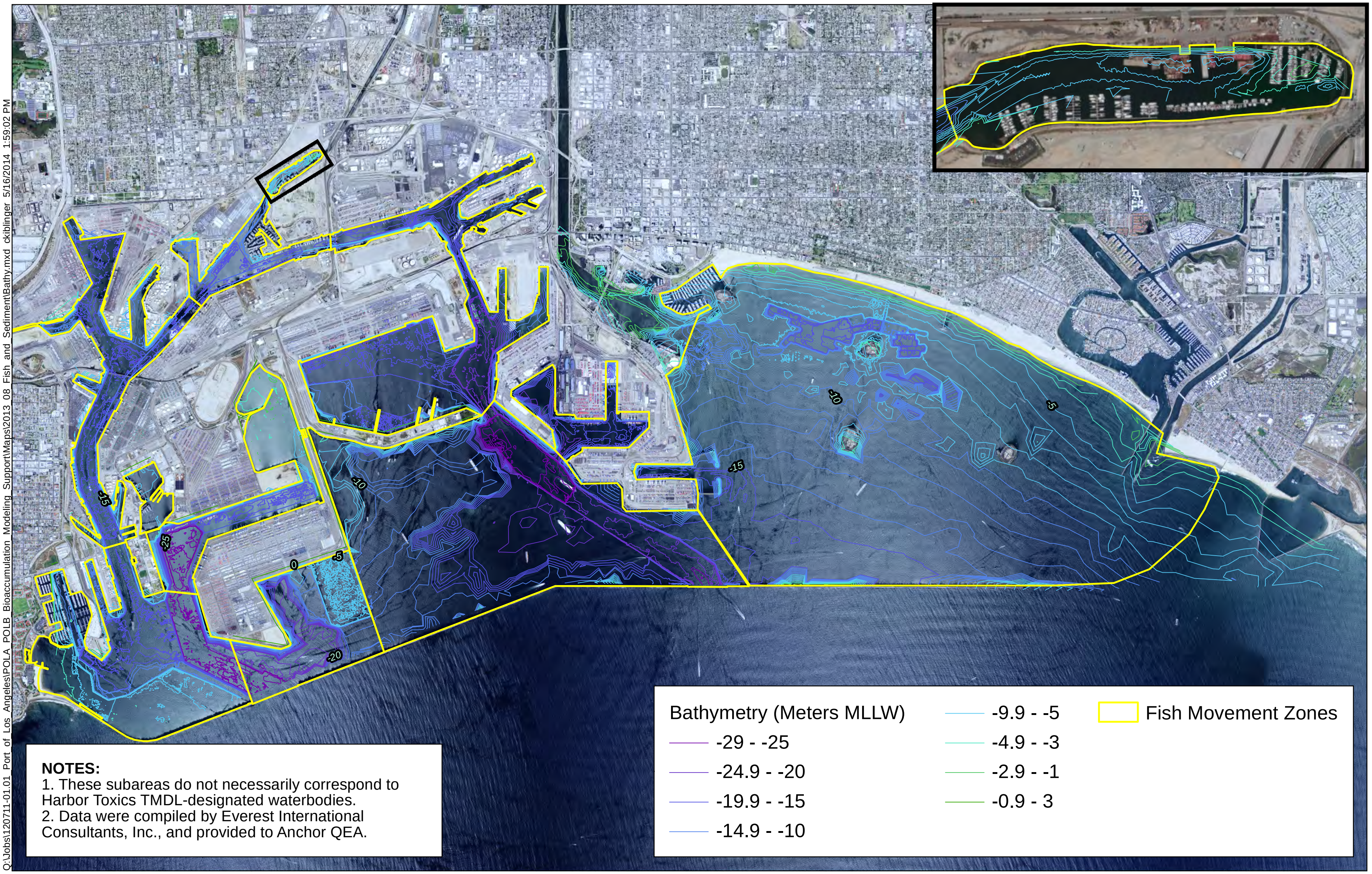

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Miles
0 1 2

Figure 3-7
Bathymetry
Greater Los Angeles and Long Beach Harbor Waters

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Miles
0 0.5 1

Figure 3-8
CSULB Fish Tracking Study Phase II Receiver Locations
Greater Los Angeles and Long Beach Harbor Waters

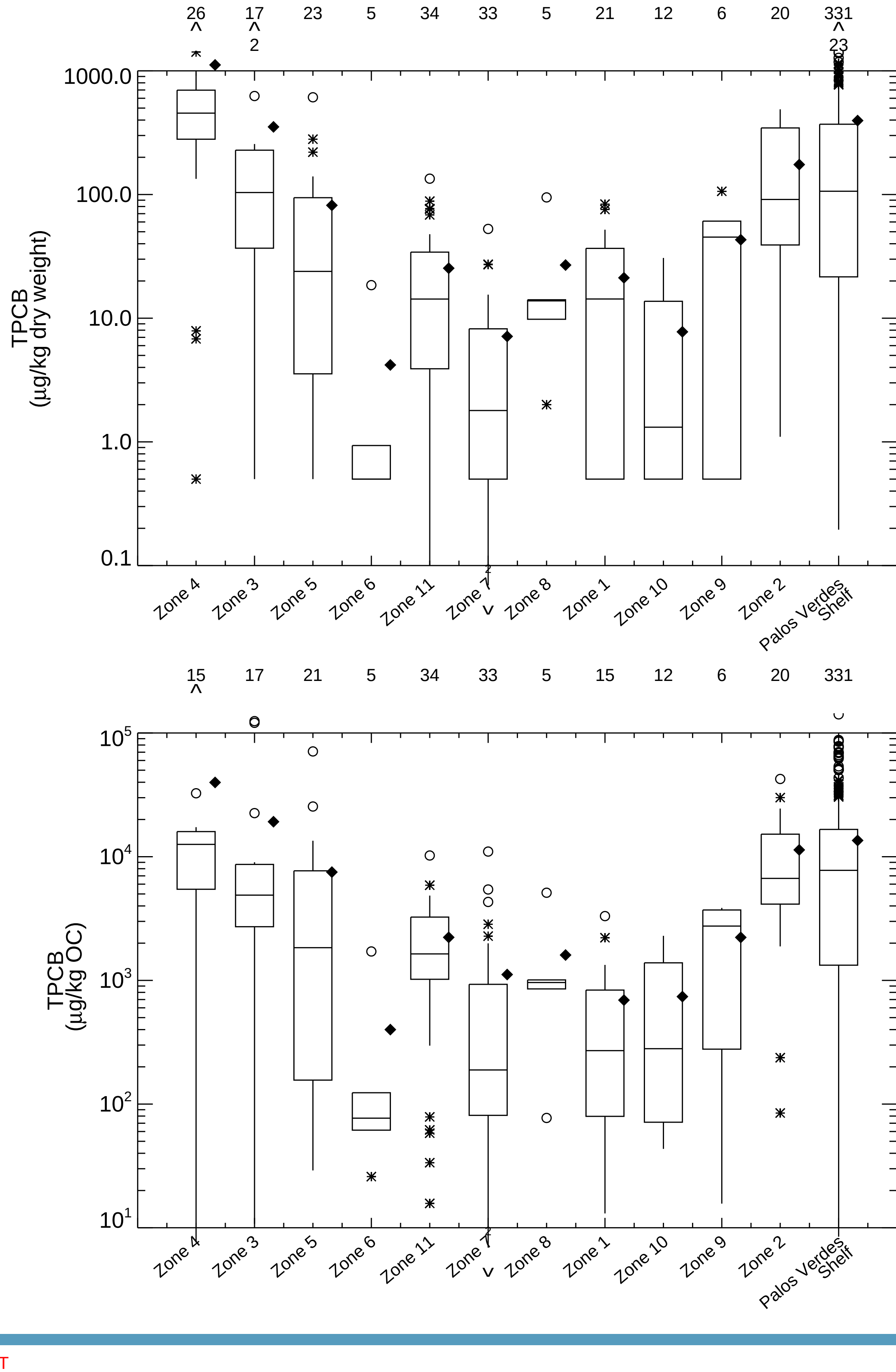

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Figure 4−1

Box Plots of TPCB Concentrations in Surface Sediment

Surface (top 16 cm) data collected between 1998 and 2012.
Number of samples shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes; 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars) and outer (open circles) outliers. Zones delineated based on fish movement. Palos Verdes Shelf data identified using GIS. Carets and adjacent numbers indicate off−panel data. Database: sed_DBcomb_NDhalfMDL_tot_20140229.xlsx

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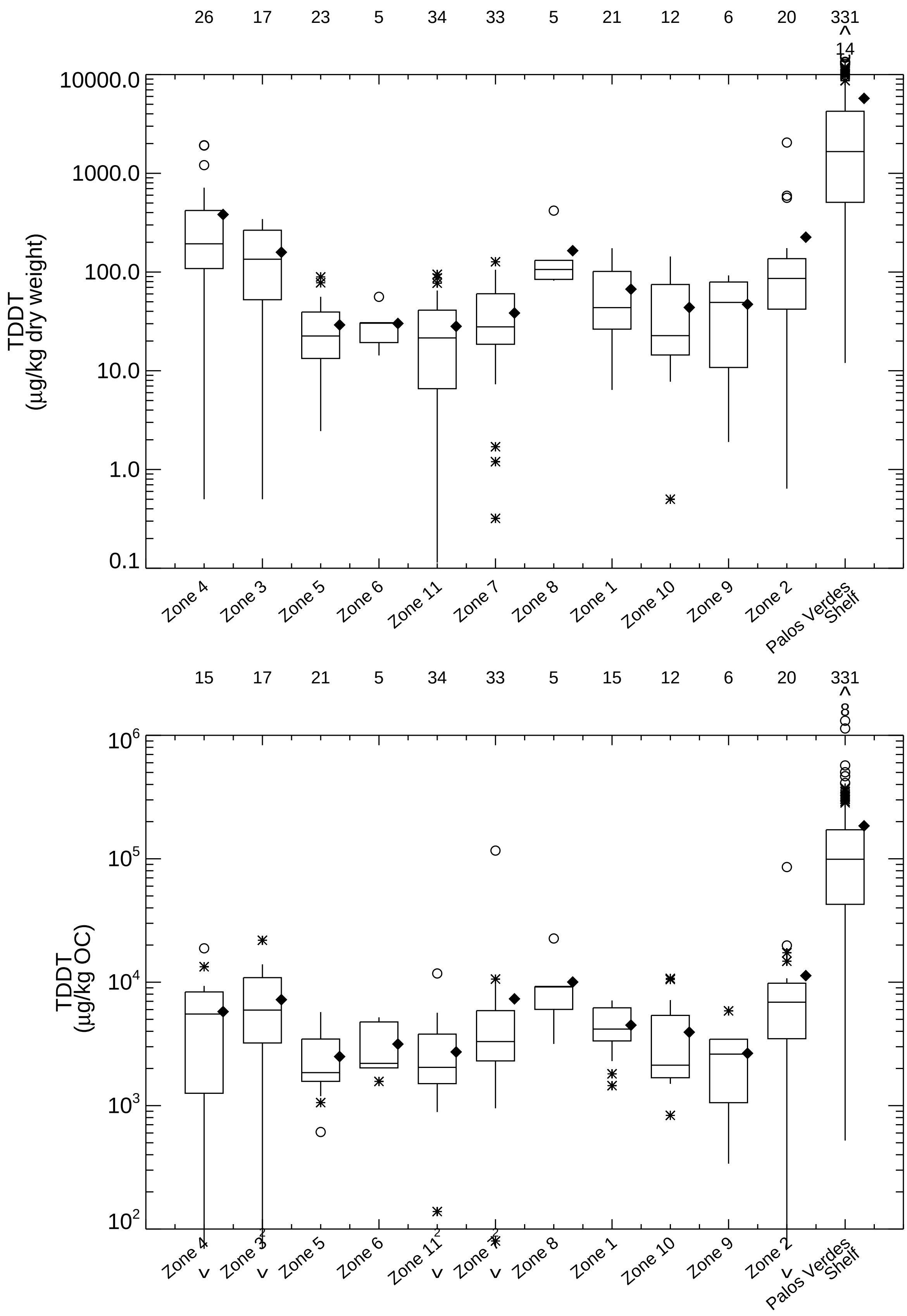

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Figure 4−2

Box Plots of TDDT Concentrations in Surface Sediment

Surface (top 16 cm) data collected between 1998 and 2012. Number of samples shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes; 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars) and outer (open circles) outliers. Zones delineated based on fish movement. Palos Verdes Shelf data identified using GIS. Carets and adjacent numbers indicate off−panel data. Database: sed_DBcomb_NDhalfMDL_tot_20140229.xlsx

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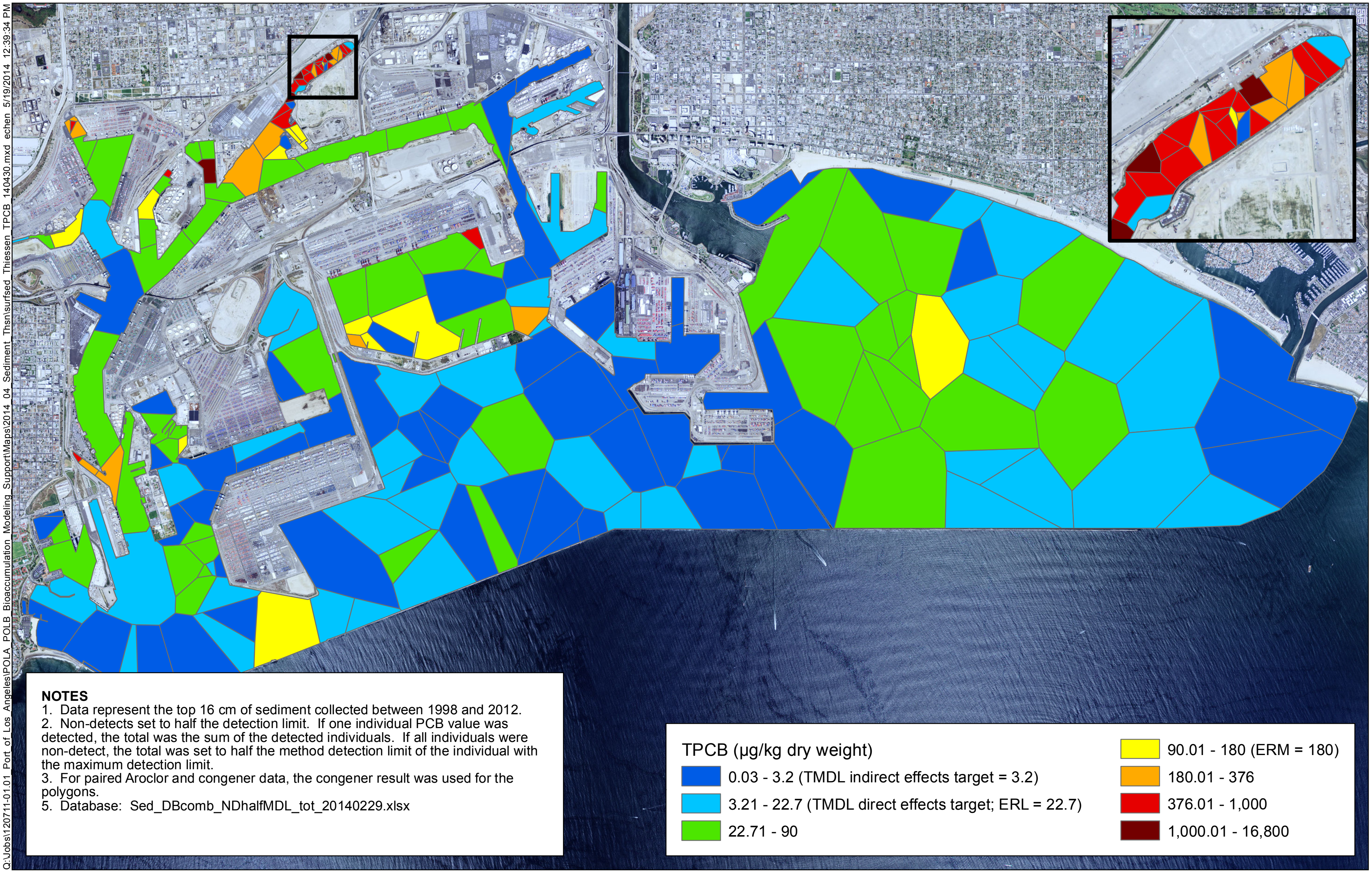

NOTES

1. Data represent the top 16 cm of sediment collected between 1998 and 2012.
2. Non-detects set to half the detection limit. If one individual PCB value was detected, the total was the sum of the detected individuals. If all individuals were non-detect, the total was set to half the method detection limit of the individual with the maximum detection limit.
3. For paired Aroclor and congener data, the congener result was used for the polygons.
5. Database: Sed_DBcomb_NDhalfMDL_tot_20140229.xlsx

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ANCHOR QEA

Miles

0 0.5 1

Figure 4-3

Thiessen Polygons Showing TPCB Concentrations in Surface Sediment
Greater Los Angeles and Long Beach Harbor Waters

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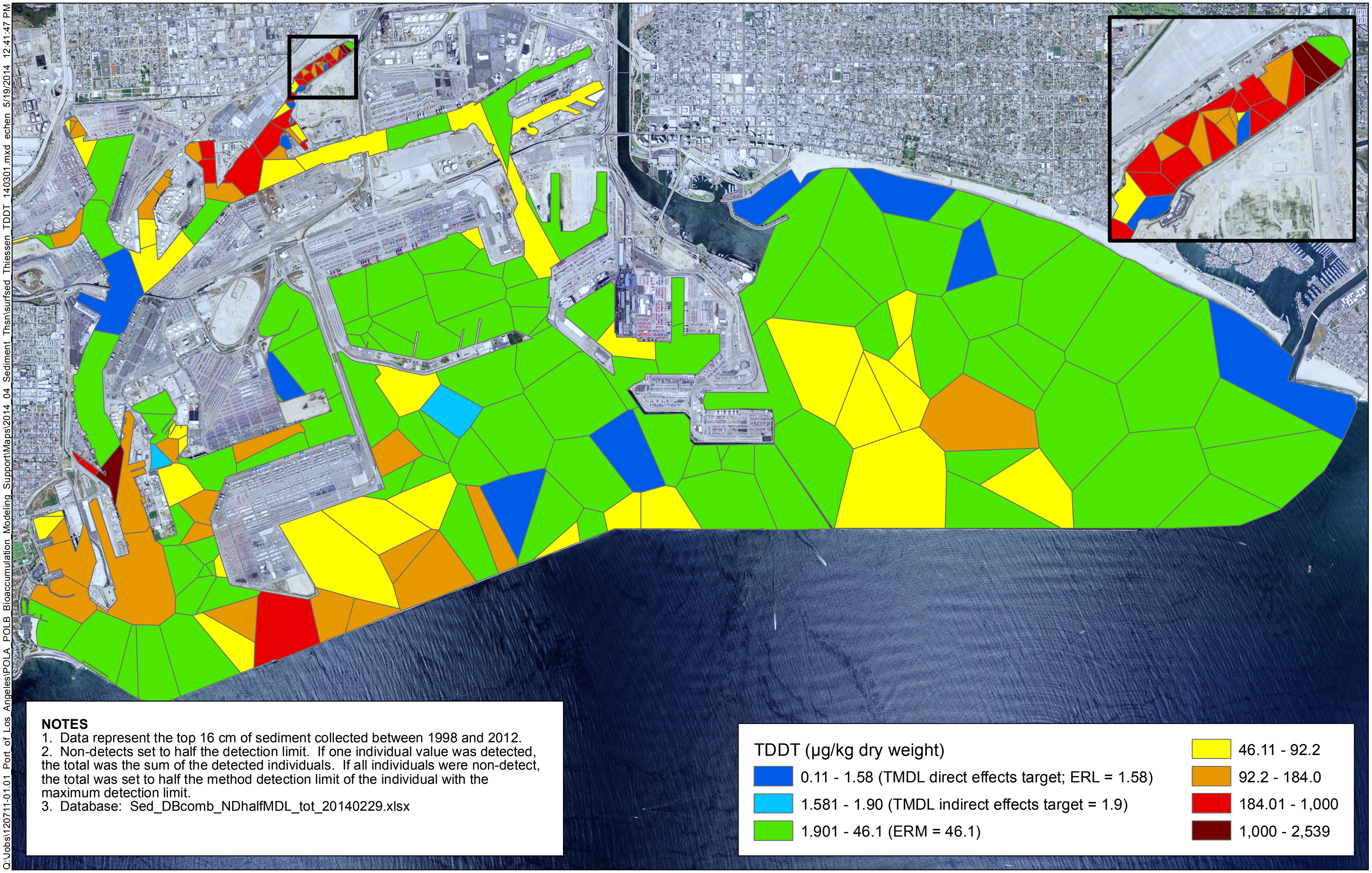

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Miles
0 0.5 1

Figure 4-4
Thiessen Polygons Showing TDDT Concentrations in Surface Sediment
Greater Los Angeles and Long Beach Harbor Waters

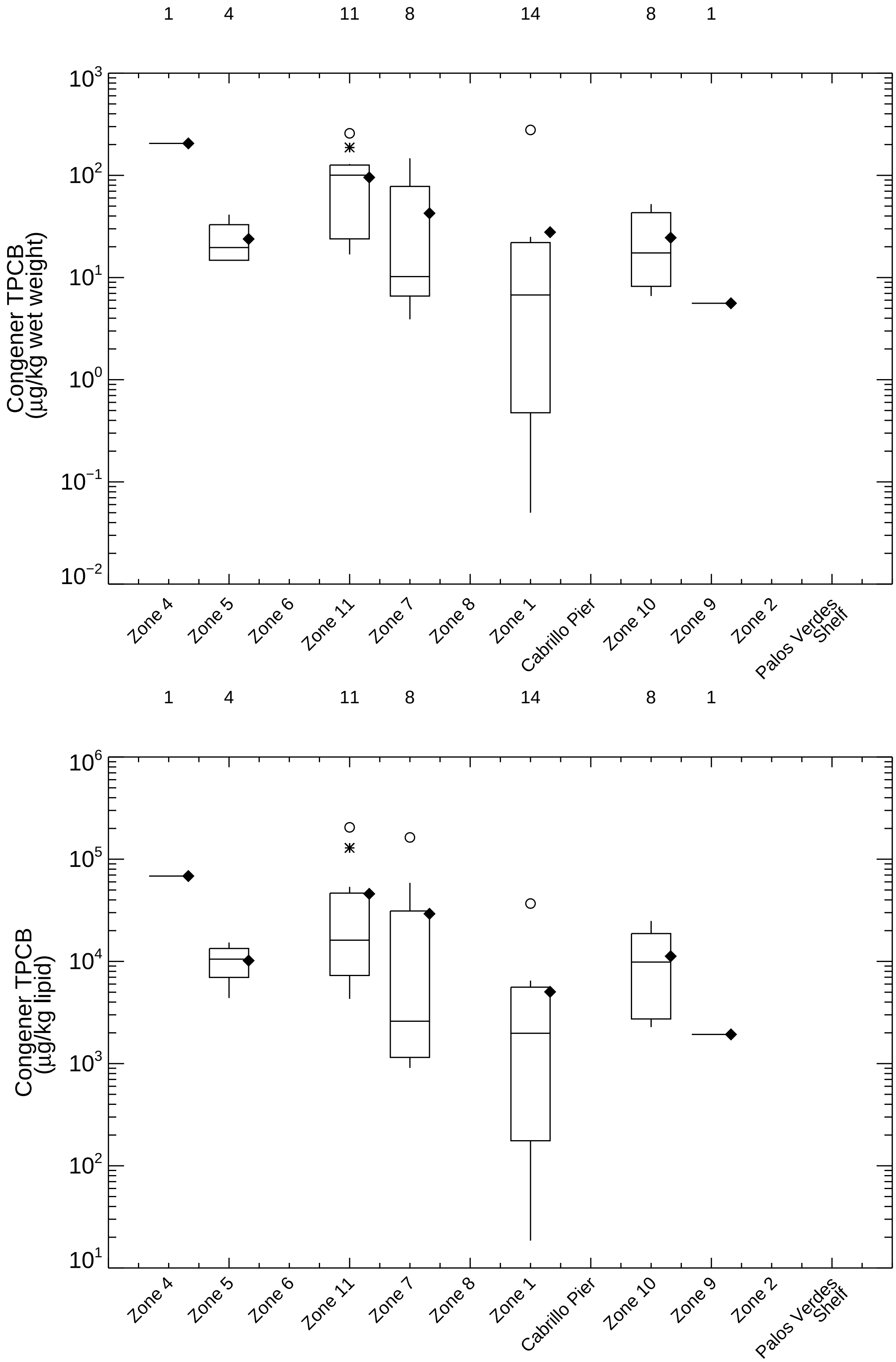

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Figure 4−5a

Box Plots of TPCB Concentrations in California Halibut

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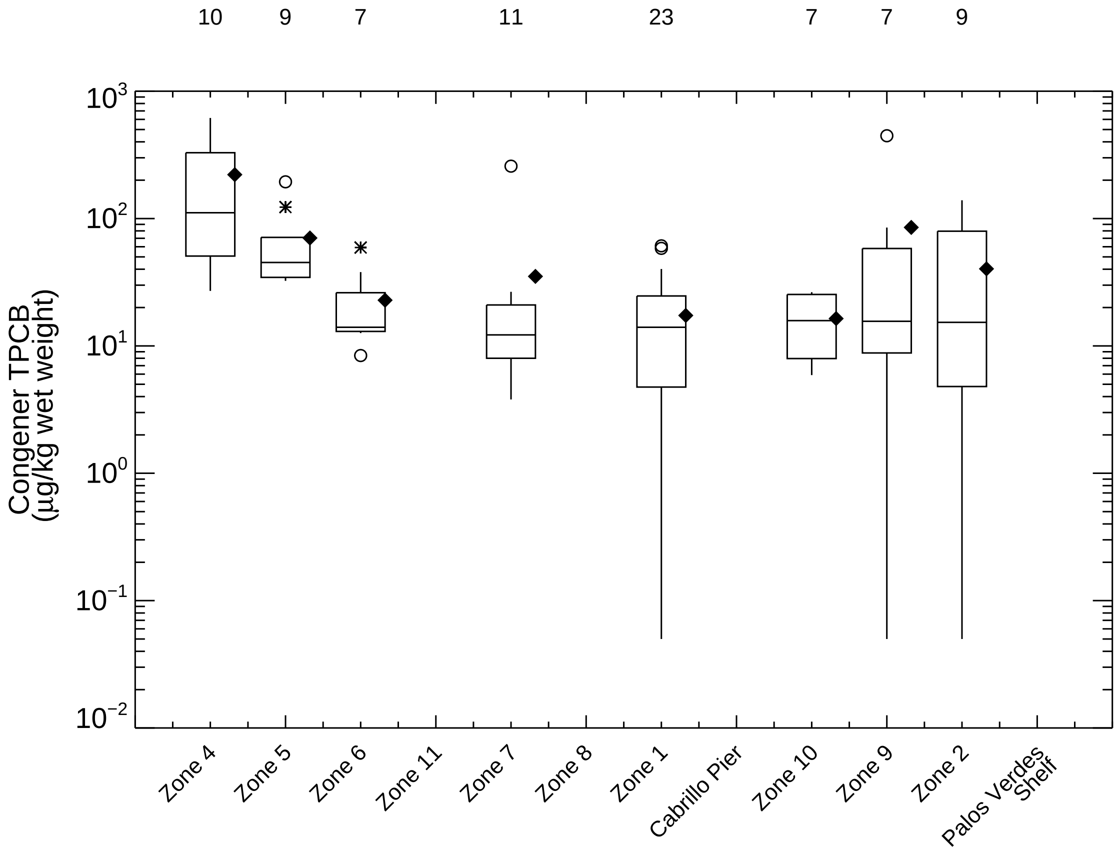
Tissues included Fillet without skin, Whole fish (lipid basis only). Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers. Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately. Database: fishData_processed_20130801_join_SketchofAreas131021



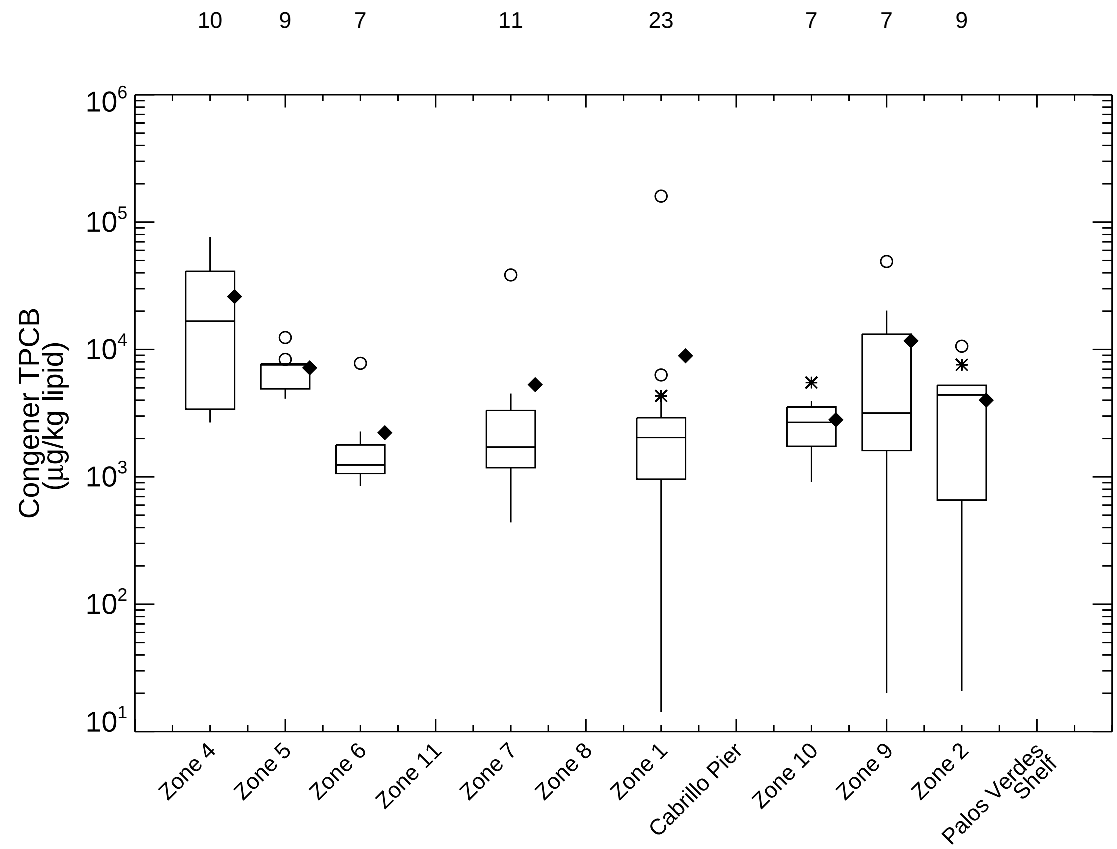


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Figure 4−5b

Box Plots of TPCB Concentrations in Queenfish

Tissues included Fillet without skin.
Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers.
Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately.
Database: fishData_processed_20130801_join_SketchofAreas131021

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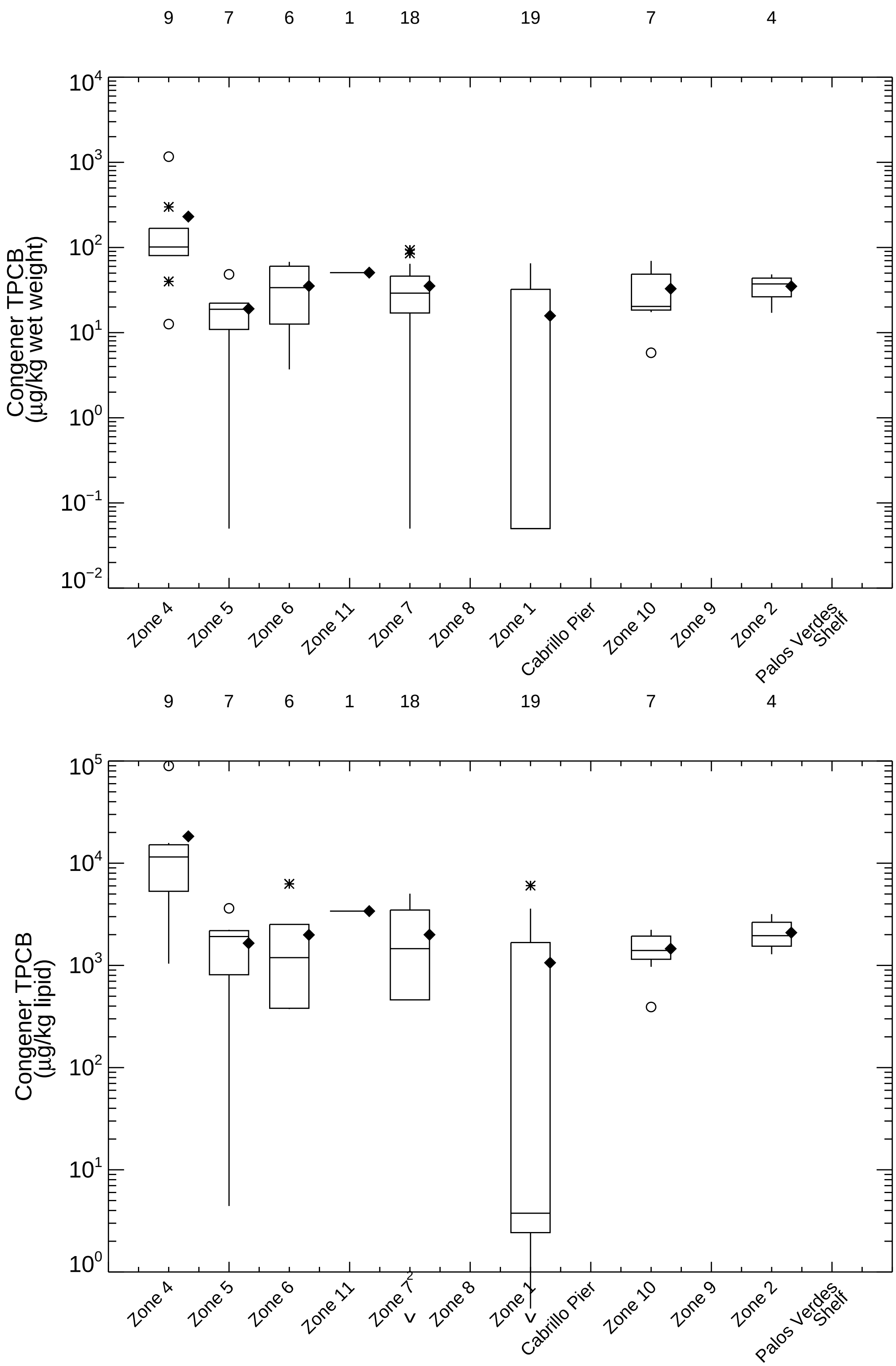
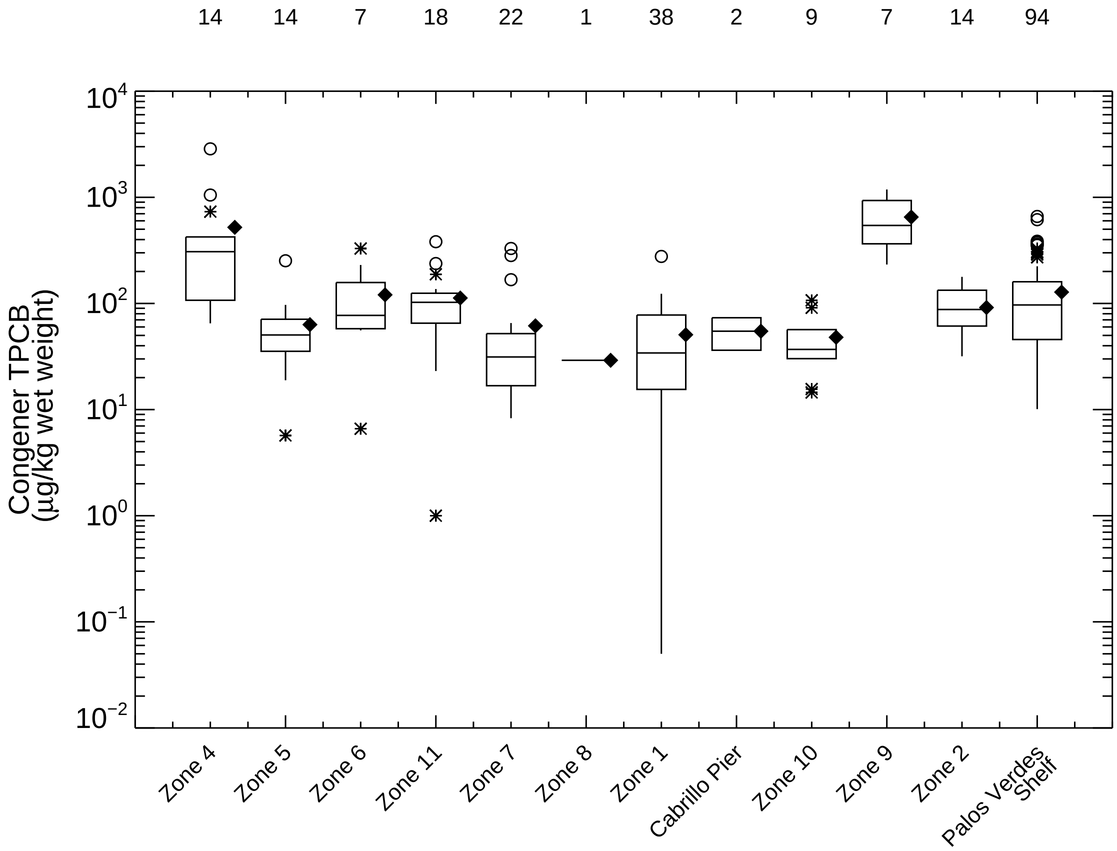


Figure 4−5c

Box Plots of TPCB Concentrations in Topsmelt

Tissues included Skin on scales off whole without head tail and guts (lipid basis only), Whole fish. Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers. Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately. Database: fishData_processed_20130801_join_SketchofAreas131021



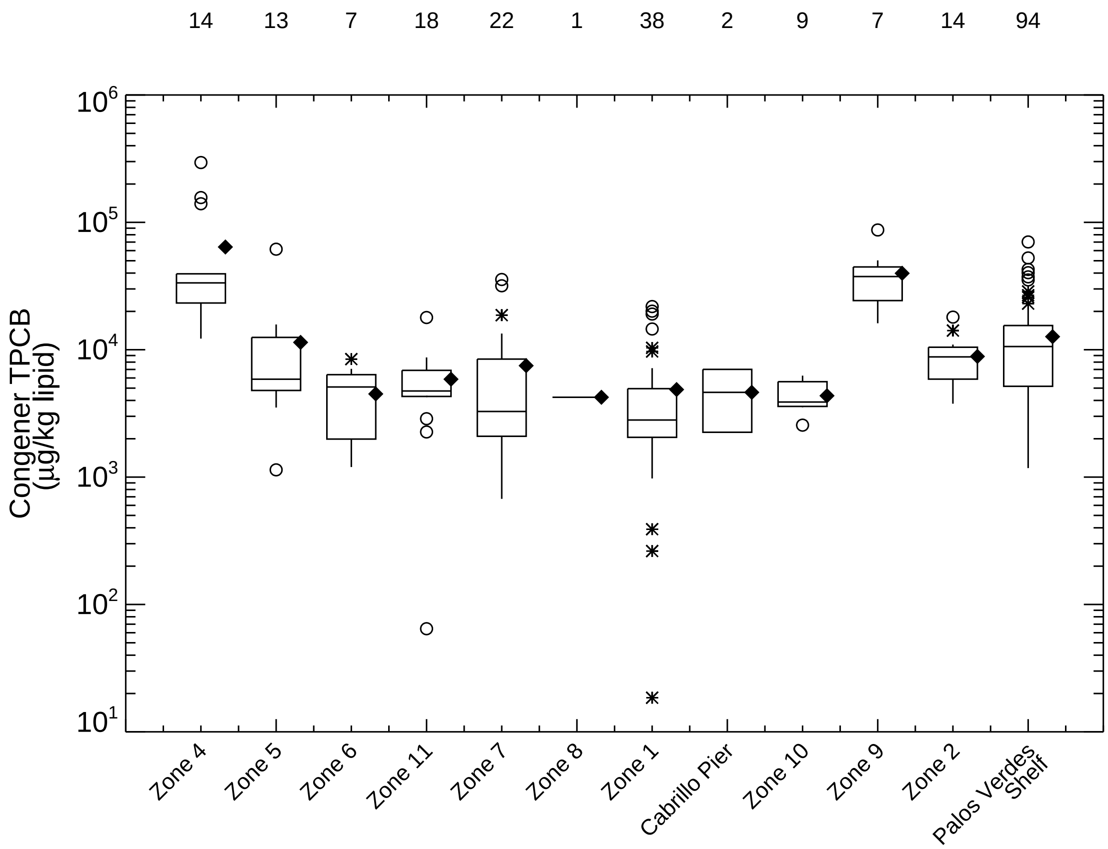


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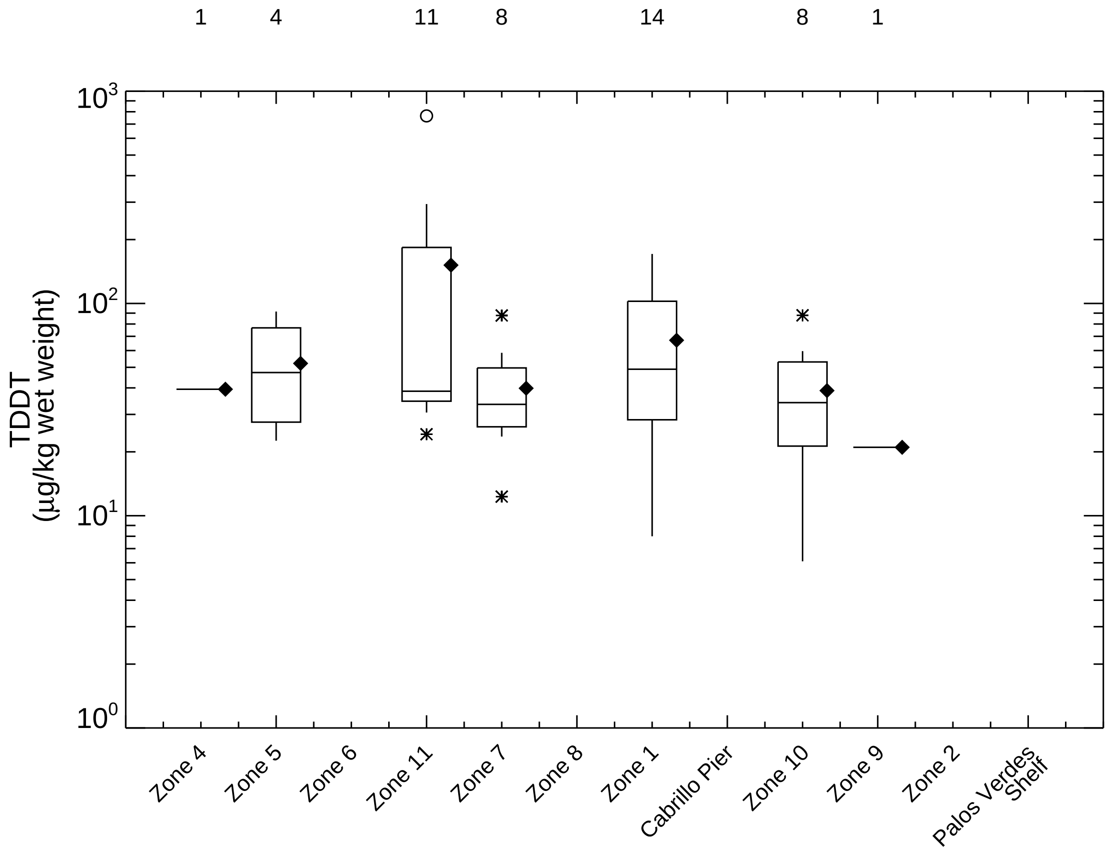
Figure 4−5d

Box Plots of TPCB Concentrations in White Croaker

Tissues included Fillet without skin, Fillet, Whole fish (lipid basis only). Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers. Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately. Sample IH5−FFF−7WC omitted due to low lipid content (0.05%). Database: fishData_processed_20130801_join_SketchofAreas131021



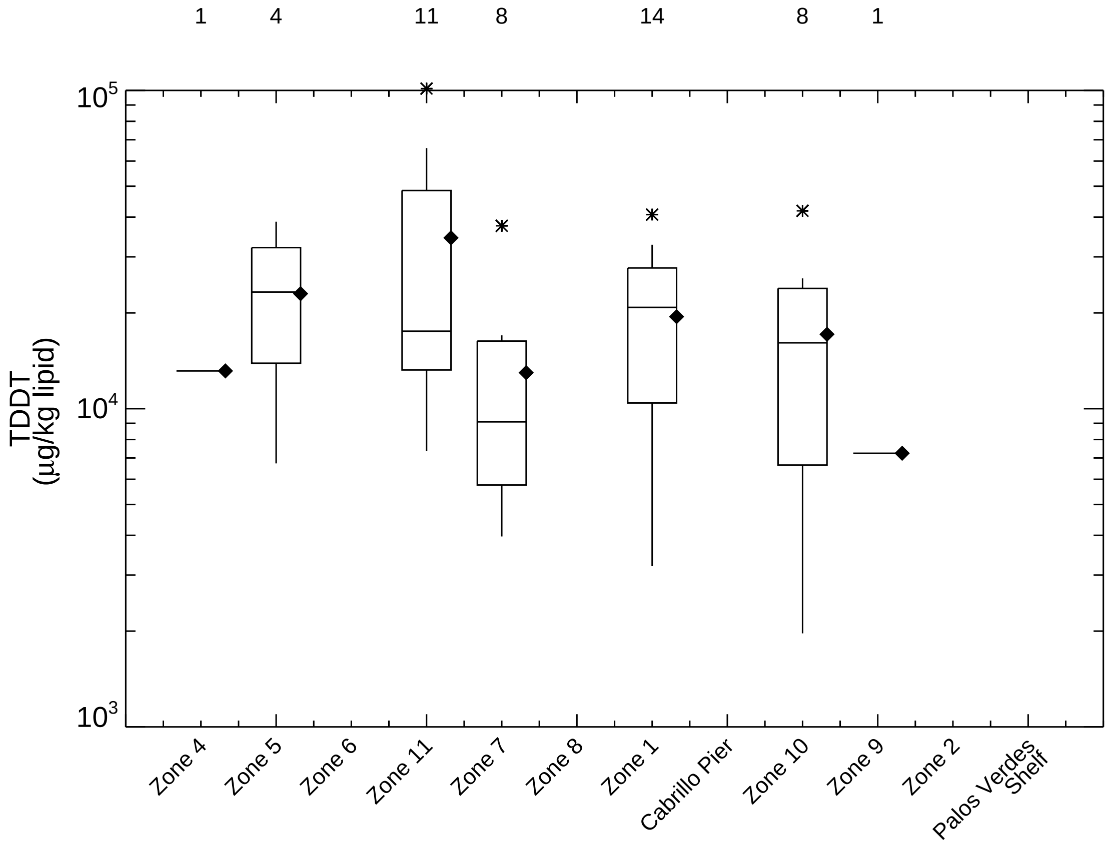


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Figure 4−6a

Box Plots of TDDT Concentrations in California Halibut

Tissues included Fillet without skin, Whole fish (lipid basis only).
Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers.
Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately.
Database: fishData_processed_20130801_join_SketchofAreas131021

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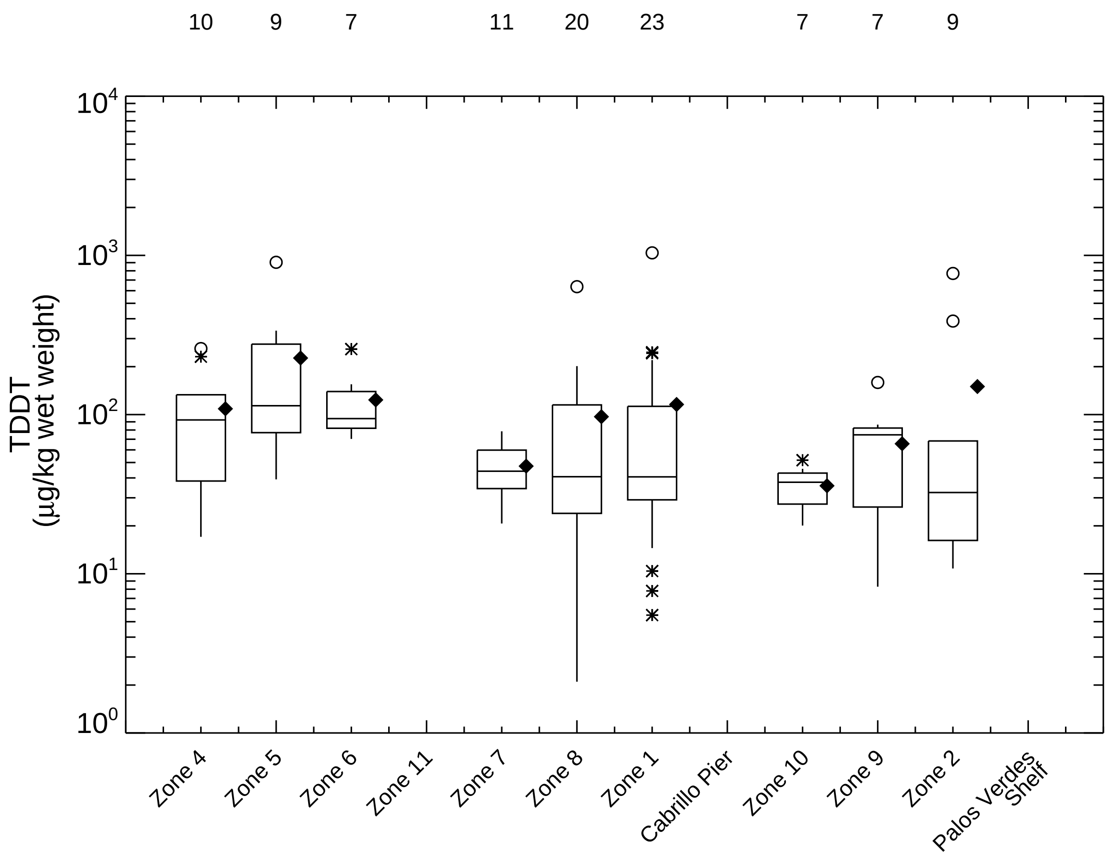
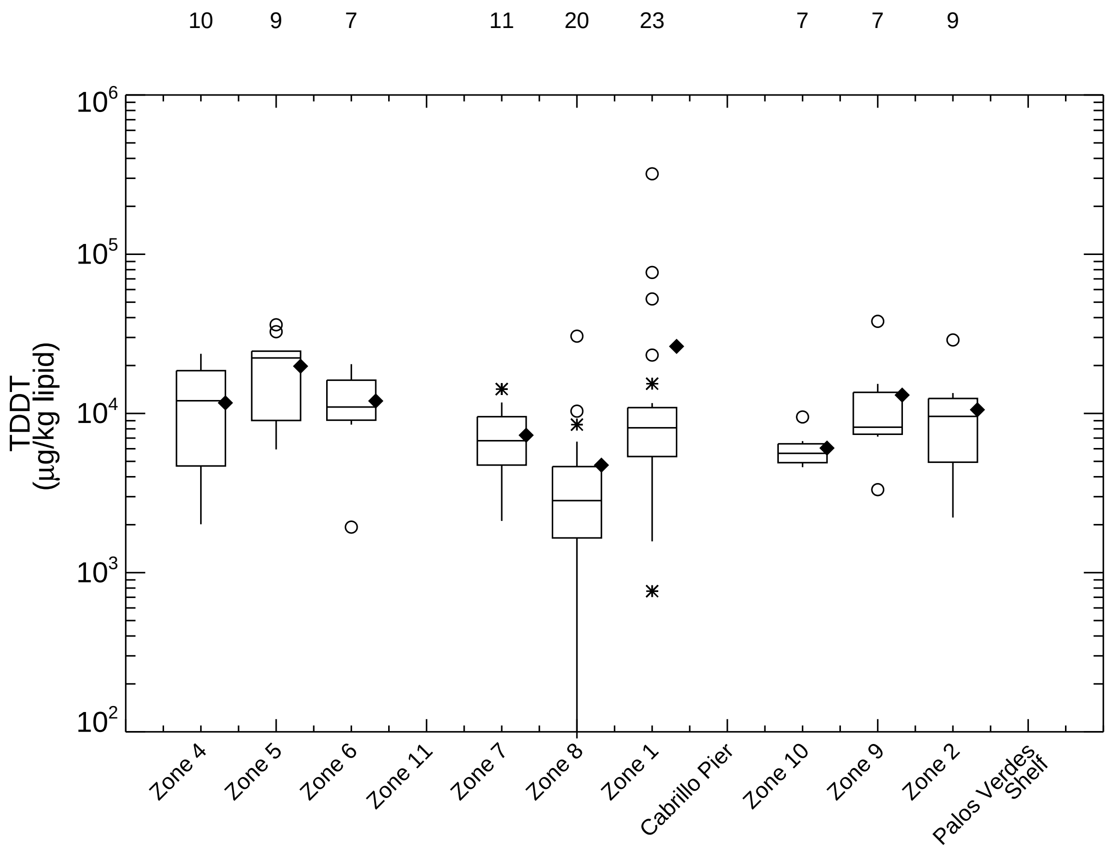




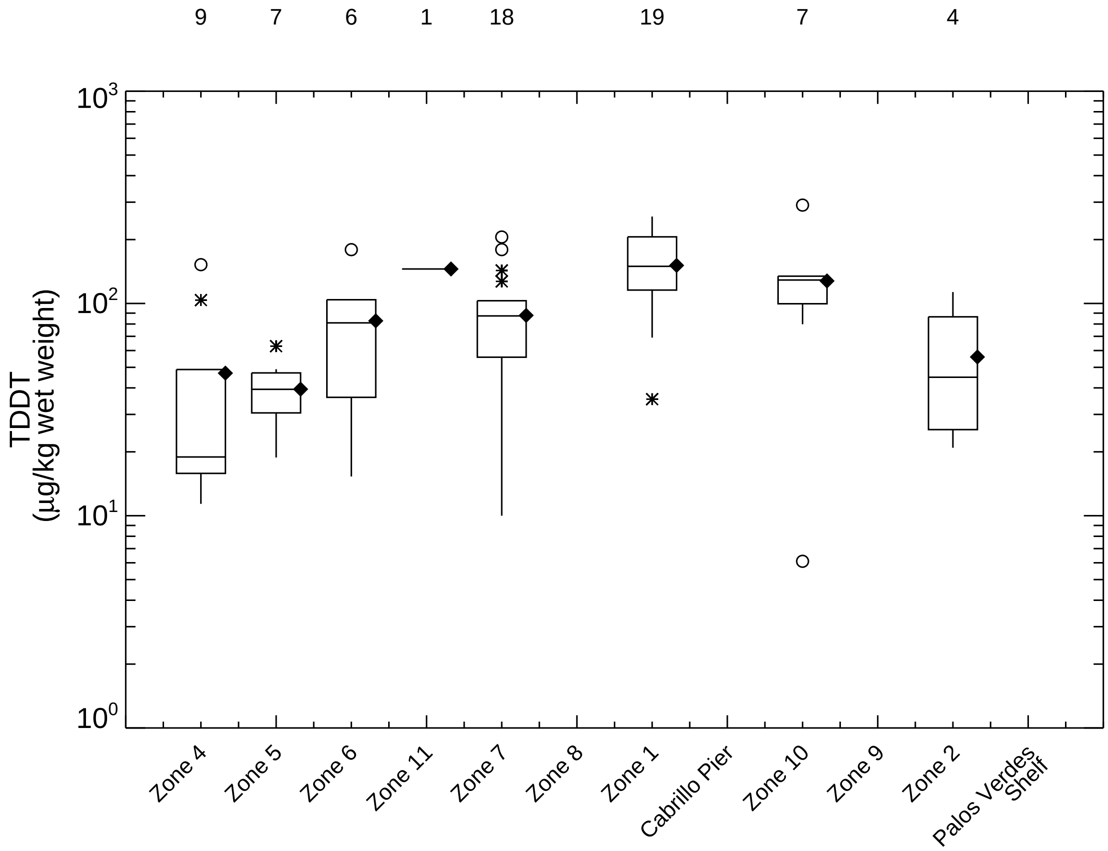
DRAFT

Figure 4−6b

Box Plots of TDDT Concentrations in Queenfish

Tissues included Fillet with skin, Fillet without skin.
Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers.
Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately.
Database: fishData_processed_20130801_join_SketchofAreas131021

ANCHOR QEA



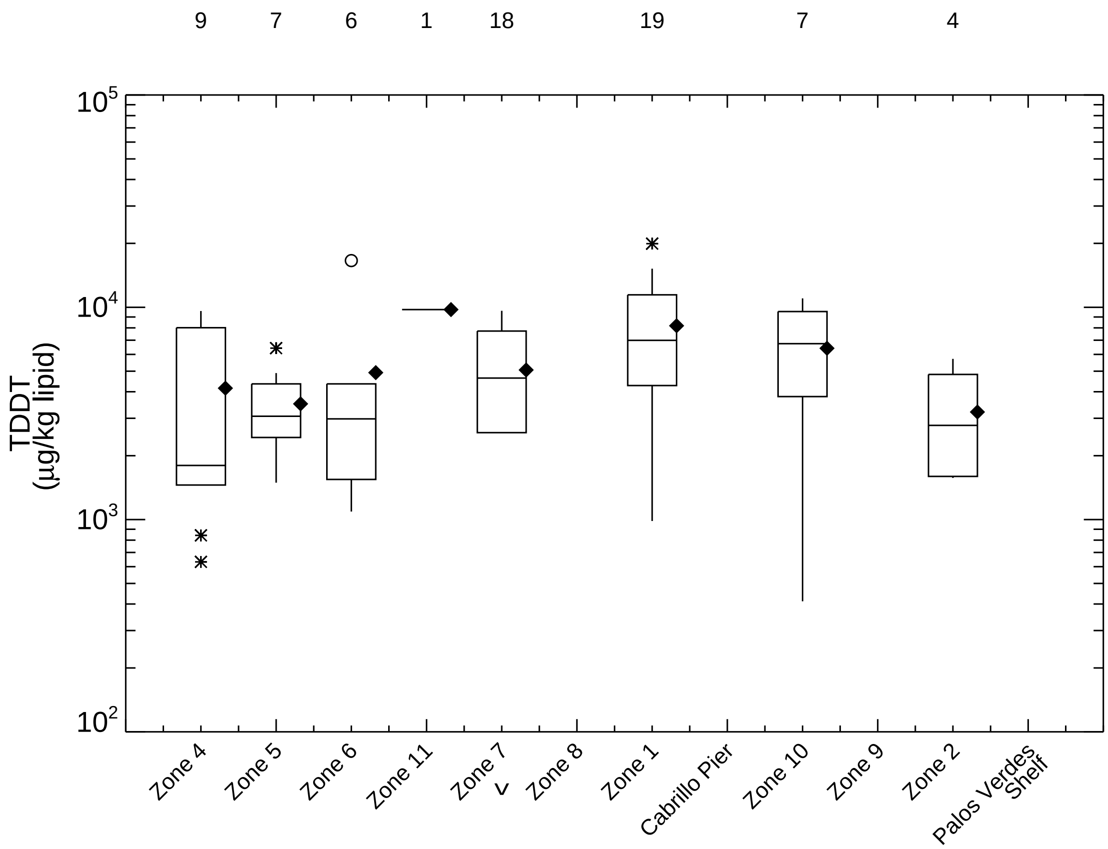


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Figure 4−6c

Box Plots of TDDT Concentrations in Topsmelt

ANCHOR QEA

Tissues included Fillet without skin (lipid basis only), Skin on scales off whole without head tail and guts (lipid basis only), Whole fish. Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers. Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately. Database: fishData_processed_20130801_join_SketchofAreas131021

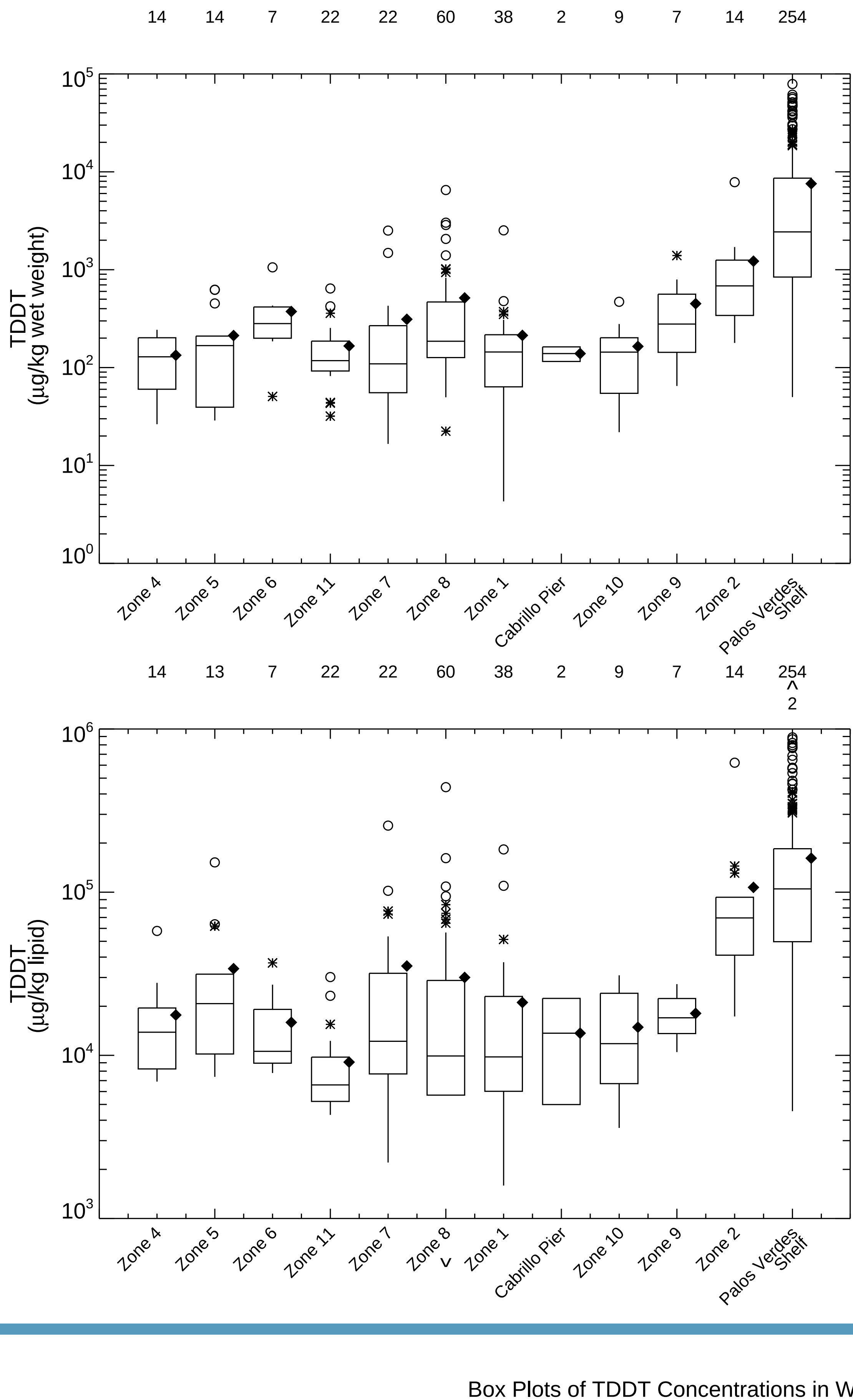

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Figure 4−6d

Box Plots of TDDT Concentrations in White Croaker

Tissues included Fillet with skin, Fillet without skin, Fillet, Whole fish (lipid basis only). Data collected between 1998 and 2012. Sample count shown above boxes. Plots show median (horizontal central line), mean (diamonds), hinges (ends of boxes, 25 and 75 percentiles), whiskers (from hinges to 1.5 times distance between hinges and median), inner (stars), and outer (open circles) outliers. Zones delineated based on fish movement. Cabrillo Pier data are located within Zone 1 but plotted separately. Sample IH5−FFF−7WC omitted due to low lipid content (0.05%). Database: fishData_processed_20130801_join_SketchofAreas131021

ANCHOR QEA

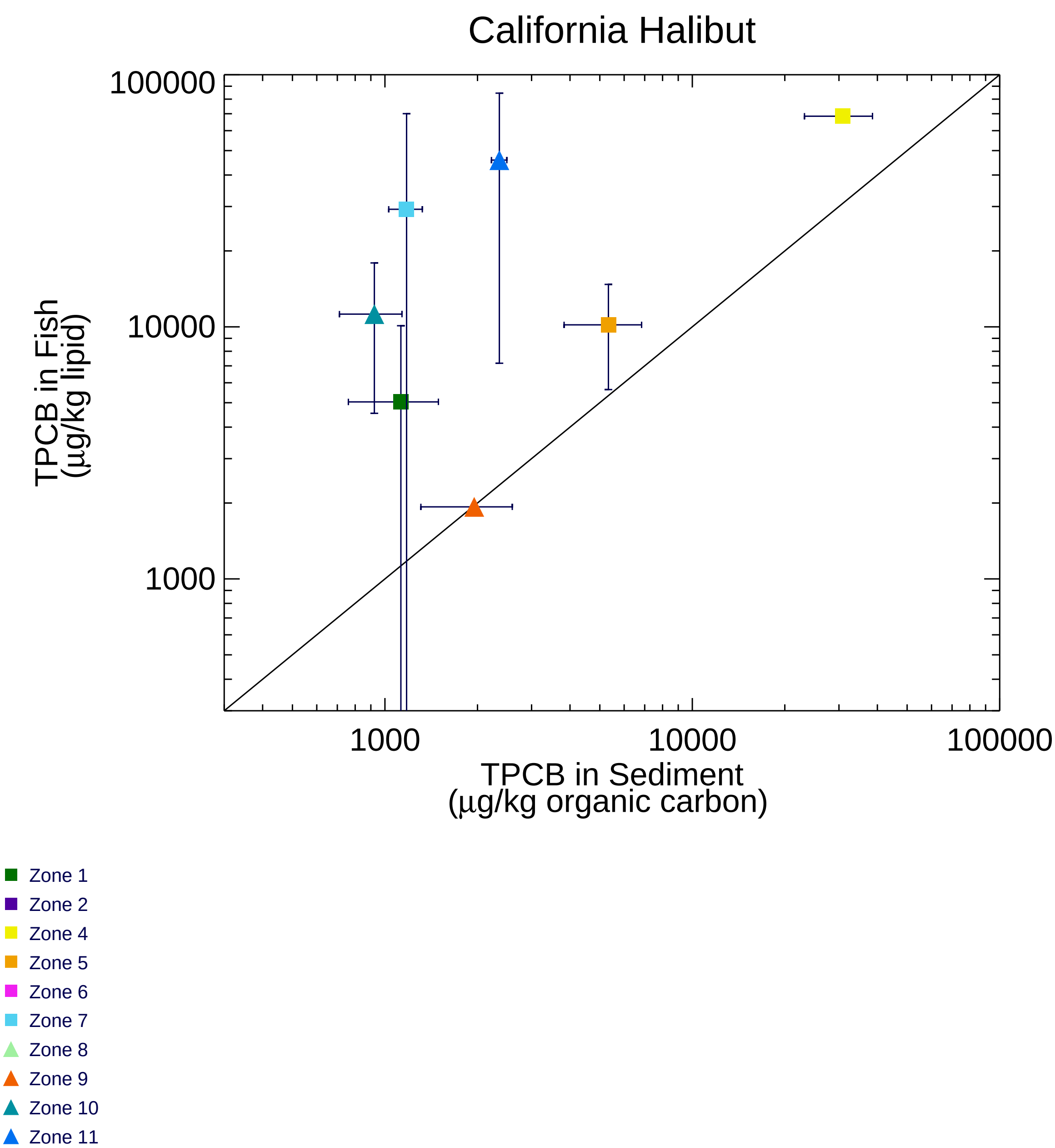

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Figure 4−7a

TPCB in California Halibut versus Surface Sediment

Surface area−weighted averages for sediment and arithmetric averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

EC/ZW − \\austin2\austin\D_drive\Projects\PoLAPoLB_TMDL_2012\2012−2015_TMDL_Contract_(120343−01)\4_Existing_Data_Review\Analysis\Fish_Plots\subarea_sed_vs_fish.pro Fri May 16 13:29:09 2014

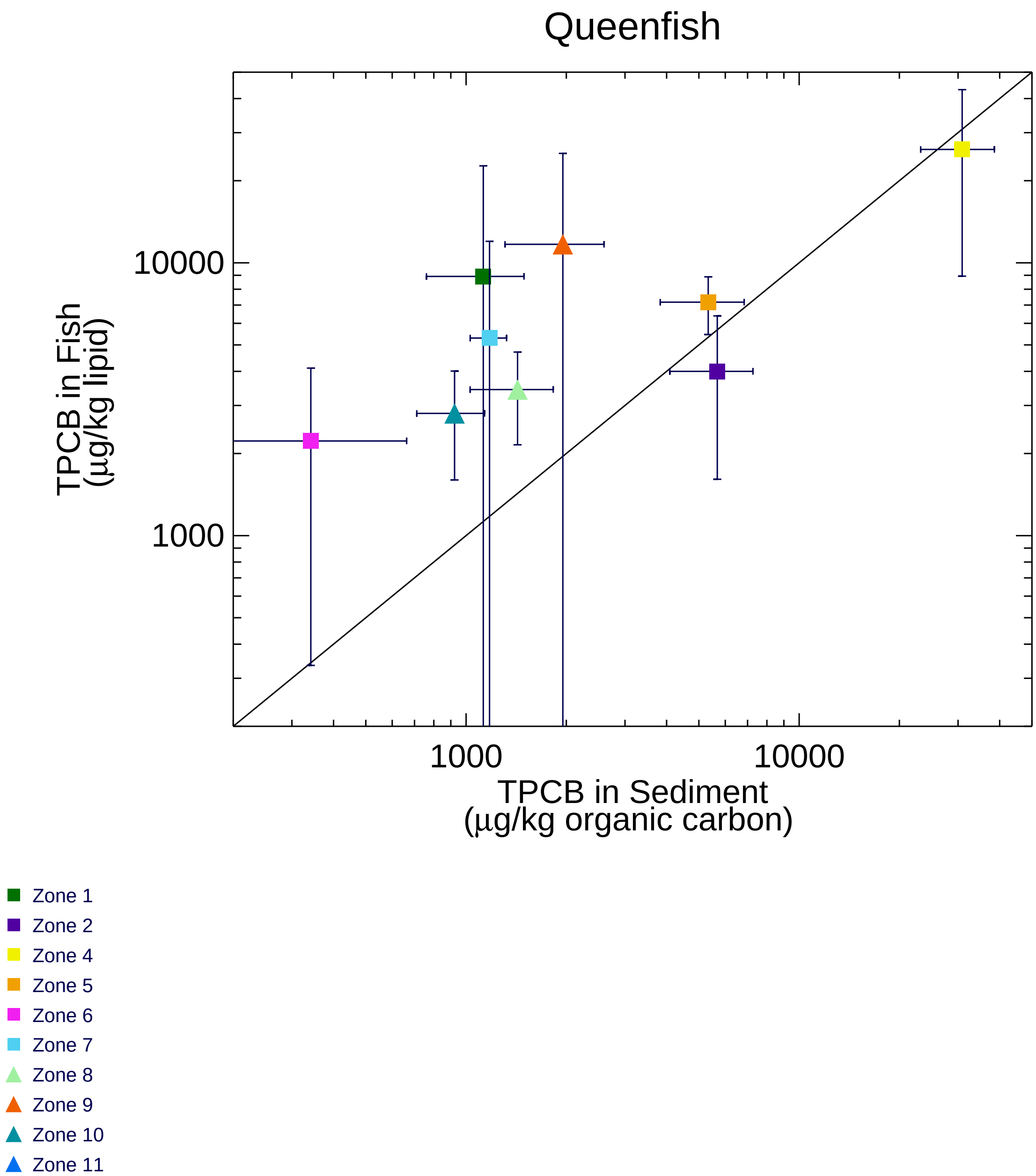

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Figure 4−7b

TPCB in Queenfish versus Surface Sediment

ANCHOR QEA

Surface area−weighted averages for sediment and arithmetric averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

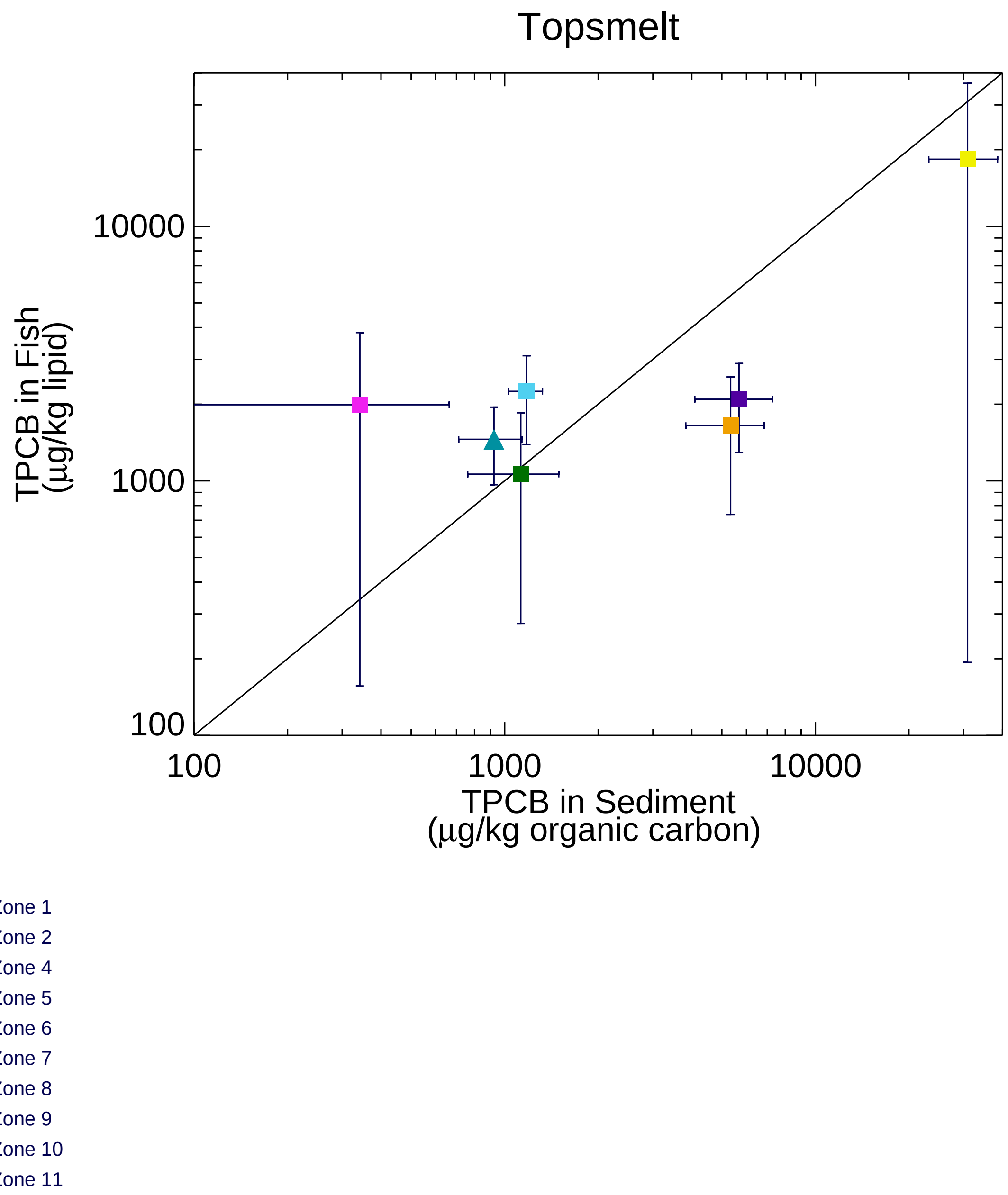

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Figure 4−7c

TPCB in Topsmelt versus Surface Sediment

Surface area−weighted averages for sediment and arithmetic averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

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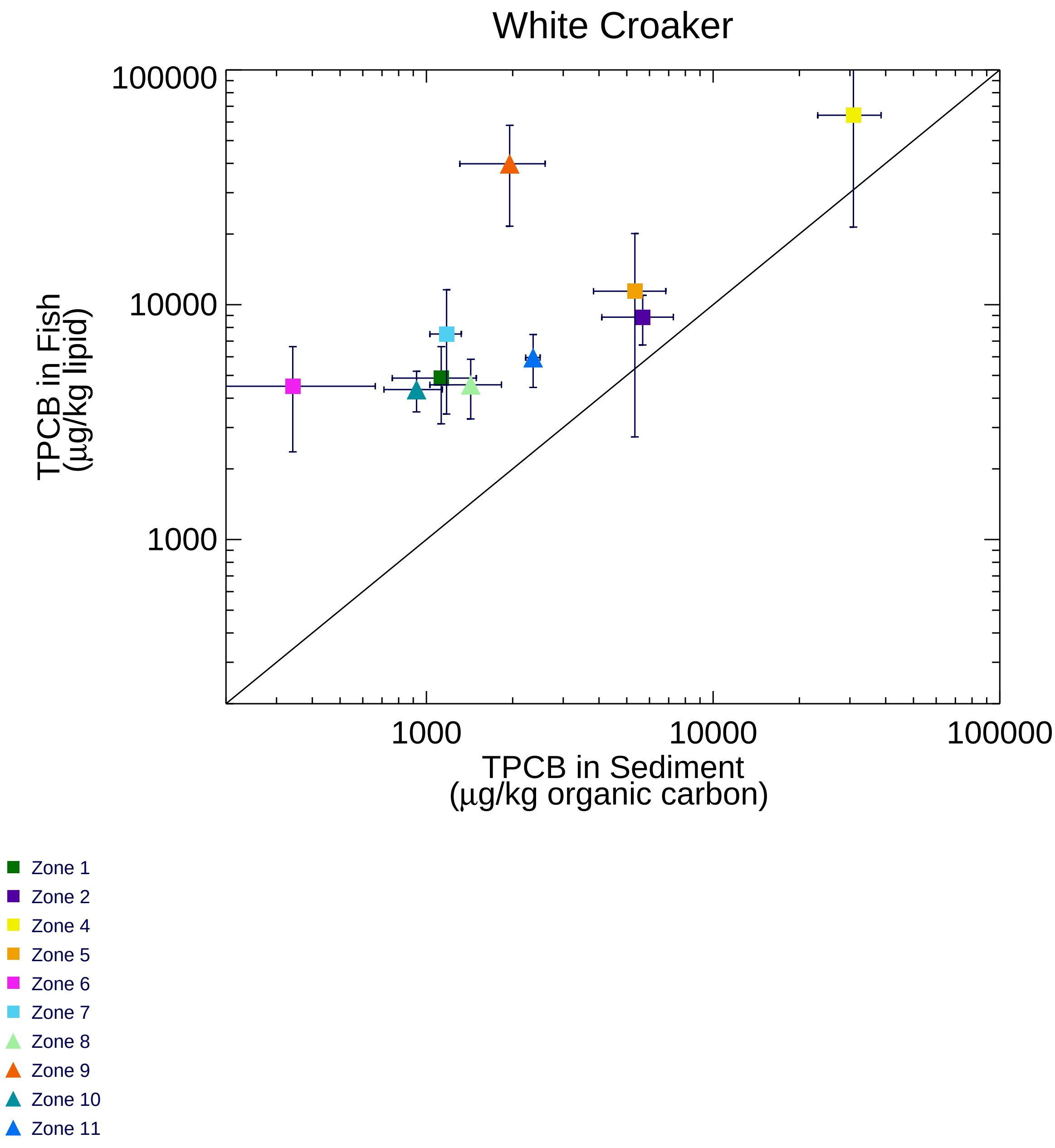

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Figure 4−7d

TPCB in White Croaker versus Surface Sediment

ANCHOR QEA

Surface area−weighted averages for sediment and arithmetric averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002), one White Croaker (IH5−FFF−7WC) with low lipid (0.05%). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

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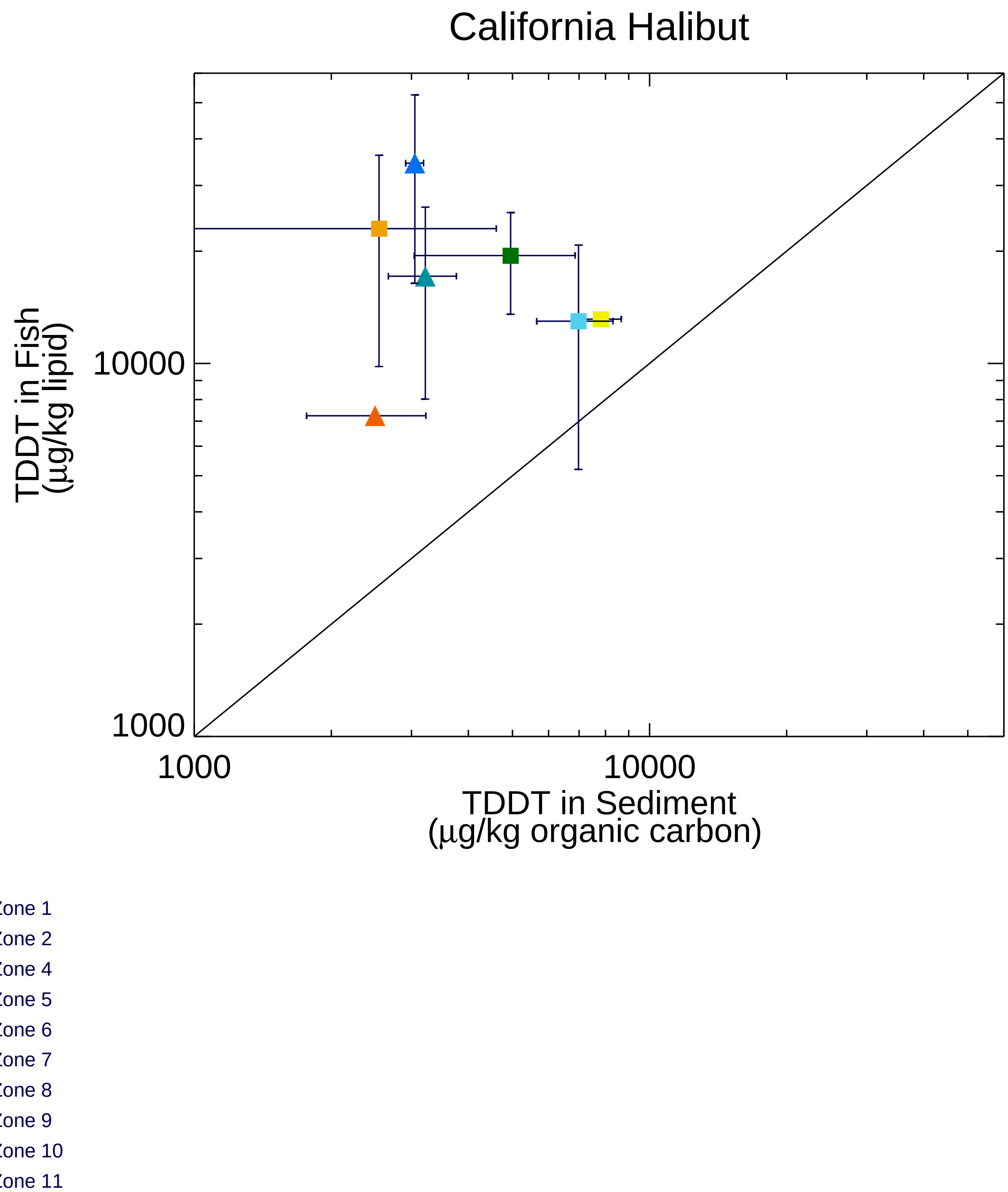

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Figure 4−8a

TDDT in California Halibut versus Surface Sediment

ANCHOR QEA

Surface area−weighted averages for sediment and arithmetric averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

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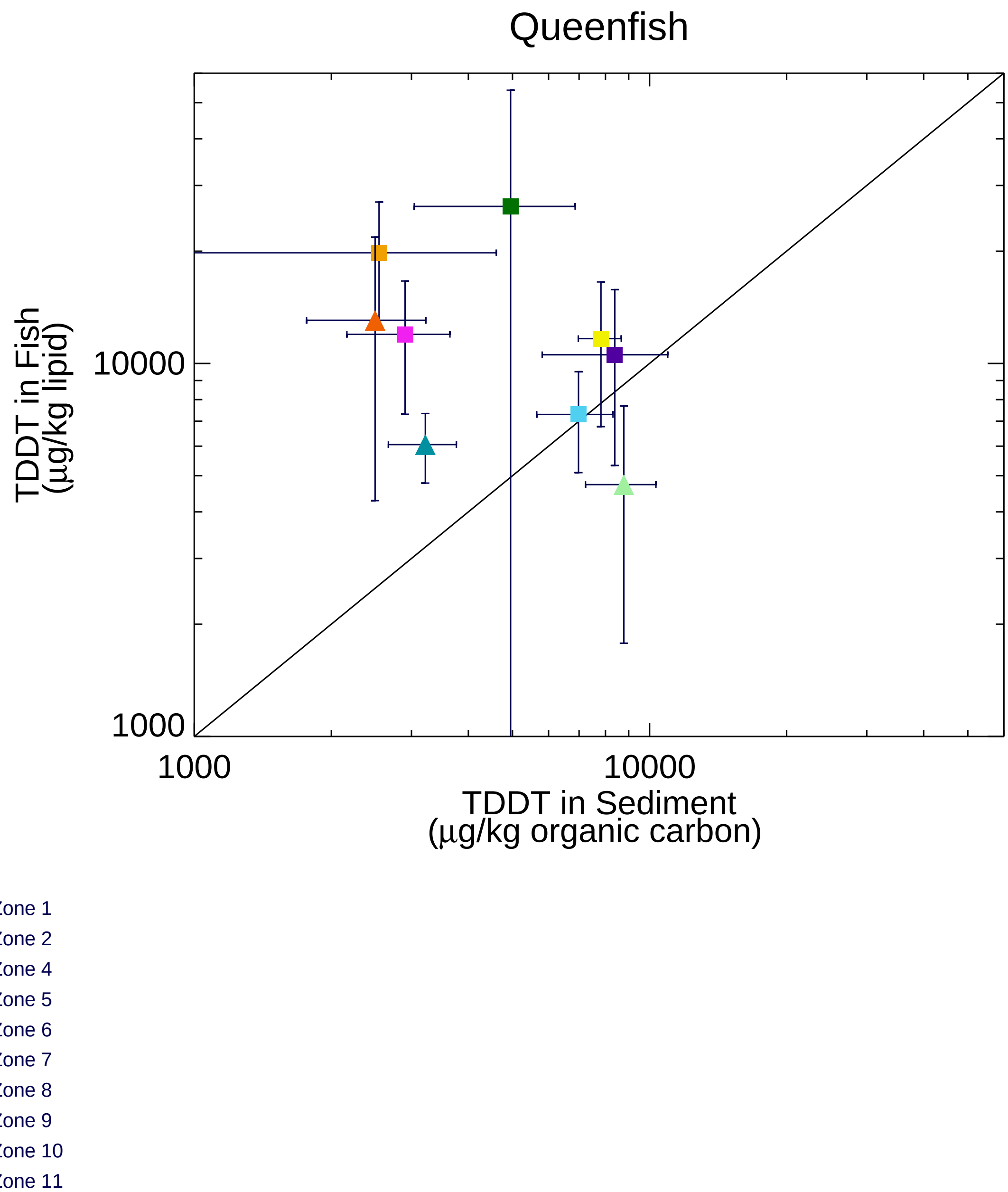

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Figure 4−8b

TDDT in Queenfish versus Surface Sediment

ANCHOR QEA

Surface area−weighted averages for sediment and arithmetic averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

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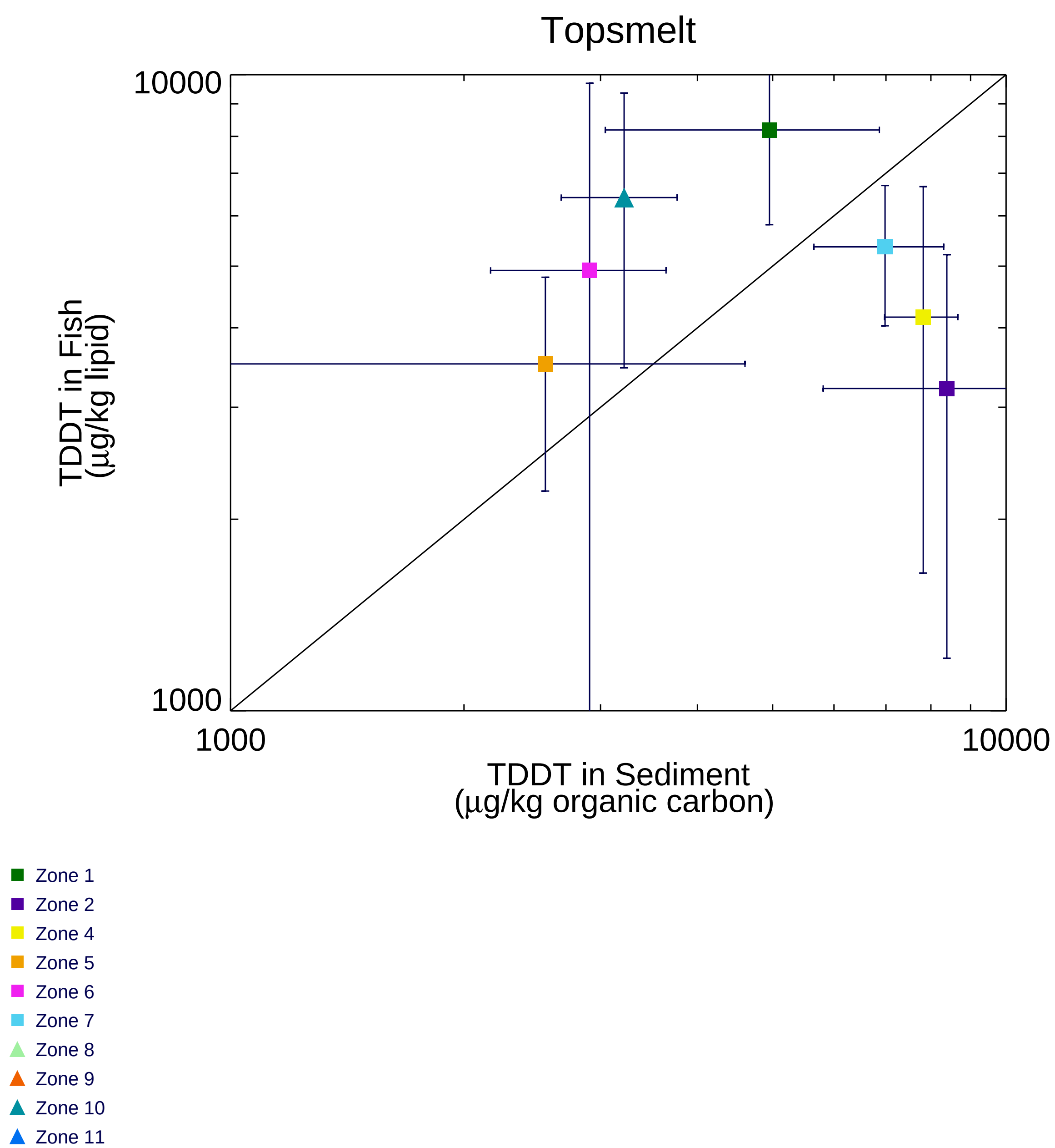

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Figure 4−8c

TDDT in Topsmelt versus Surface Sediment

Surface area−weighted averages for sediment and arithmetric averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

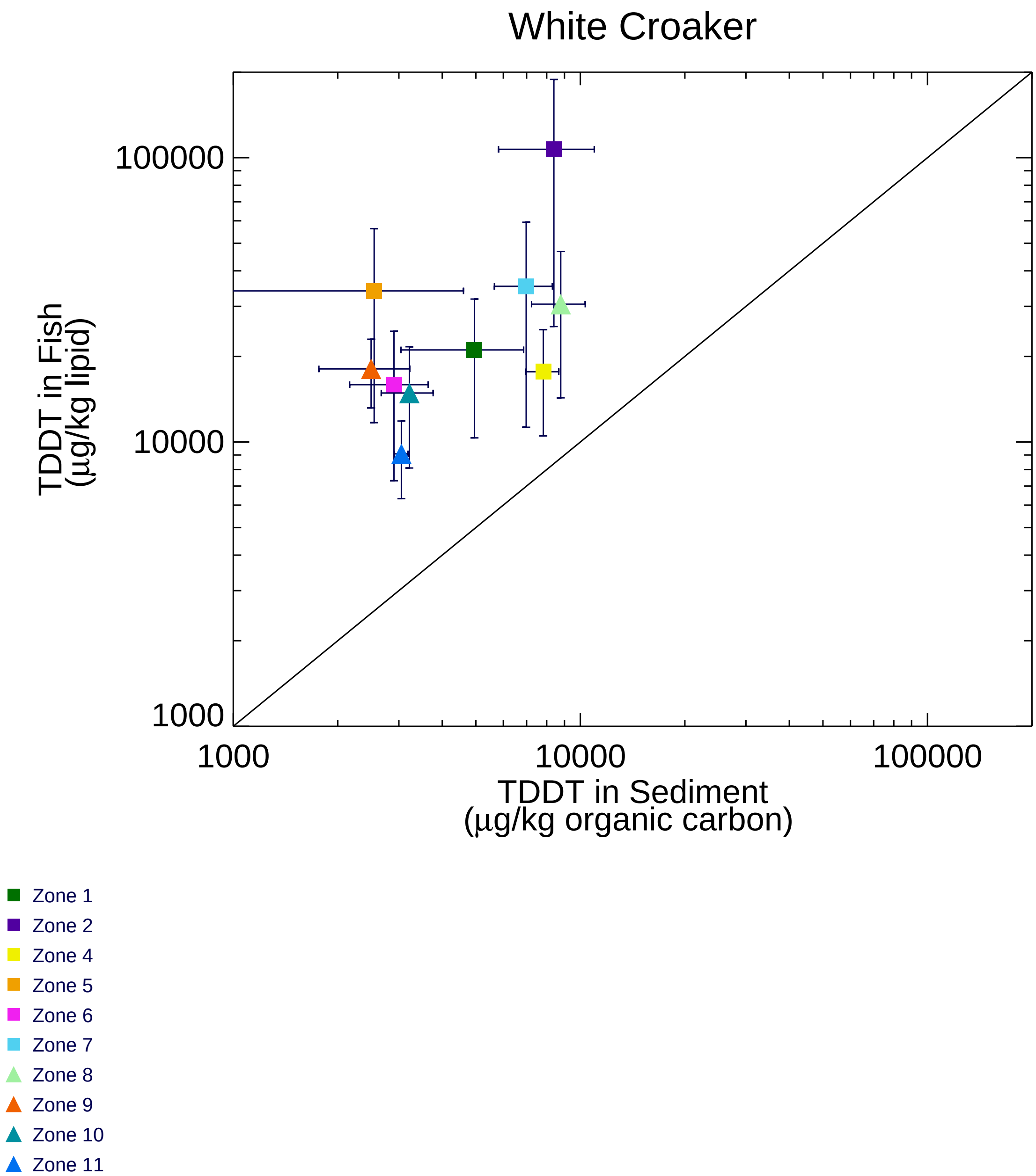

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Figure 4−8d

TDDT in White Croaker versus Surface Sediment

ANCHOR QEA

Surface area−weighted averages for sediment and arithmetic averages for fish collected between 1998 and 2012. Error bars show two standard errors. Non−detects set to half detection limit. Surface sediment is top 16 cm. Tissue types include fillet (all types) and whole fish. Thiessen polygons without total organic carbon data assigned value of nearest surface sediment sample. Congeners used when paired Aroclor and congener exist. Fish data excluded Cabrillo Pier (four stations), ten Aroclor non−detects of 500 ppm (LA TIWRP 2002), one White Croaker (IH5−FFF−7WC) with low lipid (0.05%). Databases: Sed_DBcomb_NDhalfMDL_indv_20140229, AllFishData_Compile_130731

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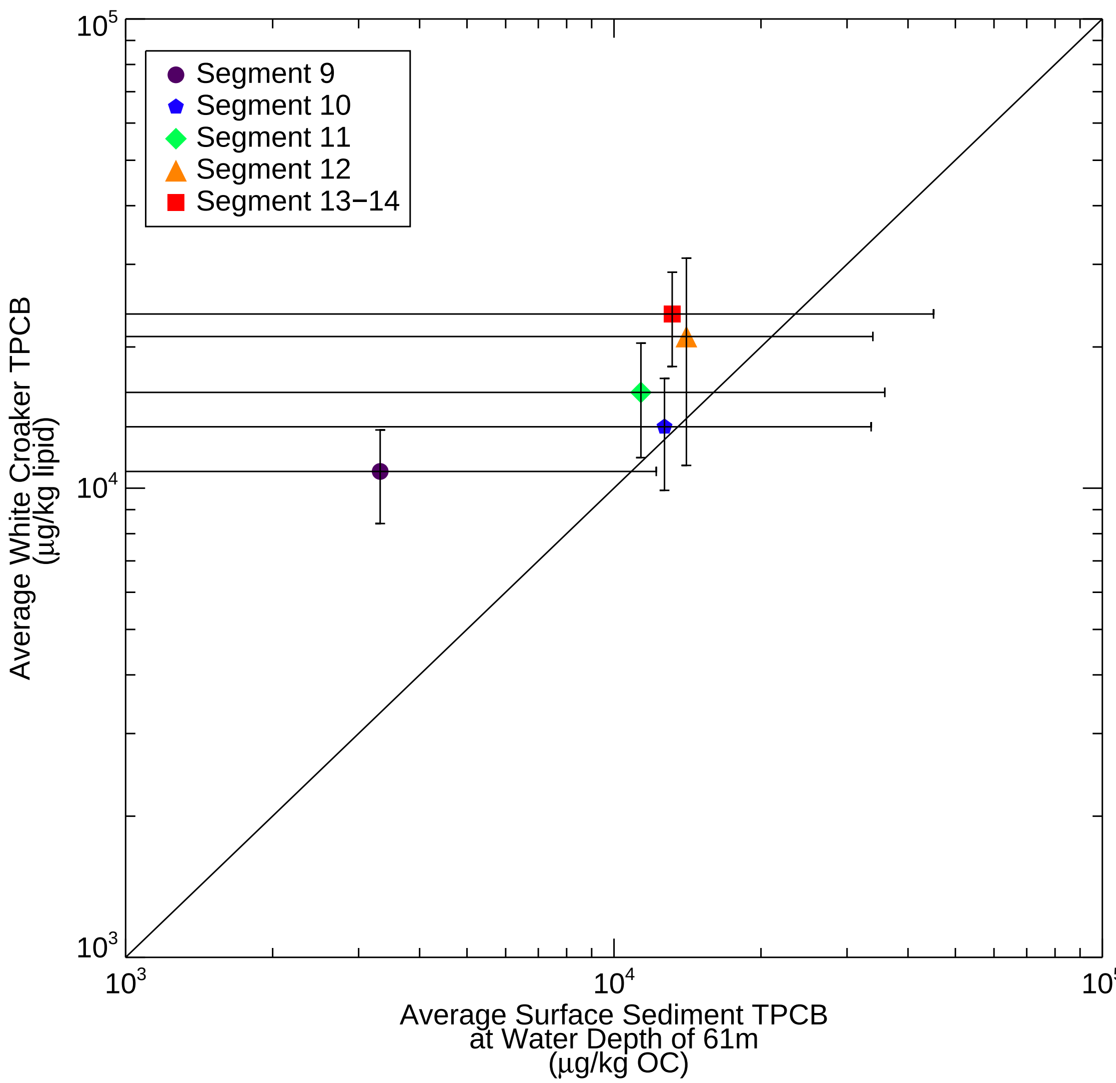

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Figure 4−9a

TPCB in White Croaker versus Surface Sediment from the Palos Verdes Shelf

ANCHOR QEA

Data are means +/−two standard errors. Data collected between 1998 and 2011. Diagonal line is 1 to 1 line. Surface sediment is 0 to 16 cm. Fish tissue types include fillet (all types). Non−detects set to half detection limit. Sediment from Station 8C excluded from Segment 13−14. Congener data used when paired Aroclor and congener exist. For some LACSD data, average lipid content by year, species, and tissue type used due to inability to line up same samples. Database: Fish20130719_and_Sed_DBComb_NDhalfMDL_tot_with_TOC_with_Coastline_Measurements_and_PV_Shelf_20130801

EC − \\austin2\austin\D_drive\Projects\ITSI\PV_Shelf\Analysis\Fish_and_Sed\sed_vs_fish_PVshelf_lipid_vs_OC.pro Fri May 16 13:13:44 2014

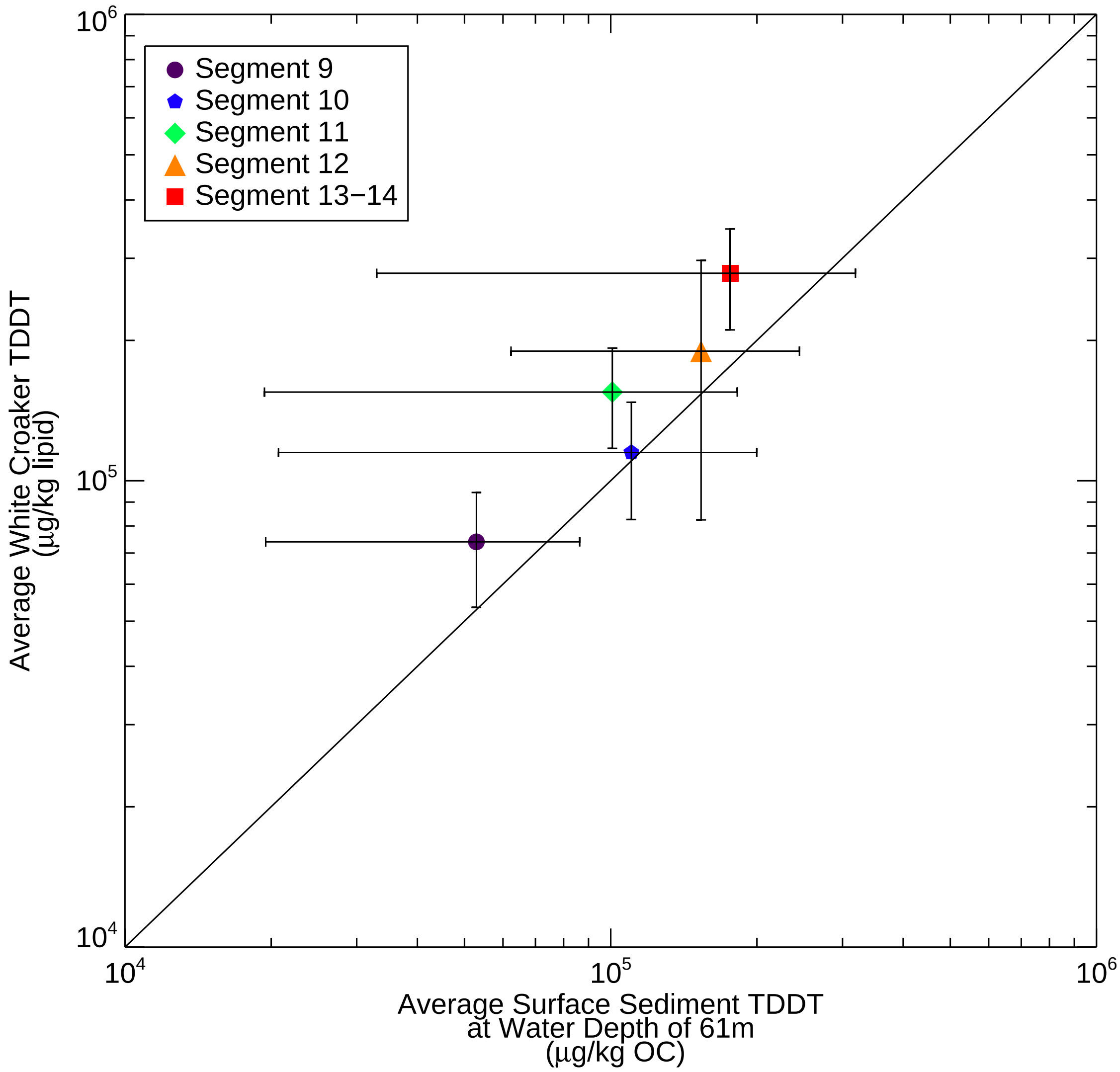

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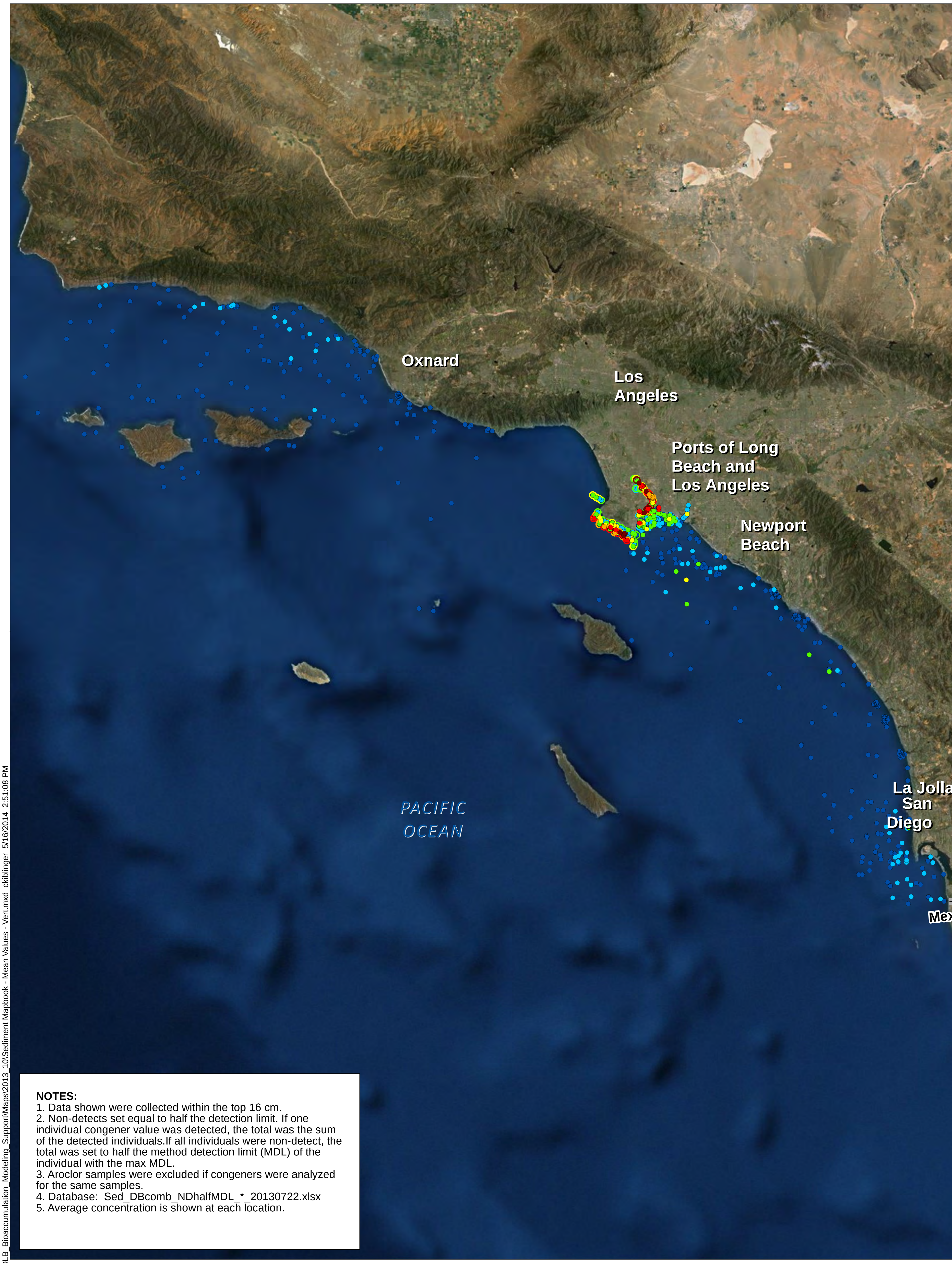
Figure 4−9b

TDDT in White Croaker versus Surface Sediment from the Palos Verdes Shelf

ANCHOR QEA

Data are means +/−two standard errors. Data collected between 1998 and 2011. Diagonal line is 1 to 1 line. Surface sediment is 0 to 16 cm. Fish tissue types include fillet (all types). Non−detects set to half detection limit. Sediment from Station 8C excluded from Segment 13−14. Congener data used when paired Aroclor and congener exist. For some LACSD data, average lipid content by year, species, and tissue type used due to inability to line up same samples. Database: Fish20130719_and_Sed_DBComb_NDhalfMDL_tot_with_TOC_with_Coastline_Measurements_and_PV_Shelf_20130801



NOTES:
1. Data shown were collected within the top 16 cm.
2. Non-detects set equal to half the detection limit. If one individual congener value was detected, the total was the sum of the detected individuals.If all individuals were non-detect, the total was set to half the method detection limit (MDL) of the individual with the max MDL.
3. Aroclor samples were excluded if congeners were analyzed for the same samples.
4. Database: Sed_DBcomb_NDhalfMDL_*_20130722.xlsx
5. Average concentration is shown at each location.

TPCB Congeners (µg/kg dw; ND = 1/2 DL)
- 0.018 - 3.2 (TMDL indirect effects target: 3.2 µg/kg)
- 3.21 - 22.7 (TMDL direct effects target; ERL: 22.7 µg/kg)
- 22.8 - 90
- 90.1 - 180 (ERM: 180 µg/kg)
- 181 - 376
- 377 - 1,000
- 1,010 - 3,020

TPCB Aroclors (µg/kg dw; ND = 1/2 DL)
- 6.8 - 22.7 (TMDL direct effects target; ERL: 22.7 µg/kg)
- 22.8 - 90
- 90.1 - 180 (ERM: 180 µg/kg)
- 181 - 376
- 377 - 1,000
- 1,010 - 16,800

Miles
0 10 20

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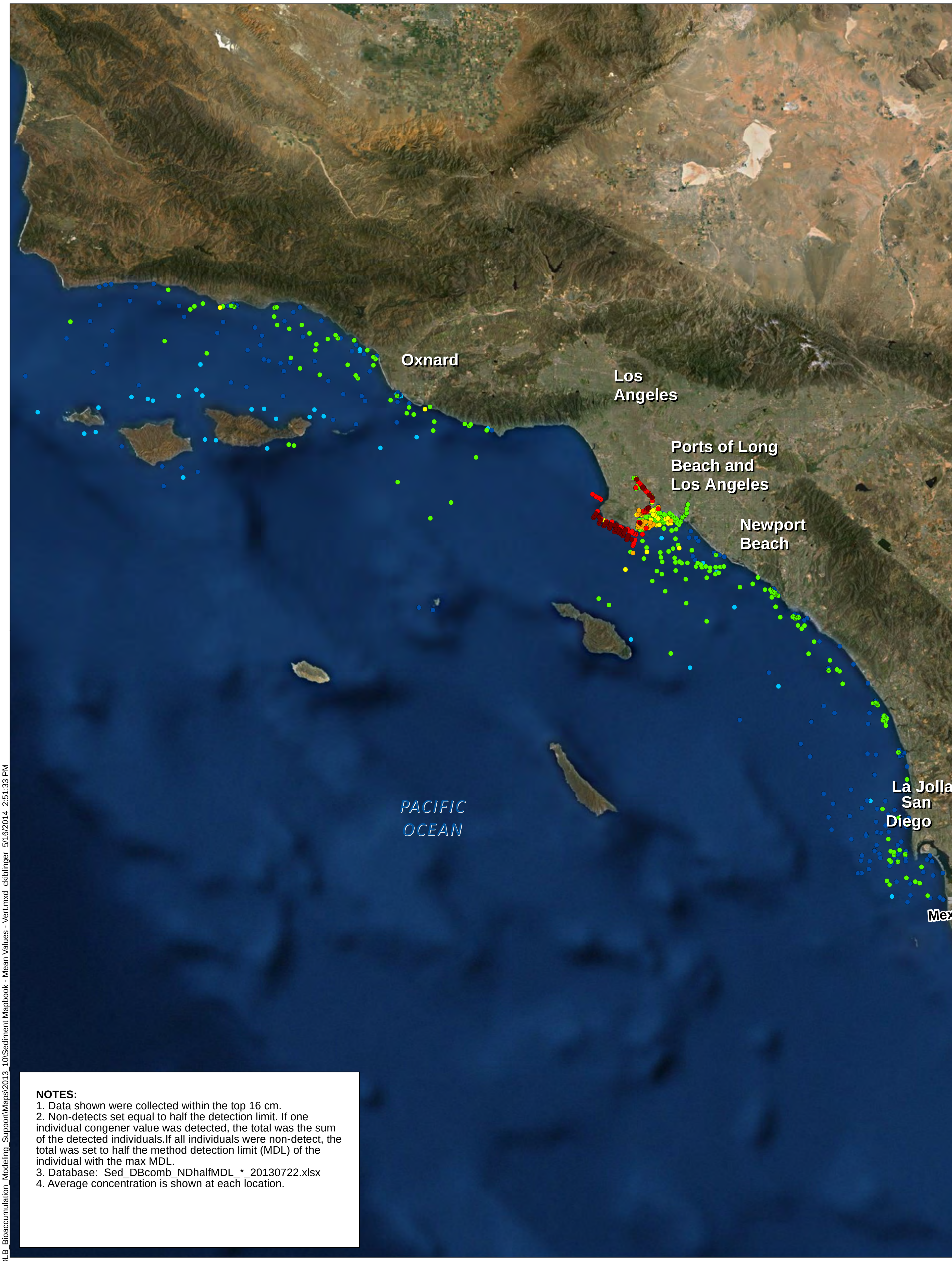
Figure 4-10
Surface Sediment TPCB Concentrations on a Dry-Weight Basis (1998-2012)
Greater Los Angeles and Long Beach Harbor Waters



NOTES:
1. Data shown were collected within the top 16 cm.
2. Non-detects set equal to half the detection limit. If one individual congener value was detected, the total was the sum of the detected individuals.If all individuals were non-detect, the total was set to half the method detection limit (MDL) of the individual with the max MDL.
3. Database: Sed_DBcomb_NDhalfMDL_*_20130722.xlsx
4. Average concentration is shown at each location.

TDDT (µg/kg dw; ND = 1/2 DL)

- 0.02 - 1.58 (TMDL direct effects target; ERL: 1.58 µg/kg)
- 1.59 - 1.9 (TMDL indirect effects target: 1.9 µg/kg)
- 1.91 - 46.1 (ERM: 46.1 µg/kg)
- 46.11 - 92.2
- 92.21 - 184
- 184.01 - 1,000
- 1,000.01 - 97,034

Miles
0 10 20

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Figure 4-11
Surface Sediment TDDT Concentrations on a Dry-Weight Basis (1998-2012)
Greater Los Angeles and Long Beach Harbor Waters

NOTES:
1. Data shown are for fillet, fillet without skin, and fillet with skin.
2. Non-detects set equal to half the detection limit. If one individual congener value was detected, the total was the sum of the detected individuals.If all individuals were non-detect, the total was set to half the method detection limit (MDL) of the individual with the max MDL.
3. Database: fishData_processed_20130801.csv (based on AllFishData_Compile_130731).
4. Average concentration is shown at each location.

TPCB Congeners (µg/kg wet-weight)
- 0.87 - 3.59
- 3.6 - 22.69 (3.6 = TMDL fish tissue target)
- 22.7 - 43
- 43.01 - 90
- 90.01 - 180
- 180.01 - 376
- 376.01 - 754.14

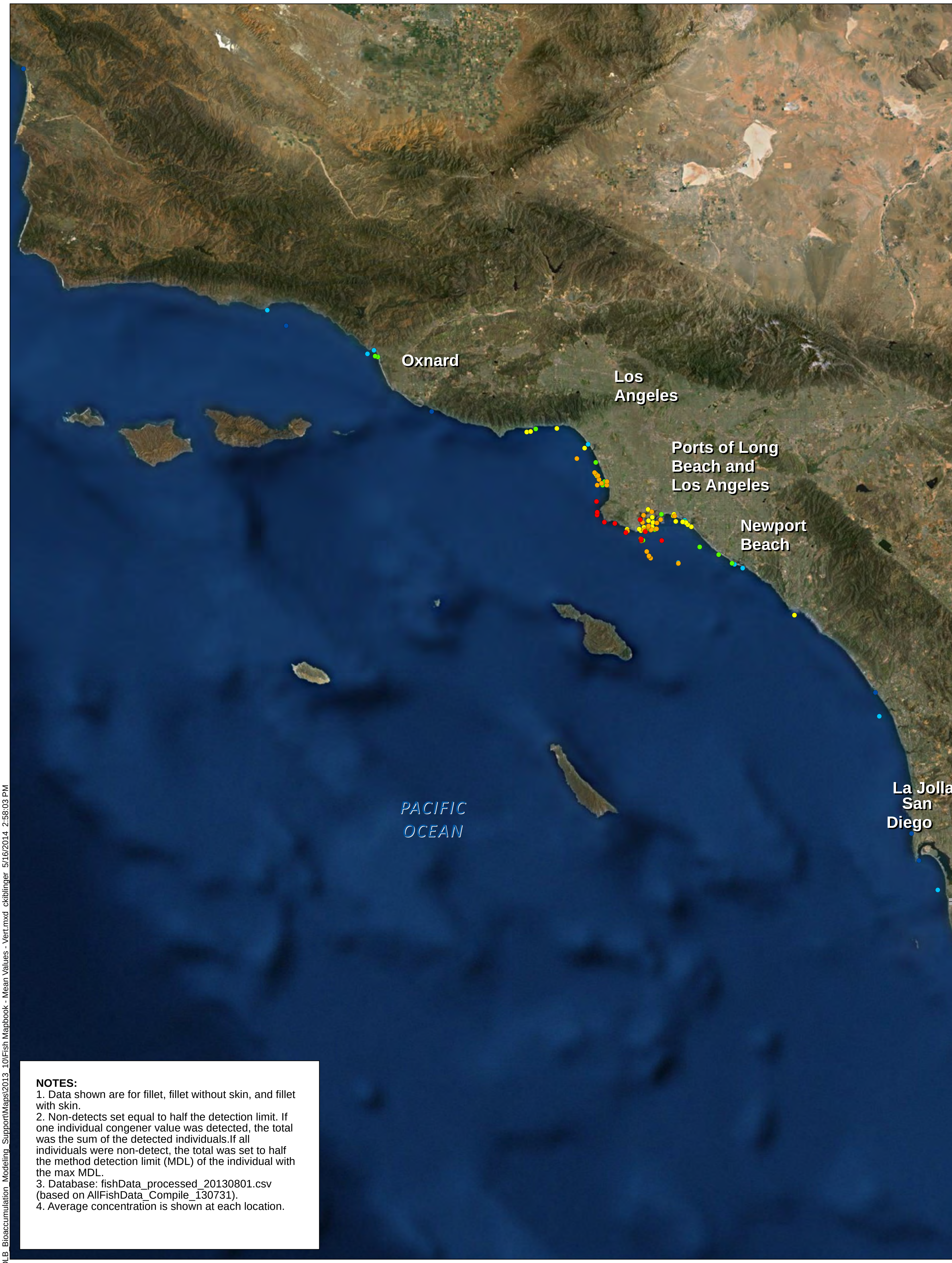
TPCB Aroclors (µg/kg wet-weight)
- 21 - 22.69 (3.6 = TMDL fish tissue target)
- 22.7 - 43
- 43.01 - 90
- 90.01 - 180
- 180.01 - 376
- 376.01 - 1,716.17

Miles
0 10 20

DRAFT

ANCHOR QEA

Figure 4-12
White Croaker TPCB Concentrations on a Wet-Weight Basis (1998-2012)
Greater Los Angeles and Long Beach Harbor Waters



NOTES:
1. Data shown are for fillet, fillet without skin, and fillet with skin.
2. Non-detects set equal to half the detection limit. If one individual congener value was detected, the total was the sum of the detected individuals.If all individuals were non-detect, the total was set to half the method detection limit (MDL) of the individual with the max MDL.
3. Database: fishData_processed_20130801.csv (based on AllFishData_Compile_130731).
4. Average concentration is shown at each location.

TDDT (µg/kg wet-weight)

- 2.52 - 20.99
- 21 - 46.09 (21 = TMDL fish tissue target)
- 46.1 - 92.2
- 92.21 - 184
- 184.01 - 1,000
- 1,000.01 - 20,150.38

Miles
0 10 20

DRAFT

ANCHOR QEA

Figure 4-13
White Croaker TDDT Concentrations on a Wet-Weight Basis (1998-2012)
Greater Los Angeles and Long Beach Harbor Waters

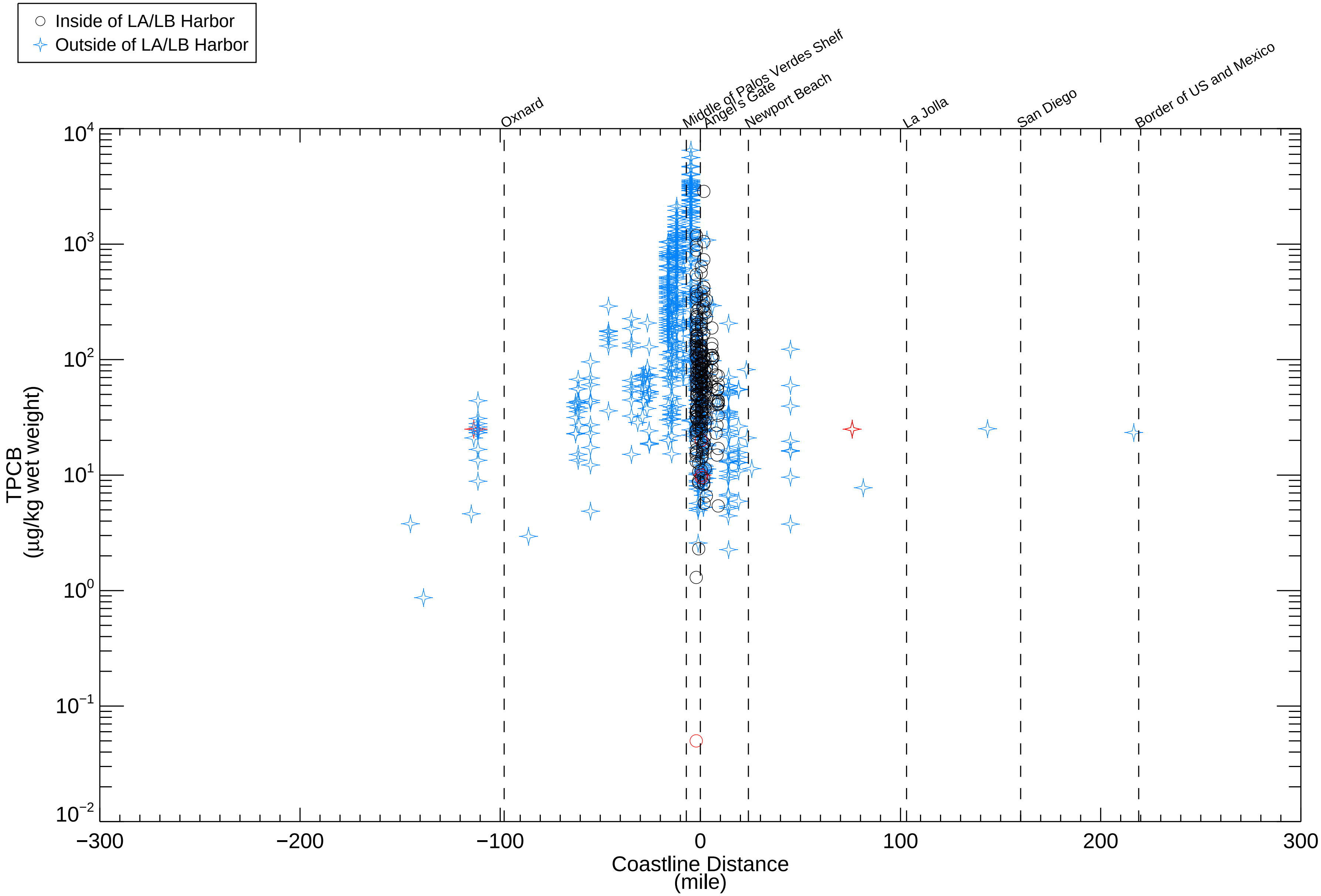


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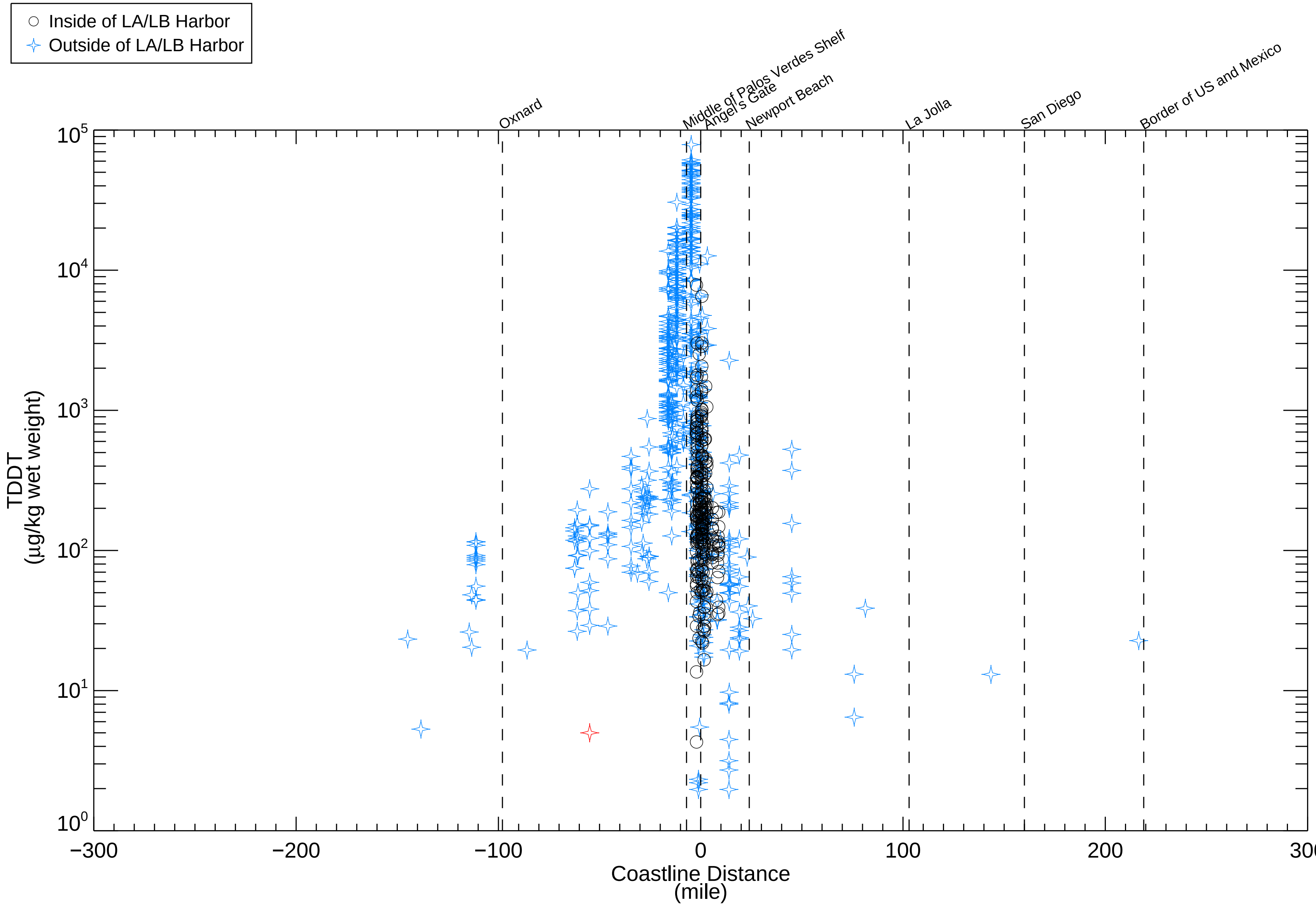
Figure 4−14

Wet−Weight White Croaker TPCB Concentrations versus Distance Along Coastline

Data collected between 1998 and 2012. Tissue types included fillet with and without skin. White Croaker data shown. Non−detects set to half MDL. Non−detects indicated with red symbol. Los Angeles River Estuary samples excluded.

Fish datafile: Fish20130719_DBComb_NDhalfMDL_tot_with_TOC_with_Coastline_Measurements_and_PV_Shelf_20130801

CF − \\austin2\austin\D_drive\Projects\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\Analysis\Data_Gap_Analysis\polalb_conc_by_coast.pro Fri May 16 14:59:41 2014



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ANCHOR QEA

Figure 4−15

Wet−Weight White Croaker TDDT Concentrations versus Distance Along Coastline

Data collected between 1998 and 2012. Tissue types included fillet with and without skin. White Croaker data shown. Non−detects set to half MDL. Non−detects indicated with red symbol. Los Angeles River Estuary samples excluded.

Fish datafile: Fish20130719_DBComb_NDhalfMDL_tot_with_TOC_with_Coastline_Measurements_and_PV_Shelf_20130801

CF − \\austin2\austin\D_drive\Projects\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\Analysis\Data_Gap_Analysis\polalb_conc_by_coast.pro Fri May 16 14:59:41 2014

Q:\Jobs\120711-01.01_Port_of_Los_Angeles\POLA_POLB_Bioaccumulation_Modeling_Support\Maps\2013_08_Regional_Bckgrd\Regional_bckgrd_sketch_131120.mxd ckiblinger 5/16/2014 2:32:49 PM

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ANCHOR QEA

Miles

0 10 20

Figure 4-16

Local and Regional Background Areas

Greater Los Angeles and Long Beach Harbor Waters

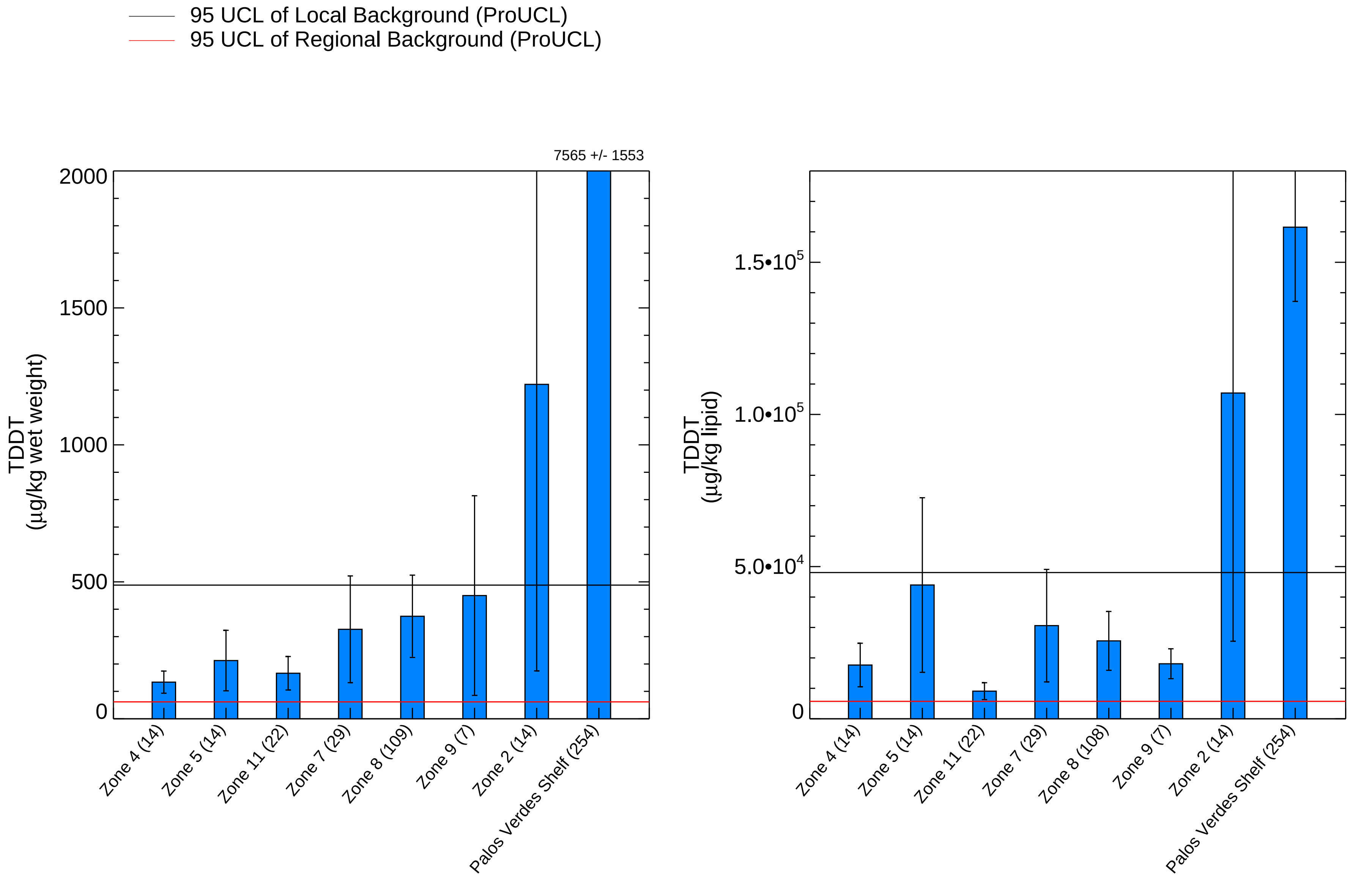

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Figure 4-17a

White Croaker TDDT Concentrations Compared to Background Levels

Bars represent average +/- two standard errors. Number of samples is labeled within parentheses after zone names.
Fish data collected between year 1998 and 2012. Tissue types include fillet and whole fish (lipid basis only). Non-detects set to half detection limit.
Database: processed_fish_forSQO_20131127.csv.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Spatial_Distribution\fish_barplot_w_background.pro Tue May 20 16:20:52 2014

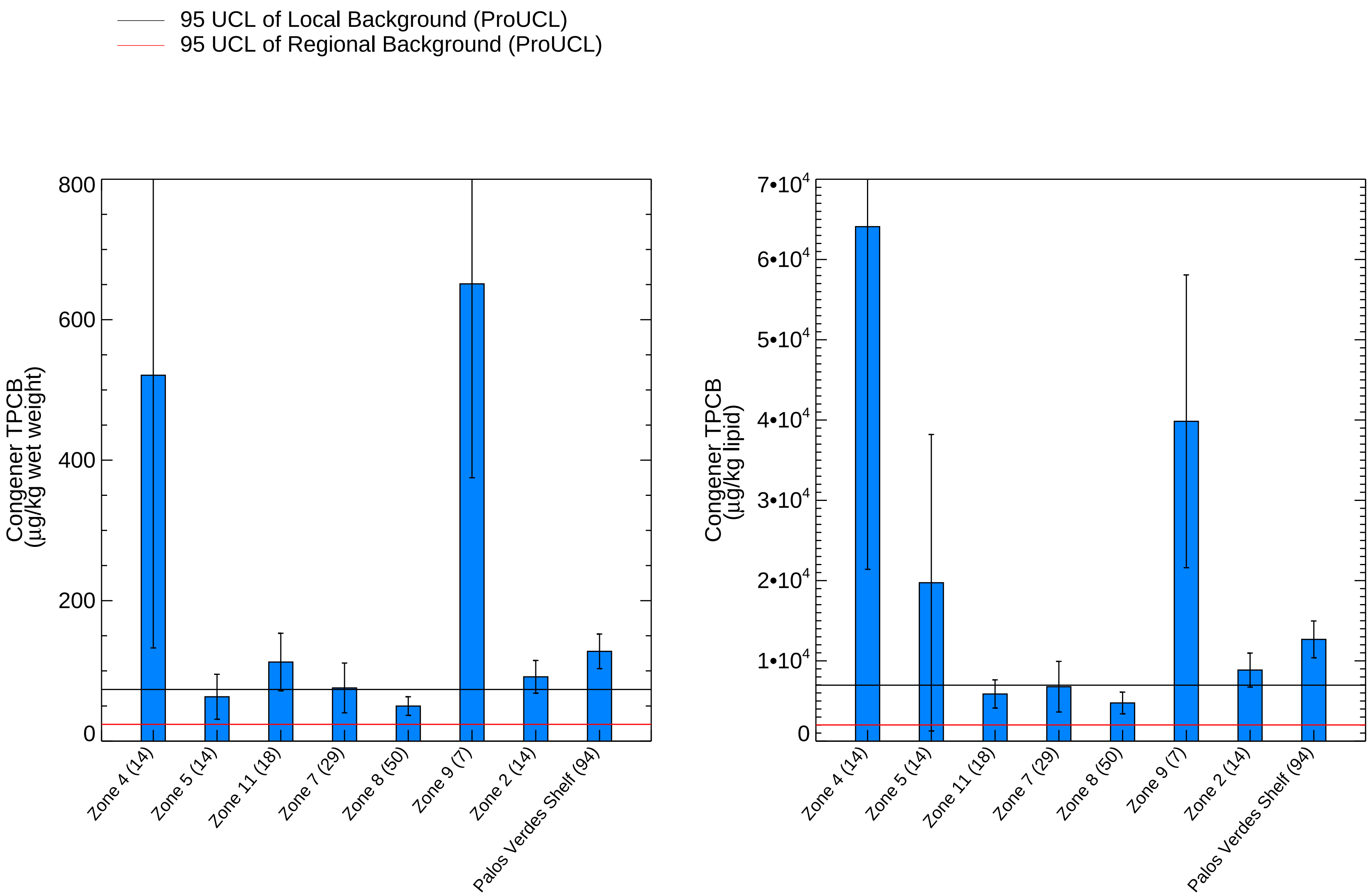

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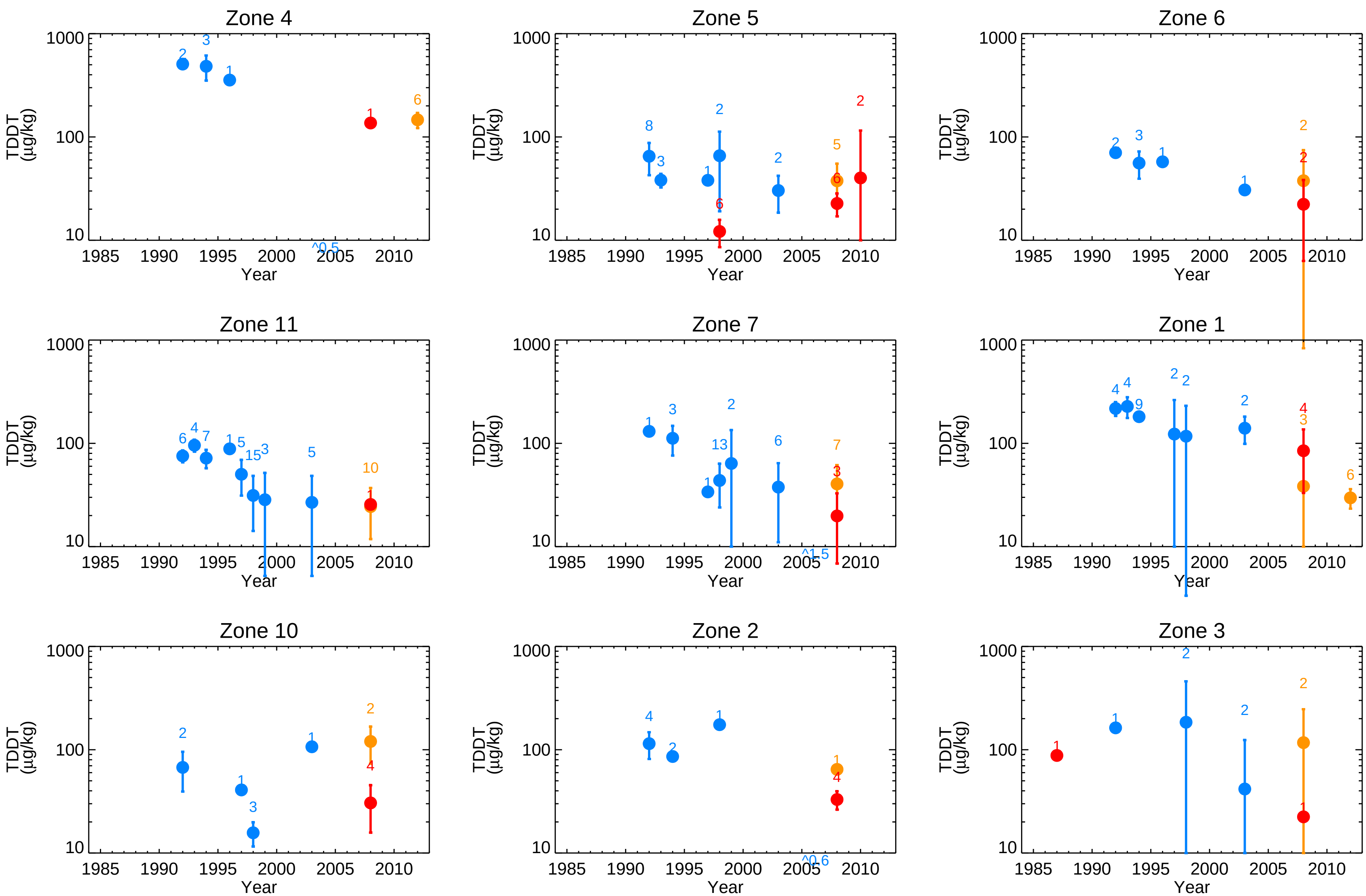
Figure 4-17b

White Croaker Congener TPCB Concentrations Compared to Background Levels

Bars represent average +/- two standard errors. Number of samples is labeled within parentheses after zone names.
Fish data collected between year 1998 and 2012. Tissue types include fillet and whole fish (lipid basis only). Non-detects set to half detection limit.
Database: processed_fish_forSQO_20131127.csv.



0 to 2 cm
0 to 5 cm
0 to 10 cm

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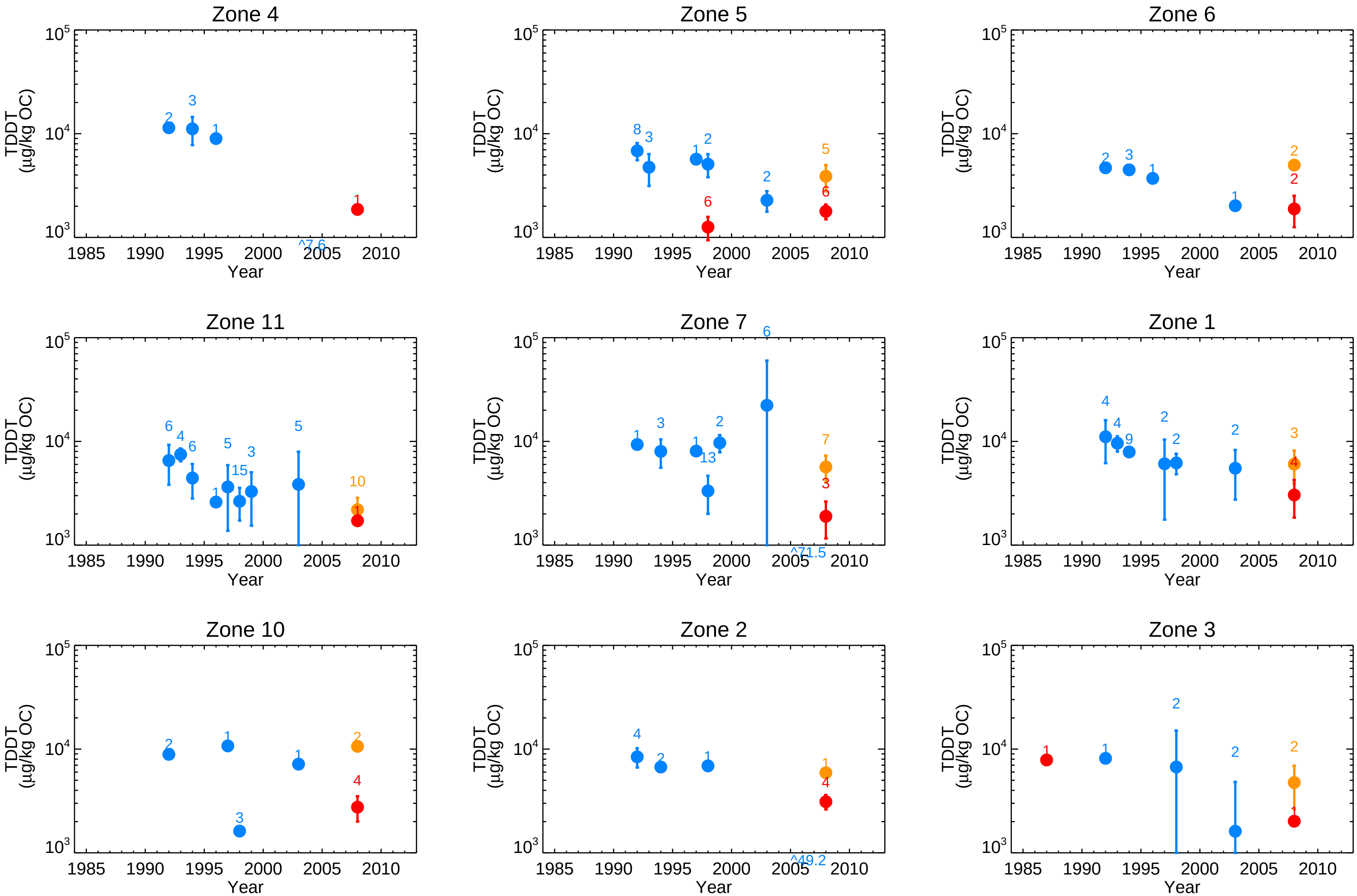
Figure 5−1a

Temporals of Dry−Weight TDDT Concentrations in Surface Sediment from the LA/LB Harbor Area

Means and +/− two standard errors are shown. Only surface samples with end depths <= 10 cm are included. Aroclor samples are shown only when congeners were not measured. Totals were calculated as the sum of detected components, or half of the highest method detection limit (or reporting limit when method detection limit not available in AMEC data) if all components were non−detects. Counts are posted next to means; off−panel data indicated by carets and posted means. Duplicates from original sample results were averaged. Database: Sed_DB_comb_ND_half_MDL__totals_20140229.bin

BG − \\socal2\Disneyland\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_temporals.pro Fri May 16 12:15:44 2014



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- 0 to 2 cm
- 0 to 5 cm
- 0 to 10 cm

Figure 5−1b

Temporals of OC−Normalized TDDT Concentrations in Surface Sediment from the LA/LB Harbor Area

Means and +/− two standard errors are shown. Only surface samples with end depths <= 10 cm are included. Aroclor samples are shown only when congeners were not measured. Results shown are TOC−normalized. Totals were calculated as the sum of detected components; or half of the highest method detection limit (or reporting limit when method detection limit not available in AMEC data) if all components were non−detects. Counts are posted next to means; off−panel data indicated by carets and posted means. Duplicates from original sample results were averaged. Database: Sed_DB_comb_ND_half_MDL__totals_TOCnorm_20140229.bin

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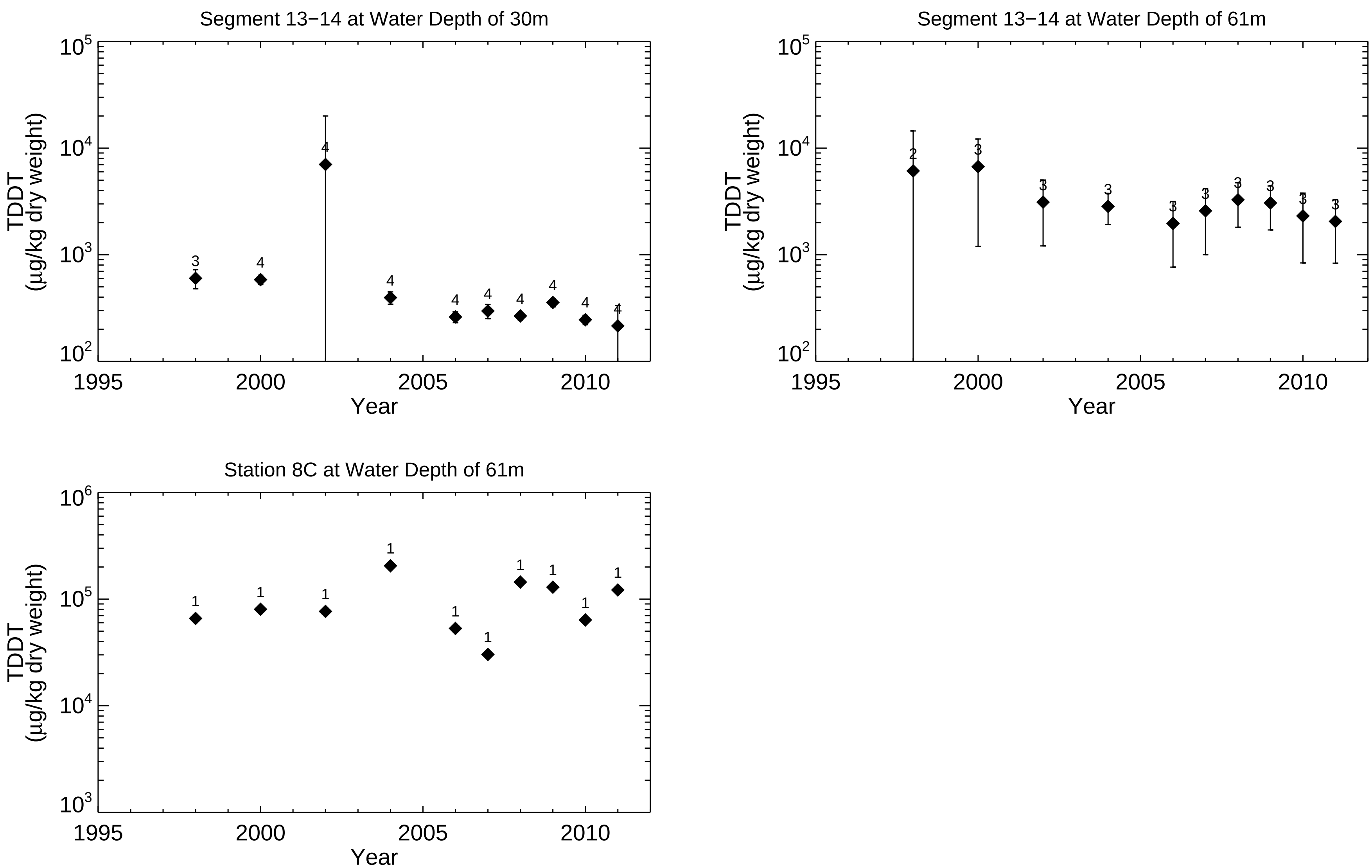

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Figure 5−2a

Temporals of Dry−Weight TDDT Concentrations in Surface Sediment from Palos Verdes Shelf

Data collected between 1998 and 2012. Totals were calculated as the sum of detected components, or half highest method detection limit. Points are means +/− two standard errors. Surface sediment samples (0−16cm) shown. Sample counts are labeled above each symbol. Station 8C is located within Segment 13−14 but plotted separately.

Database = Sed_DBcomb_NDhalfMDL_tot_20140229_alignTOC_20140301

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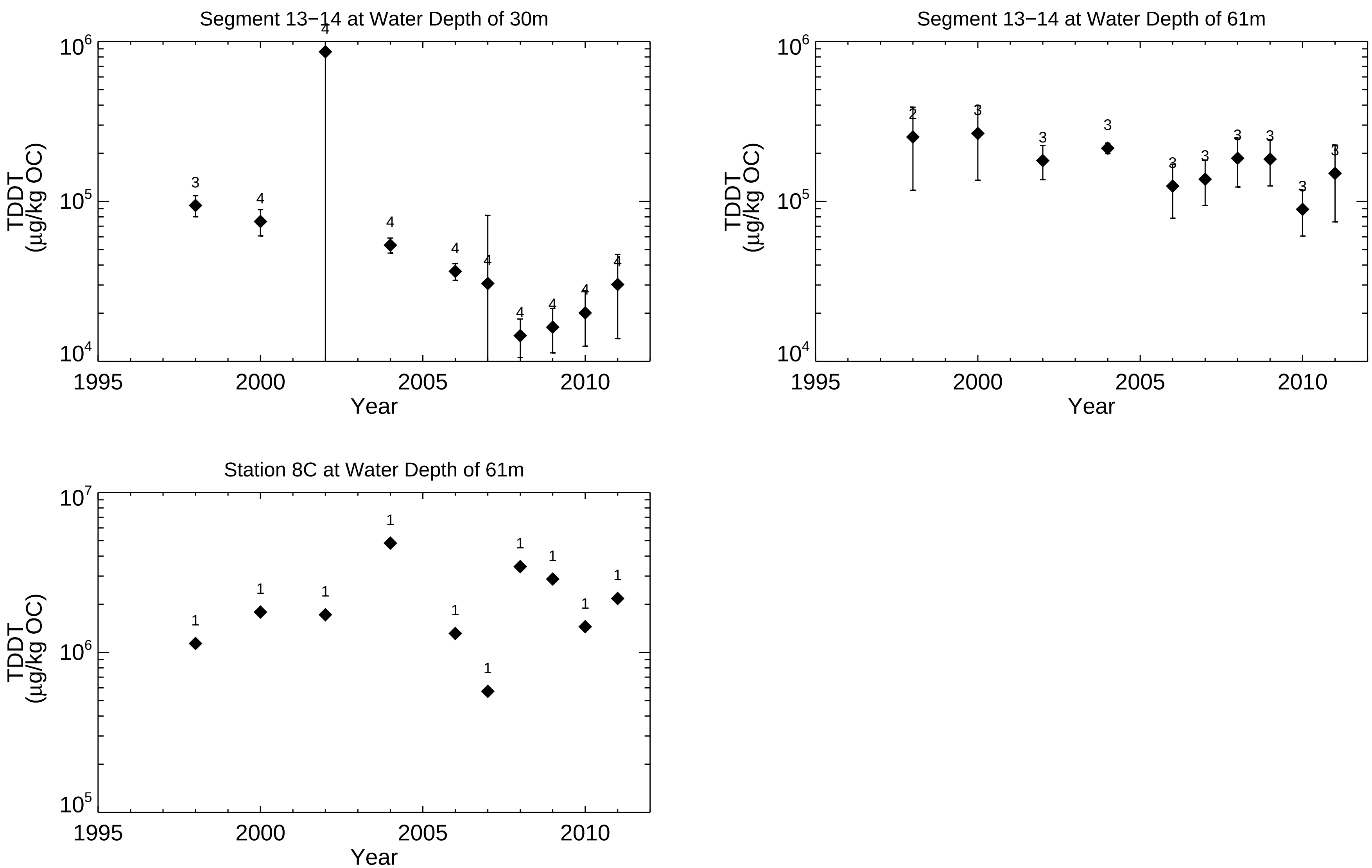

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ANCHOR QEA

Figure 5−2b

Temporals of OC−Normalized TDDT Concentrations in Surface Sediment from Palos Verdes Shelf

Data collected between 1998 and 2012. Totals were calculated as the sum of detected components, or half highest method detection limit. Points are means +/− two standard errors. Surface sediment samples (0−16cm) shown. Sample counts are labeled above each symbol. Station 8C is located within Segment 13−14 but plotted separately.

Database = Sed_DBcomb_NDhalfMDL_tot_20140229_alignTOC_20140301

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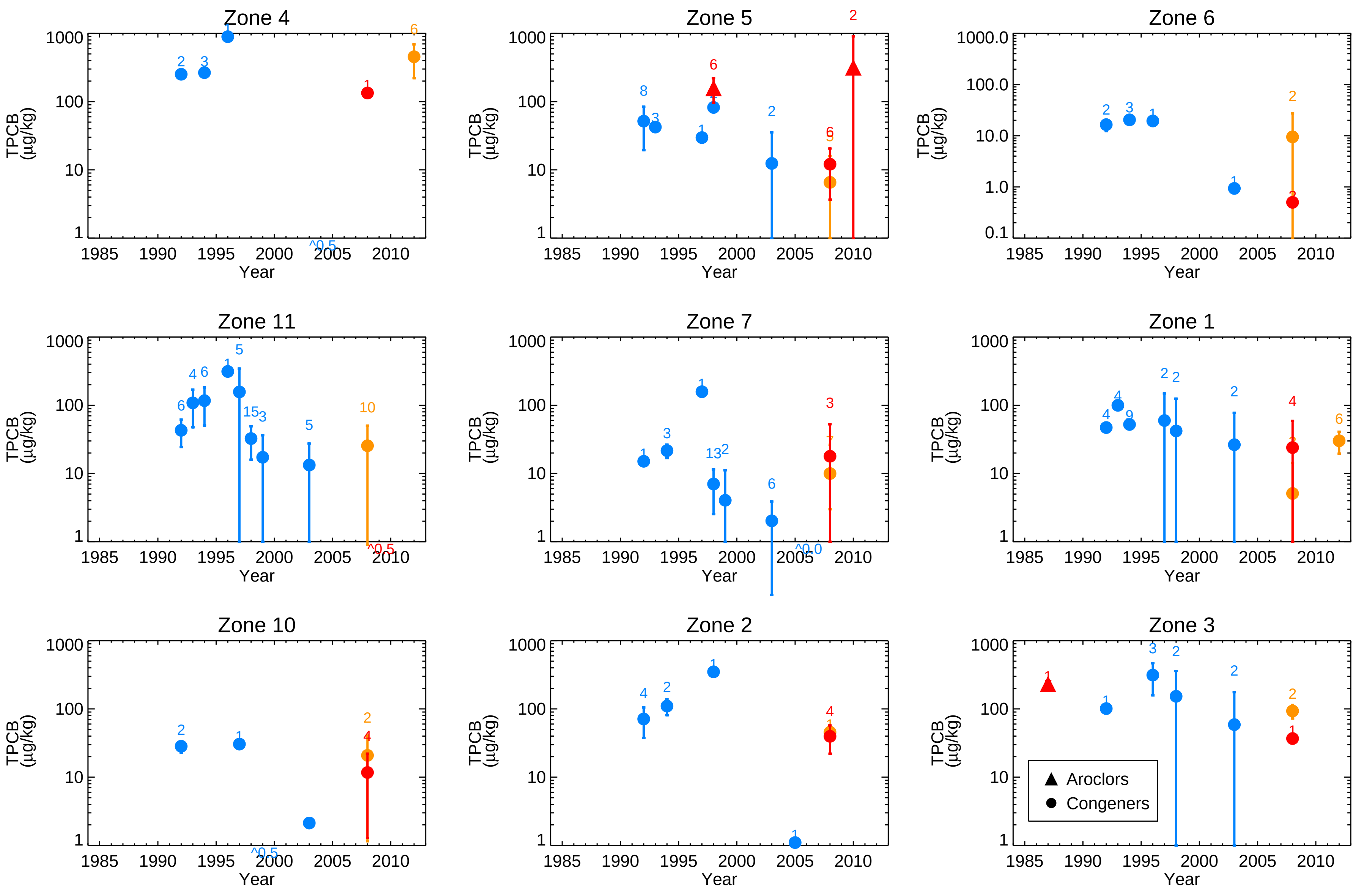

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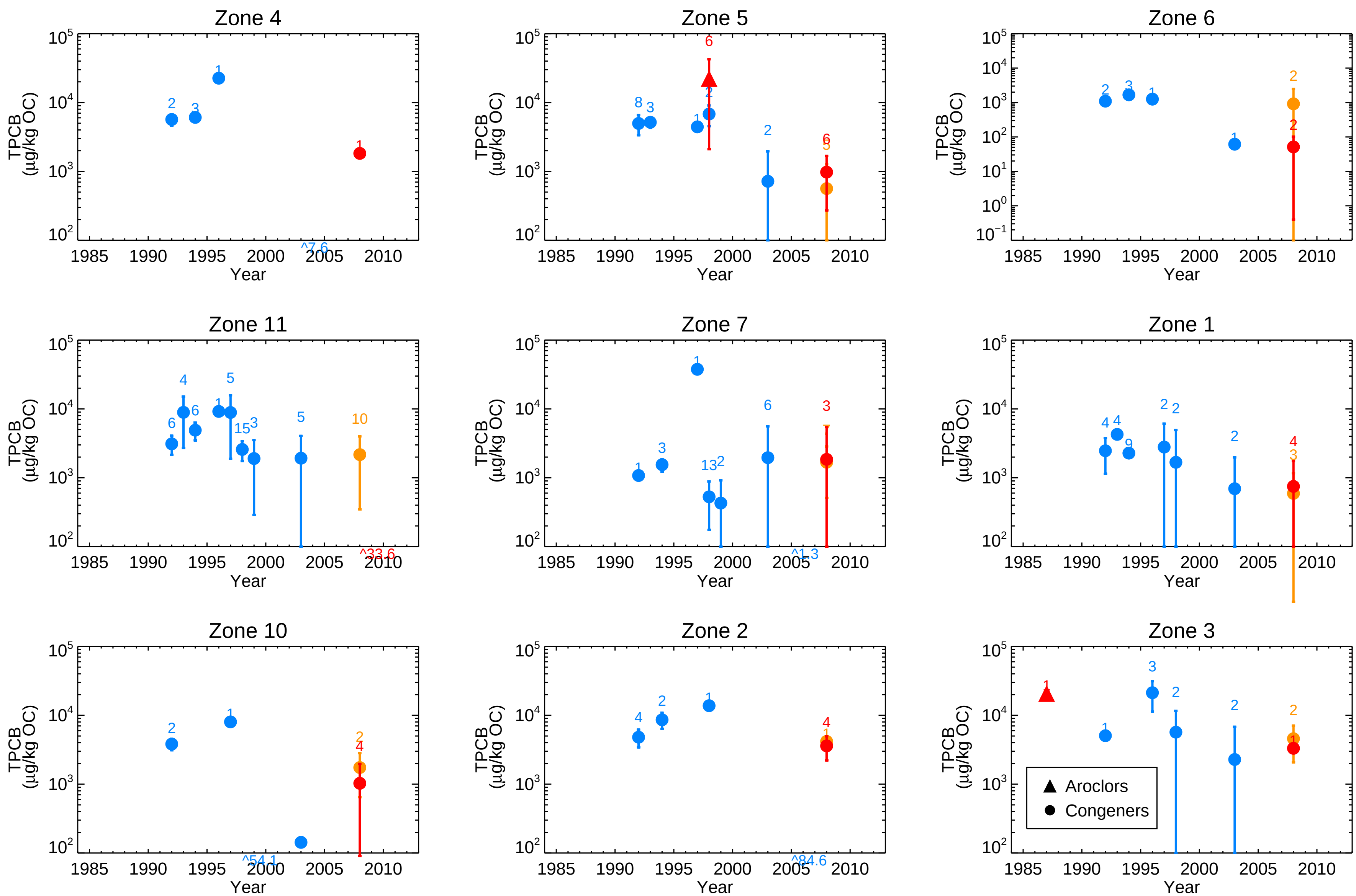
Figure 5−3a

Temporals of Dry−Weight TPCB Concentrations in Surface Sediment from the LA/LB Harbor Area

Means and +/− two standard errors are shown. Only surface samples with end depths <= 10 cm are included. Aroclor samples are shown only when congeners were not measured. Totals were calculated as the sum of detected components, or half of the highest method detection limit (or reporting limit when method detection limit not available in AMEC data) if all components were non−detects. Counts are posted next to means; off−panel data indicated by carets and posted means. Duplicates from original sample results were averaged. Database: Sed_DB_comb_ND_half_MDL__totals_20140229.bin

BG − \\socal2\Disneyland\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_temporals.pro Fri May 16 12:15:44 2014



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0 to 2 cm
0 to 5 cm
0 to 10 cm

Figure 5−3b

Temporals of OC−Normalized TPCB Concentrations in Surface Sediment from the LA/LB Harbor Area

Means and +/− two standard errors are shown. Only surface samples with end depths <= 10 cm are included. Aroclor samples are shown only when congeners were not measured. Results shown are TOC−normalized. Totals were calculated as the sum of detected components; or half of the highest method detection limit (or reporting limit when method detection limit not available in AMEC data) if all components were non−detects. Counts are posted next to means; off−panel data indicated by carets and posted means. Duplicates from original sample results were averaged. Database: Sed_DB_comb_ND_half_MDL__totals_TOCnorm_20140229.bin

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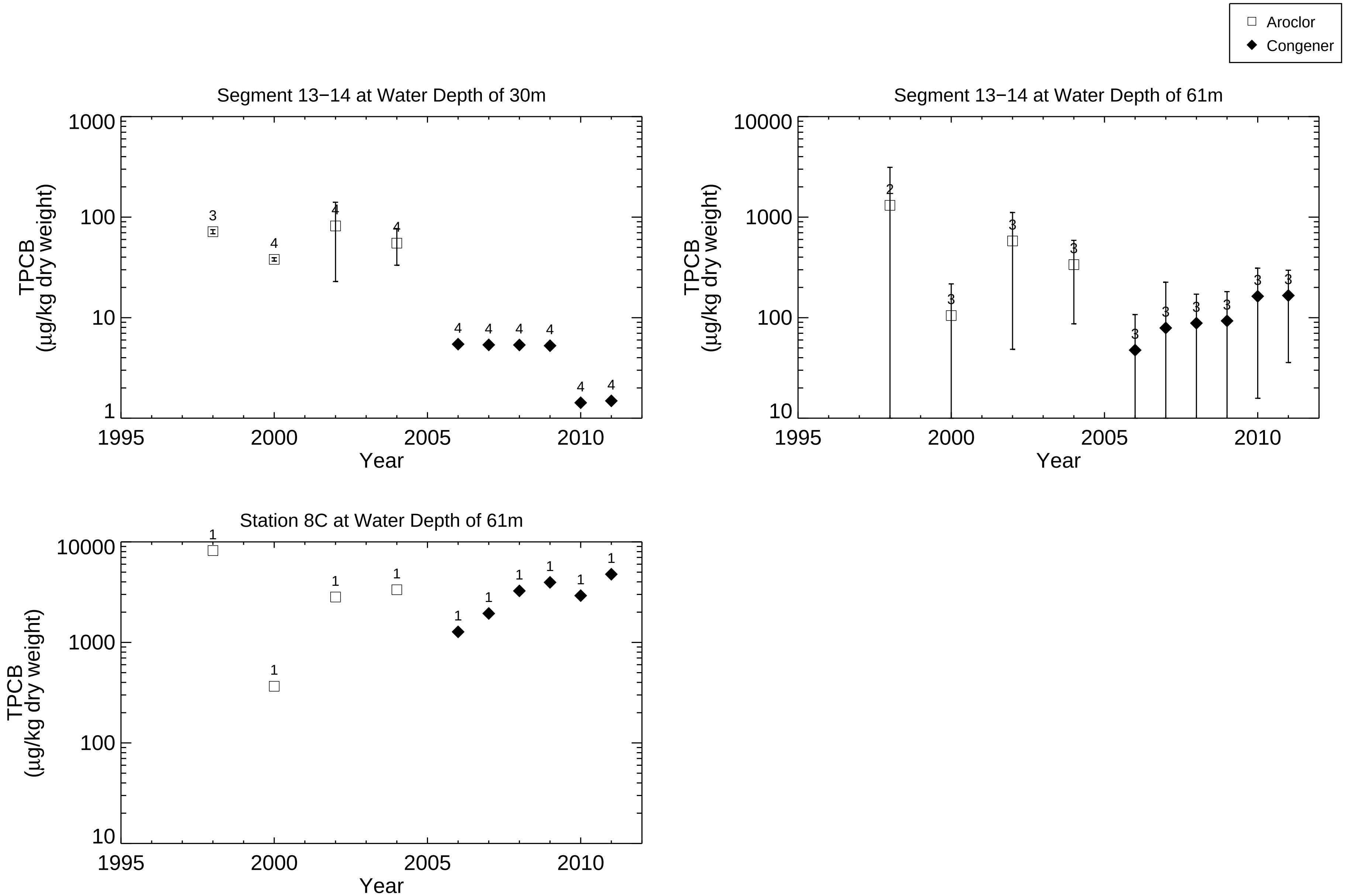

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Figure 5−4a

Temporals of Dry−Weight TPCB Concentrations in Surface Sediment from Palos Verdes Shelf

Data collected between 1998 and 2012. Totals were calculated as the sum of detected components, or half highest method detection limit. Points are means +/− two standard errors. Surface sediment samples (0−16cm) shown. Sample counts are labeled above each symbol. Station 8C is located within Segment 13−14 but plotted separately. Aroclor samples are shown only when congeners were not measured.

Database = Sed_DBcomb_NDhalfMDL_tot_20140229_alignTOC_20140301

ANCHOR QEA

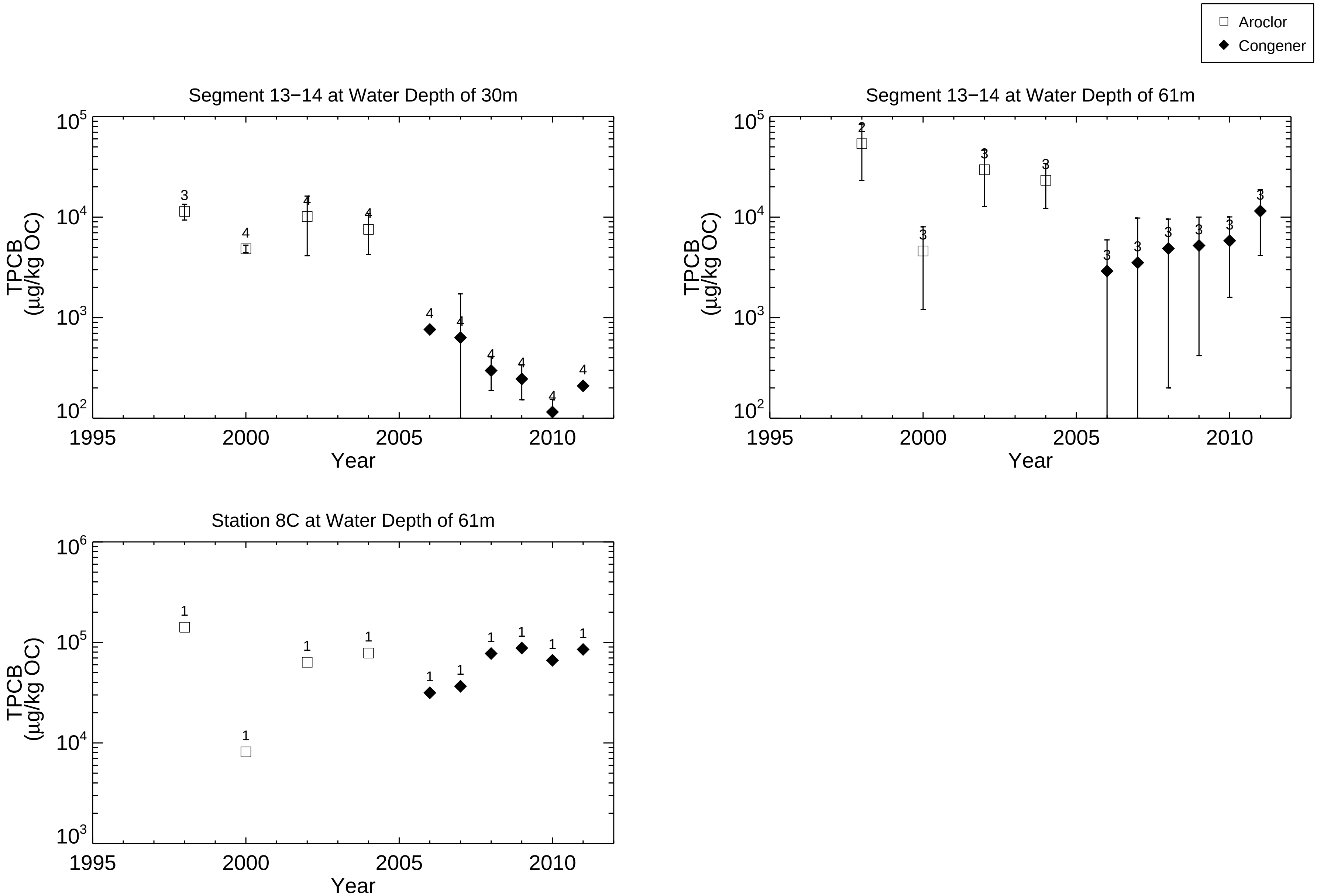

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Figure 5−4b

Temporals of OC−Normalized TPCB Concentrations in Surface Sediment from Palos Verdes Shelf

Data collected between 1998 and 2012. Totals were calculated as the sum of detected components, or half highest method detection limit. Points are means +/− two standard errors. Surface sediment samples (0−16cm) shown. Sample counts are labeled above each symbol. Station 8C is located within Segment 13−14 but plotted separately. Aroclor samples are shown only when congeners were not measured.

Database = Sed_DBcomb_NDhalfMDL_tot_20140229_alignTOC_20140301

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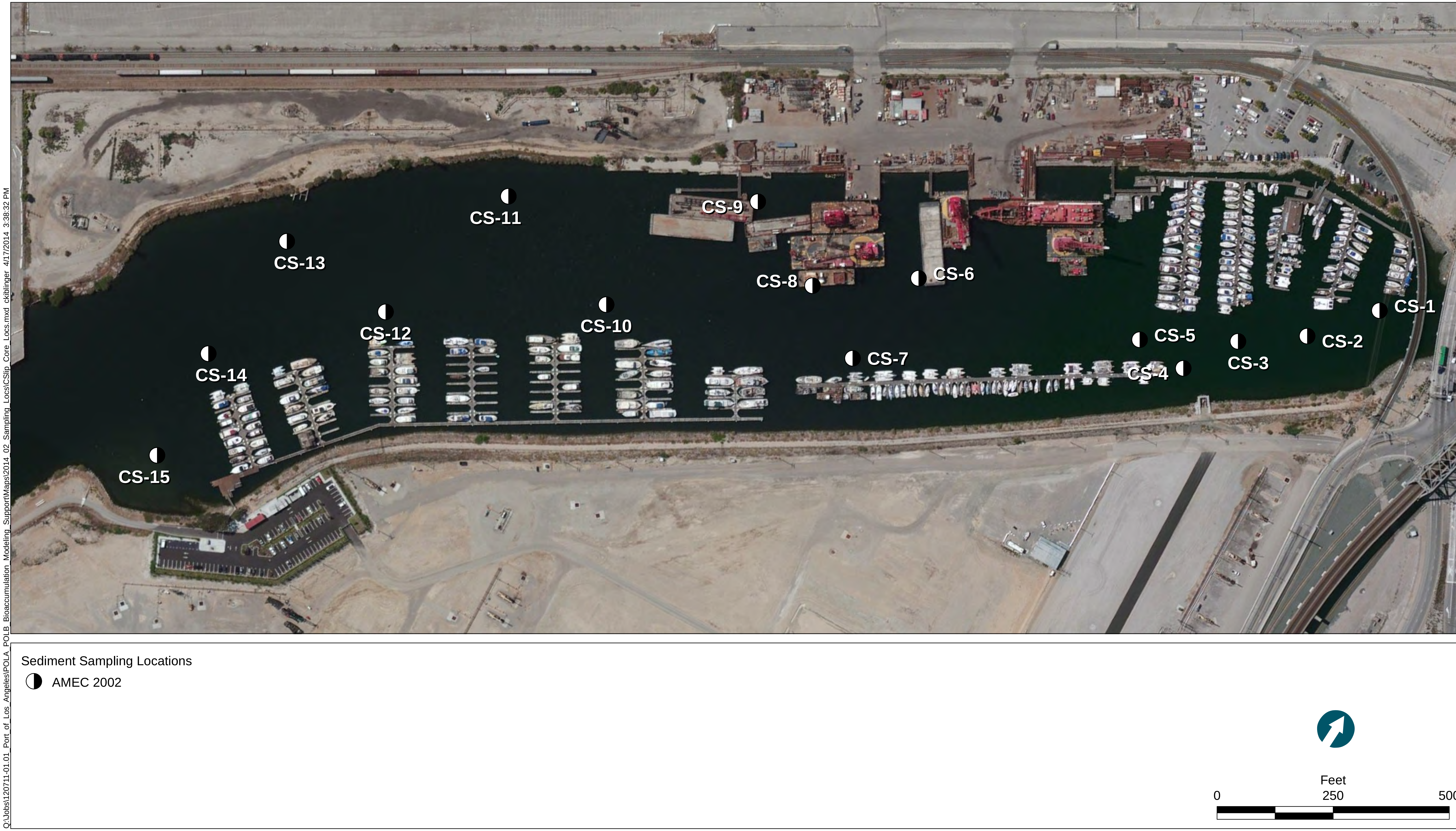

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Figure 5-5
Consolidated Slip Core Locations
Greater Los Angeles and Long Beach Harbor Waters

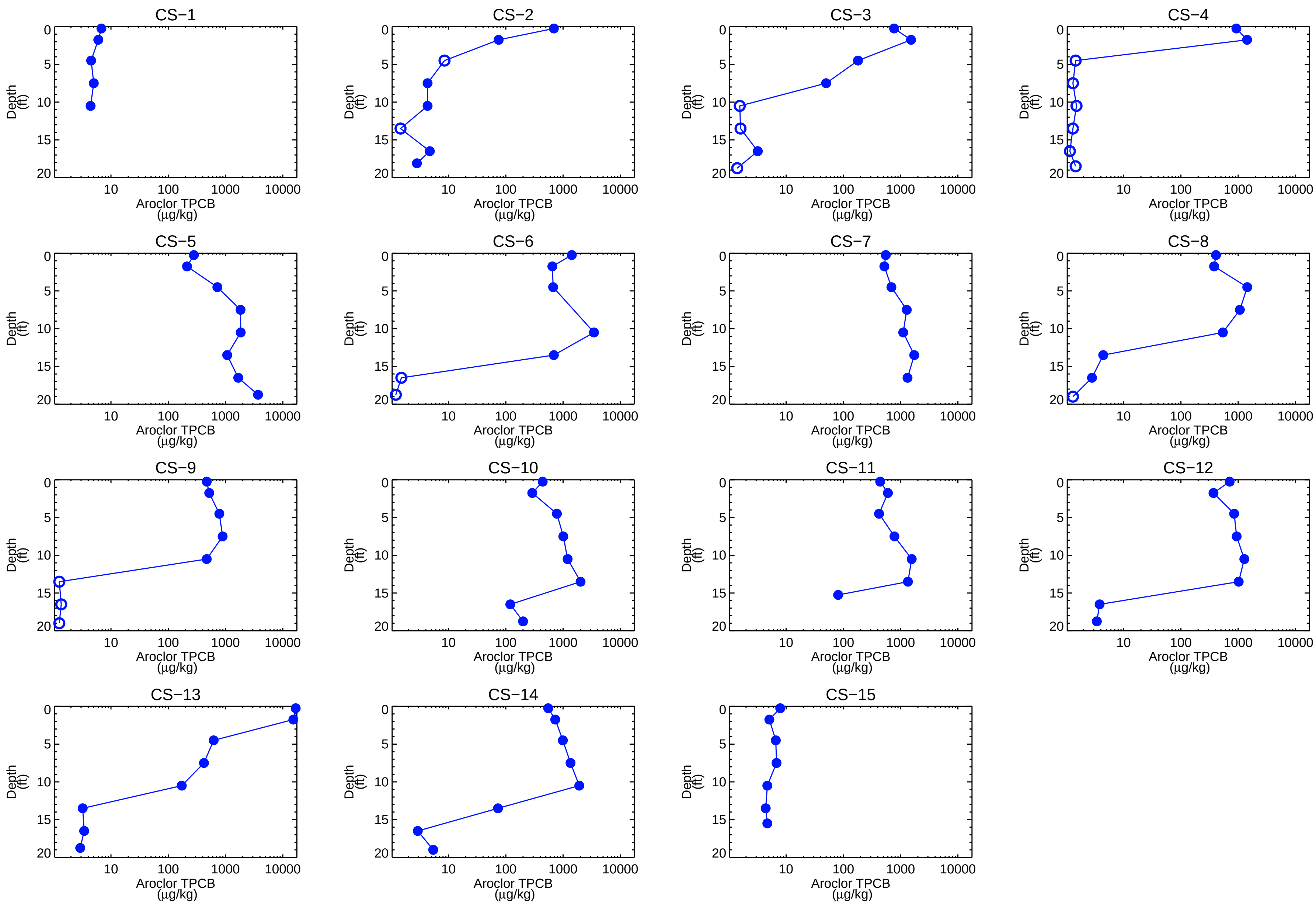

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Figure 5−6a

Dry−Weight TPCB Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths. Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols. Duplicates from original sample results were averaged
Data source: AMEC

BG − L:\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_dep_profile_Consol_slip.pro Wed Mar 05 15:53:45 2014

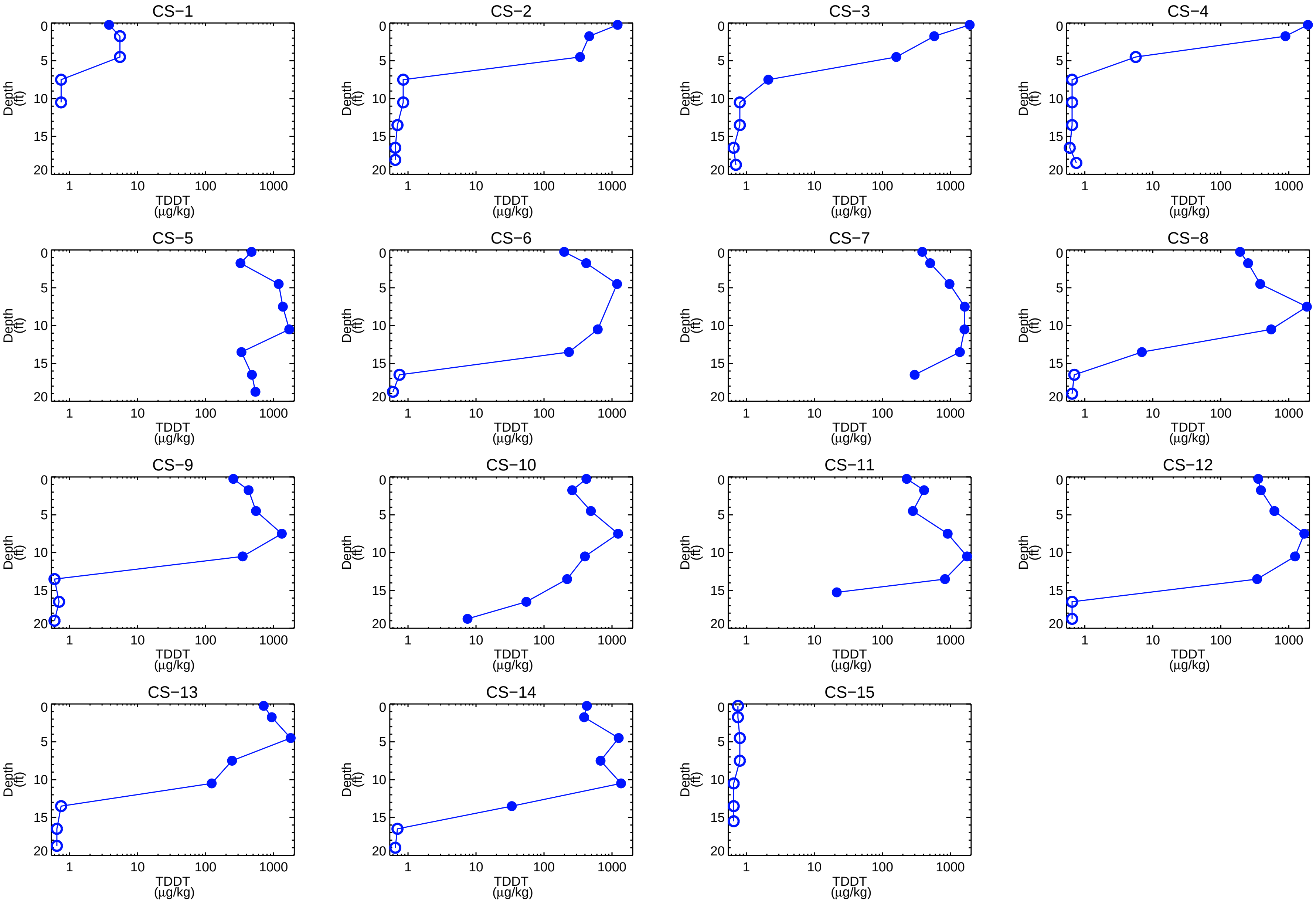

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Figure 5−6b

Dry−Weight TDDT Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths. Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols. Duplicates from original sample results were averaged

Data source: AMEC

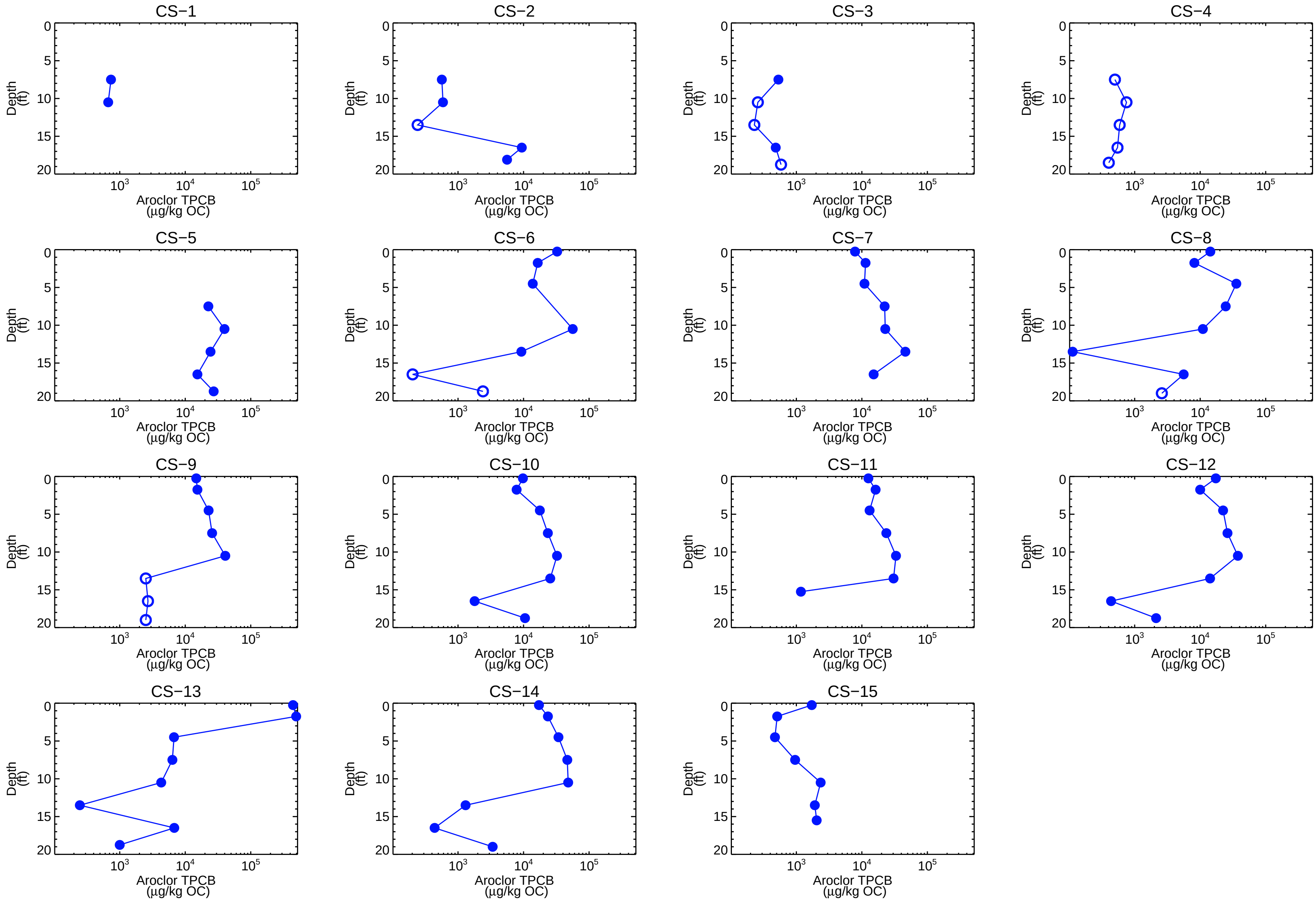

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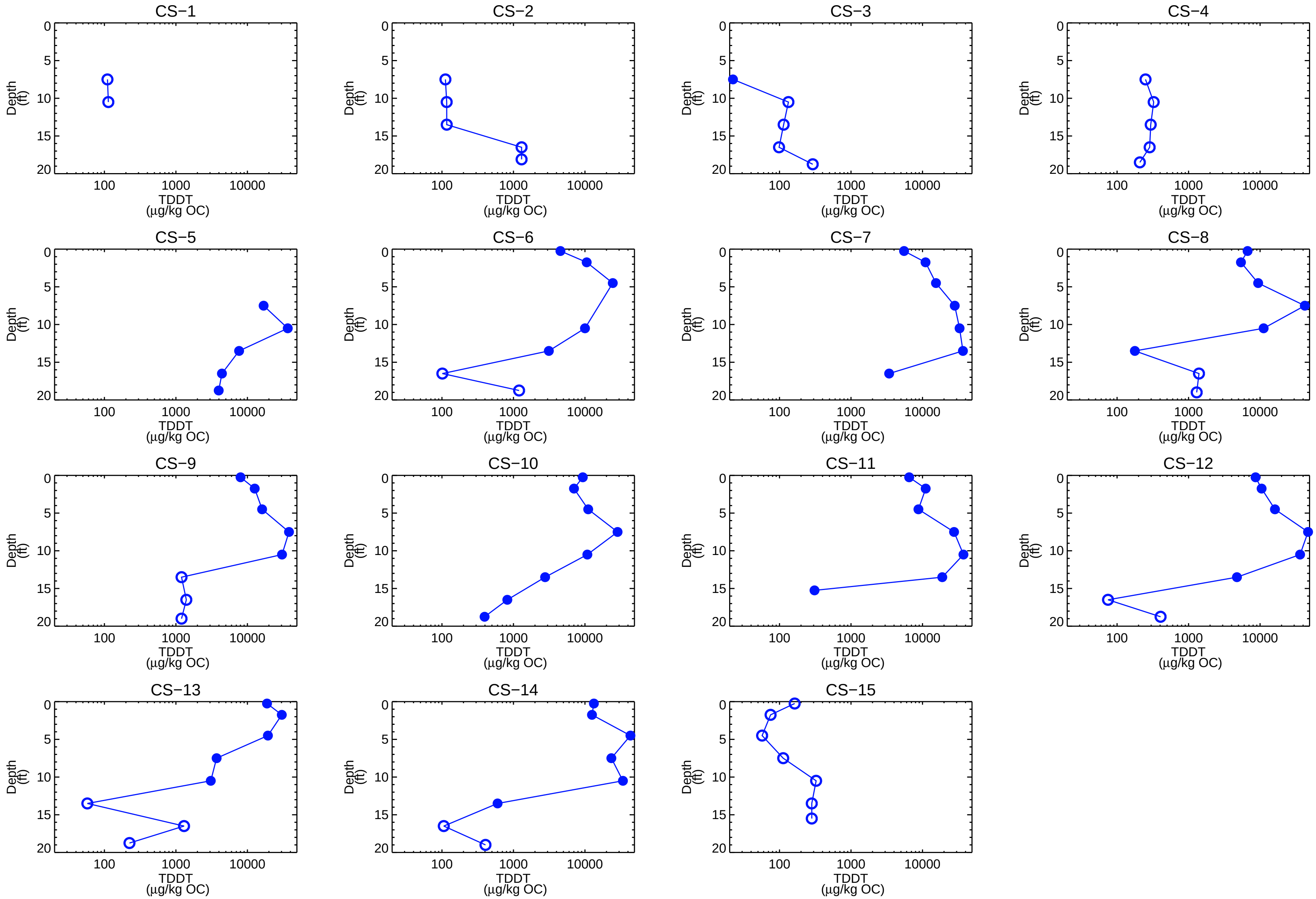
Figure 5−7a

OC−Normalized TPCB Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

BG − L:\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_dep_profile_Consol_slip.pro Tue May 13 10:06:00 2014



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ANCHOR QEA

Figure 5−7b

OC−Normalized TDDT Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

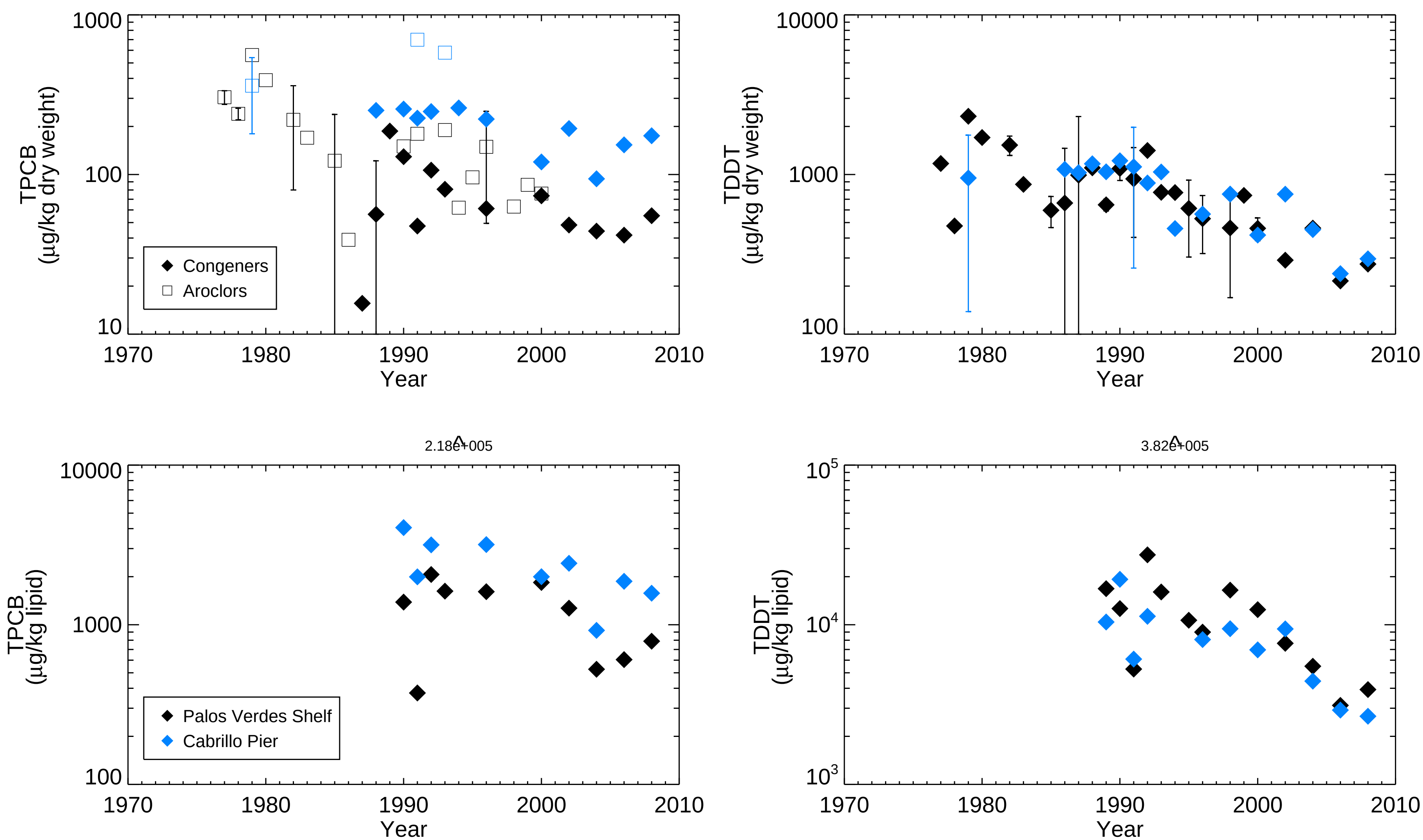

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Figure 5-8

Temporal of TPCB and TDDT Concentration in Mussel Collected near Cabrillo Pier and Palos Verdes Shelf

Cabrillo Pier data are located within Zone 1 but plotted separately. Zones delineated based on fish movement.
Totals are calculated as sum of detected components. If all components were non-detect, the total was set to zero and excluded from analysis.
Transplanted species removed from analysis. Transplanted California mussel and transplanted freshwater clam were excluded.
Database: POLA_POLB_Mussel_Dataset_20130412.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_mussel_temporal_byArea.pro Mon May 19 15:49:29 2014

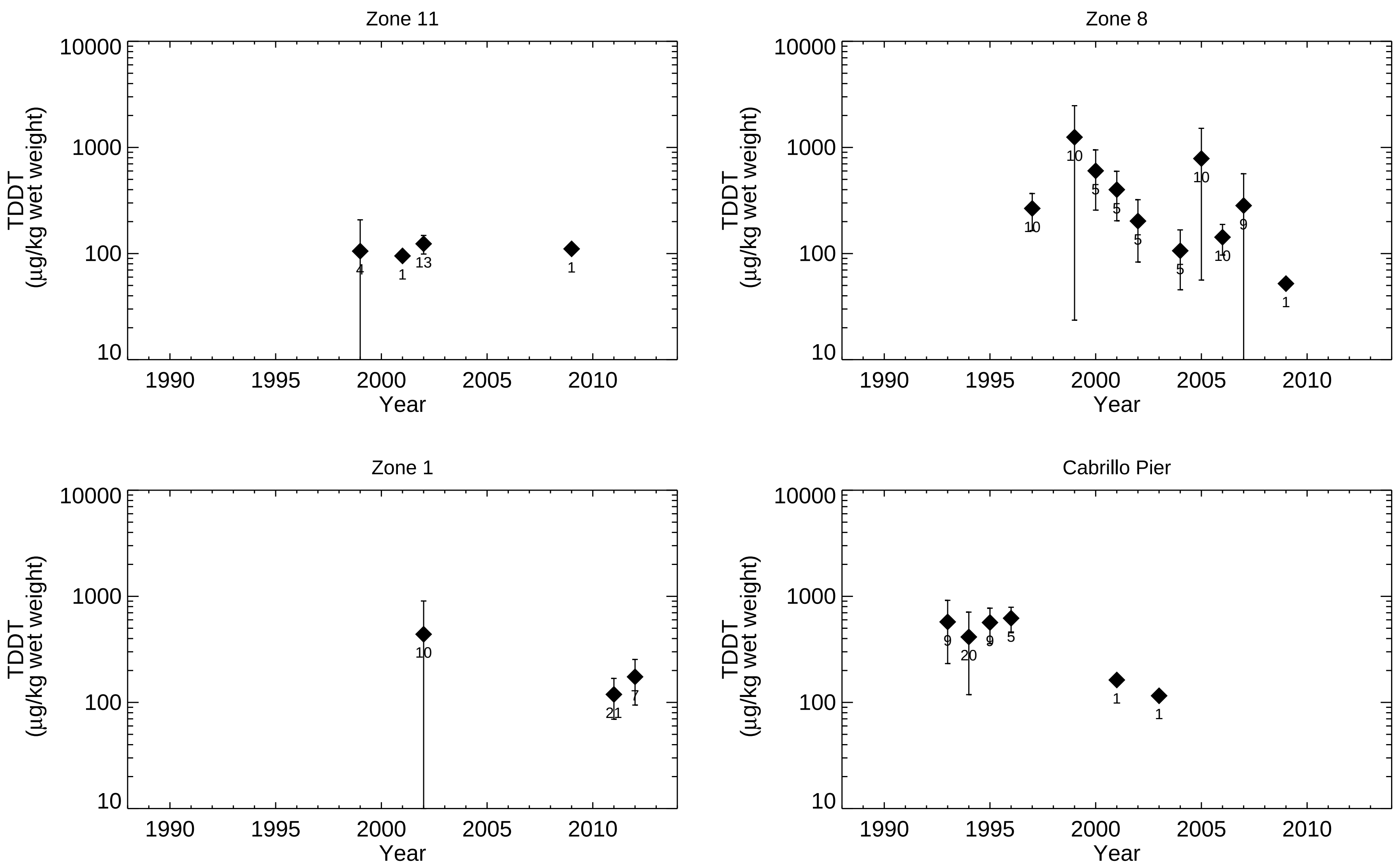

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Figure 5-9a

Temporals of Wet-Weight TDDT Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, and Fillet without skin.
Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist.
Cabrillo Pier data are located within Zone 1 but plotted separately.
Whole fish excluded for wet-weight values. Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_byArea.pro Mon May 19 16:52:42 2014

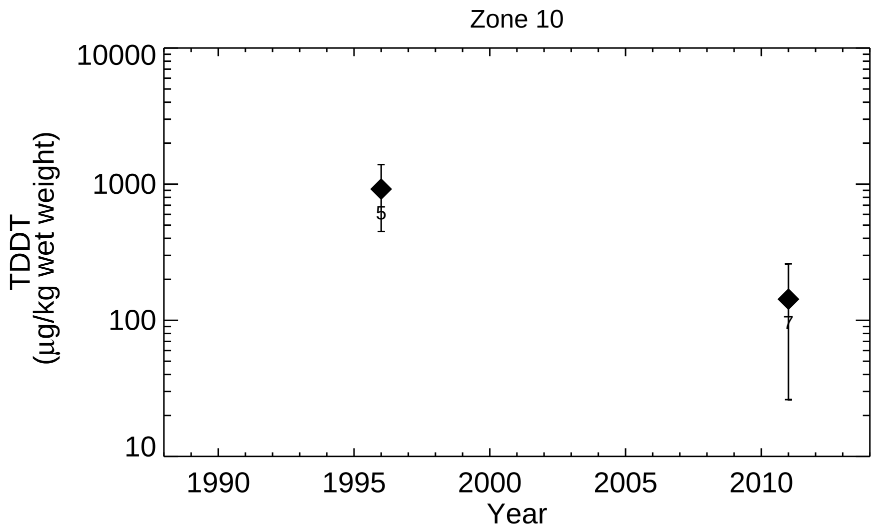

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Figure 5-9a

Temporals of Wet-Weight TDDT Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, and Fillet without skin. Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist. Cabrillo Pier data are located within Zone 1 but plotted separately. Whole fish excluded for wet-weight values. Database: AllFishData_Compile_130731.xlsx.

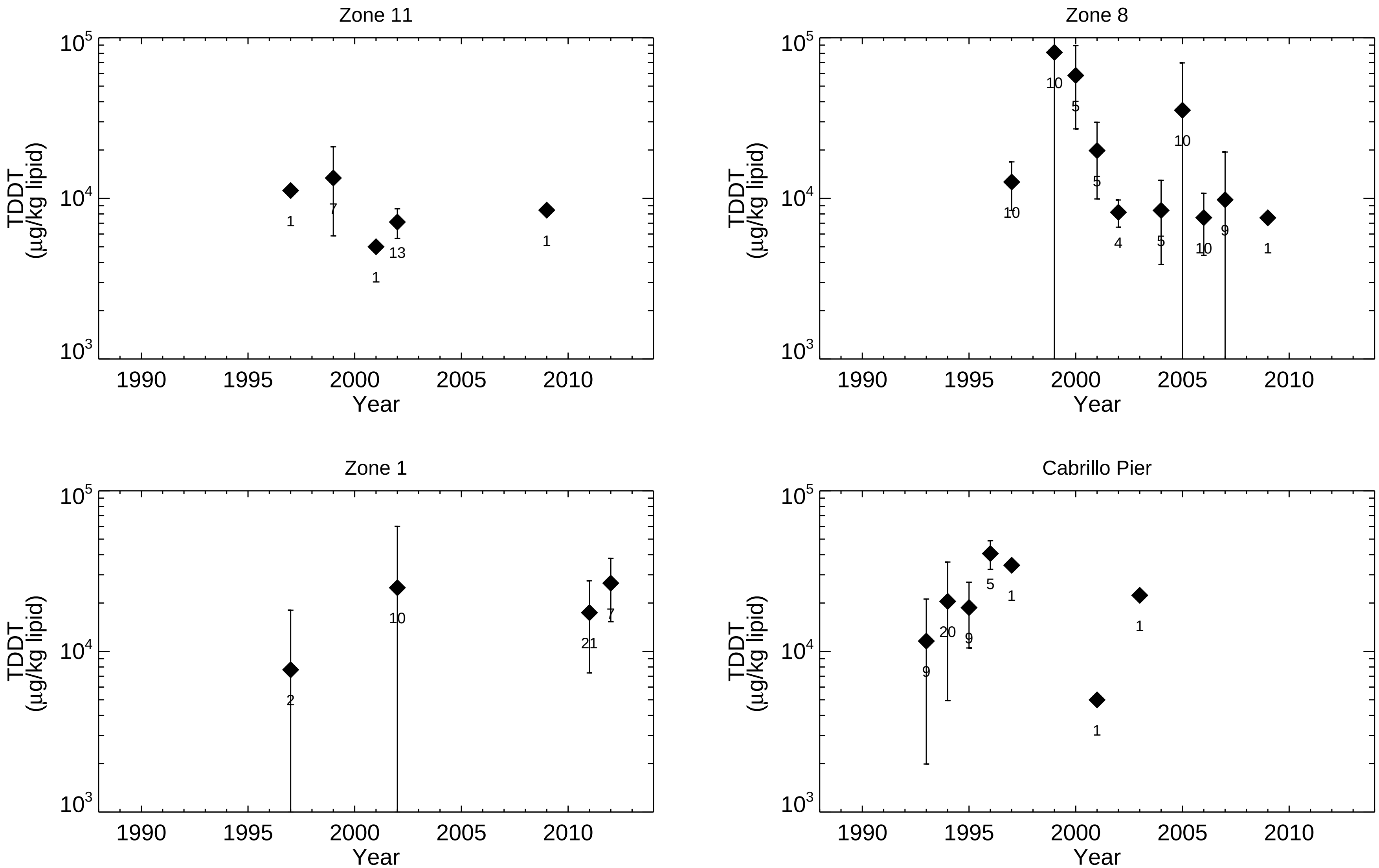

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Figure 5-9b

Temporals of Lipid-Normalized TDDT Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, Fillet without skin, and Whole fish.
Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist.
Cabrillo Pier data are located within Zone 1 but plotted separately.
Outlier (IH5-FFF-7WC) removed due to low lipid. Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_byArea.pro Mon May 19 16:52:40 2014

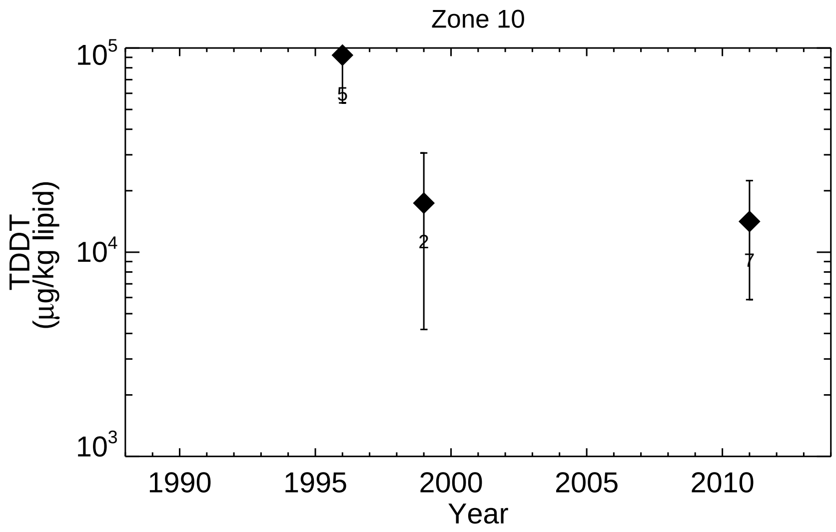

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Figure 5-9b

Temporals of Lipid-Normalized TDDT Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, Fillet without skin, and Whole fish. Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist. Cabrillo Pier data are located within Zone 1 but plotted separately. Outlier (IH5-FFF-7WC) removed due to low lipid. Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_byArea.pro Mon May 19 16:52:40 2014

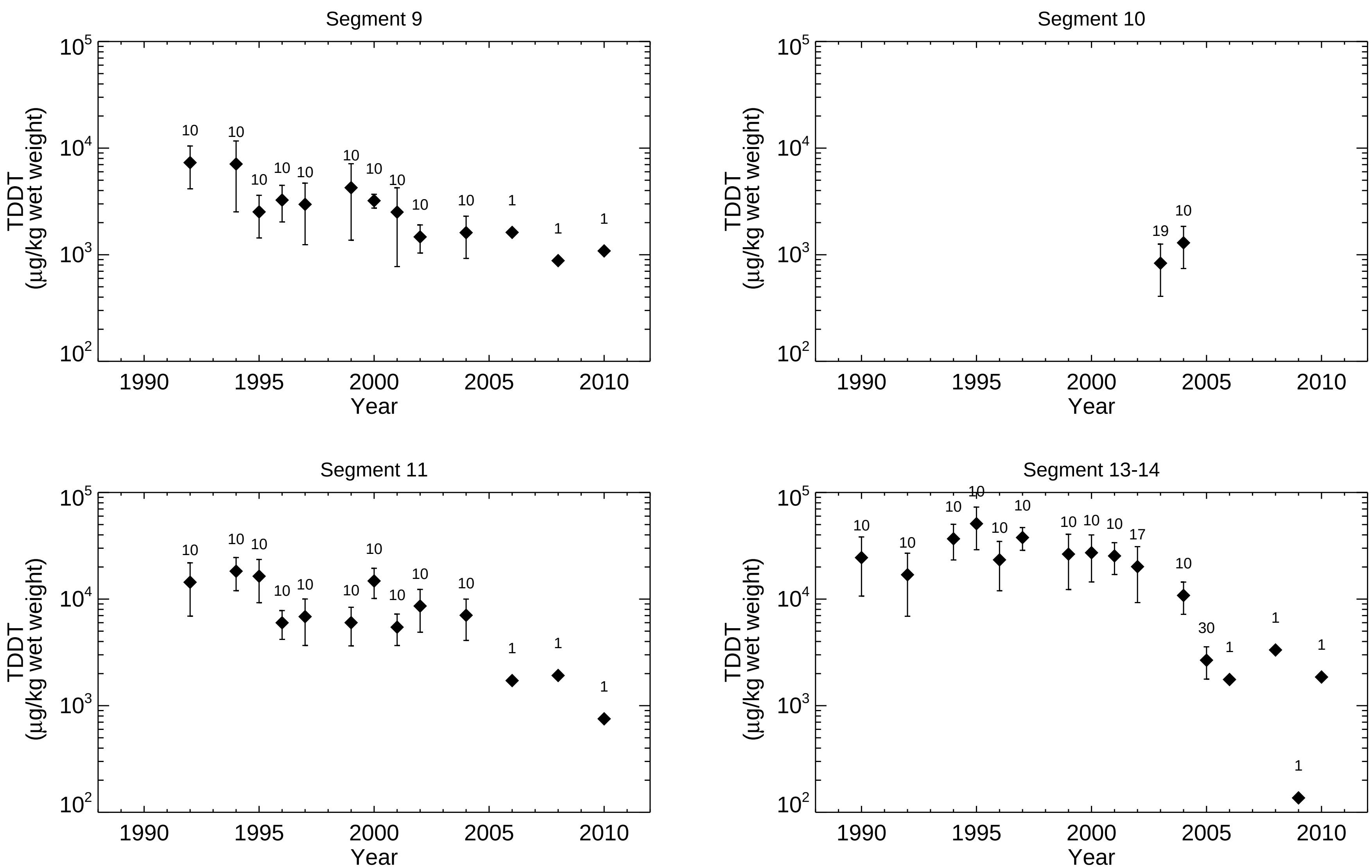

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Figure 5-10a

Wet-Weight TDDT Concentrations in White Croaker from Palos Verdes Shelf

Points are means +/- two standard errors. Data counts are posted above symbols. Data shown include fillet without skin only.
Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects.
Congener data are shown when paired Aroclor and Congener data exist.
Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_PVshelf.pro Mon May 19 16:42:02 2014

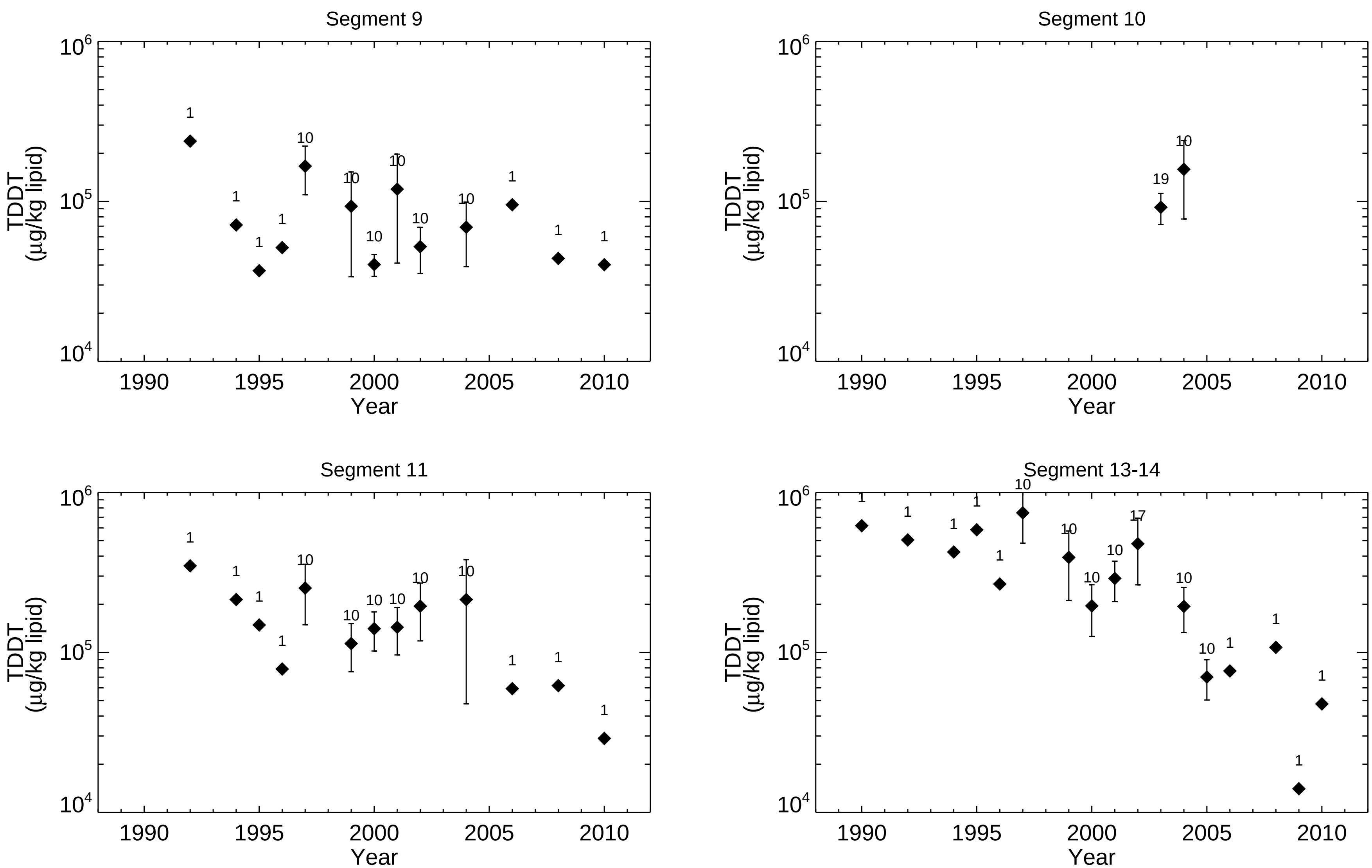

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Figure 5-10b

Lipid-Normalized TDDT Concentrations in White Croaker from Palos Verdes Shelf

Points are means +/- two standard errors. Data counts are posted above symbols. Data shown include fillet without skin only.
Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects.
Congener data are shown when paired Aroclor and Congener data exist.
Unique identifiers not available for pre-1996 LACSD data; data points represent annual average concentrations for these samples.
Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_PVshelf.pro Mon May 19 16:42:00 2014

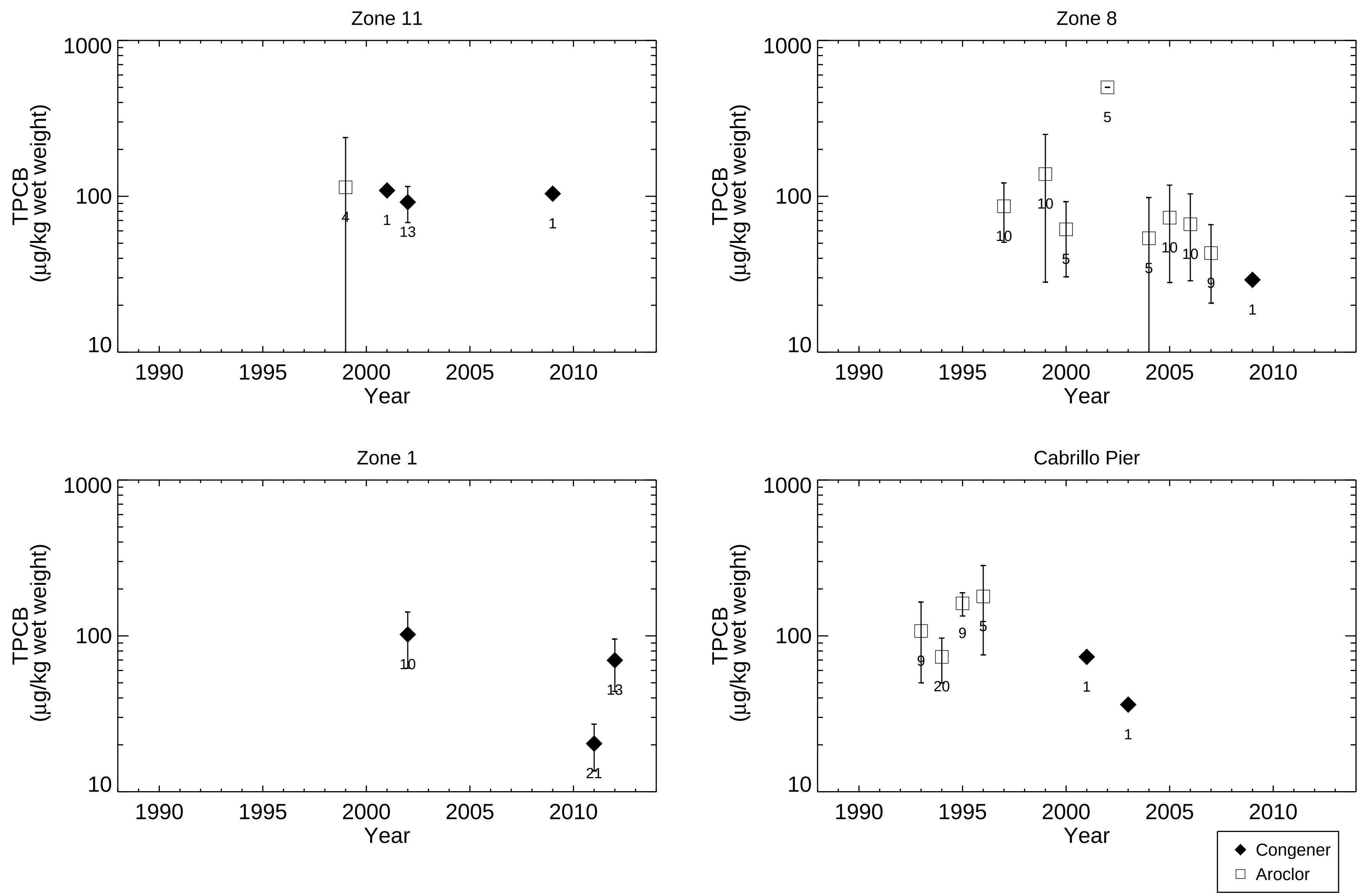

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Figure 5-11a

Temporals of Wet-Weight TPCB Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, and Fillet without skin. Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist. Cabrillo Pier data are located within Zone 1 but plotted separately. 2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis. Whole fish excluded for wet-weight values. Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_byArea.pro Mon May 19 16:52:41 2014

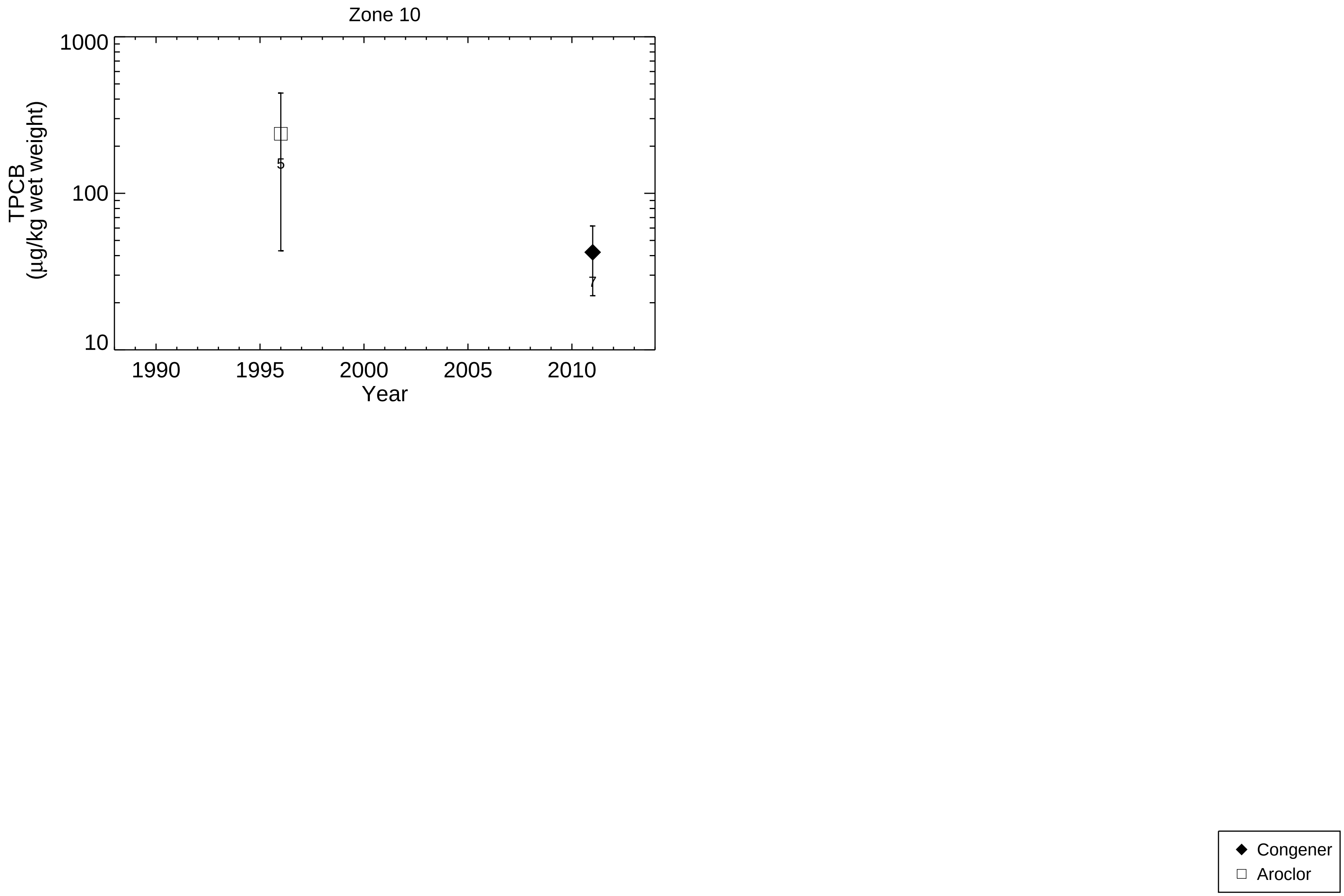

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Figure 5-11a

Temporals of Wet-Weight TPCB Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, and Fillet without skin. Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist. Cabrillo Pier data are located within Zone 1 but plotted separately. 2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis. Whole fish excluded for wet-weight values. Database: AllFishData_Compile_130731.xlsx.

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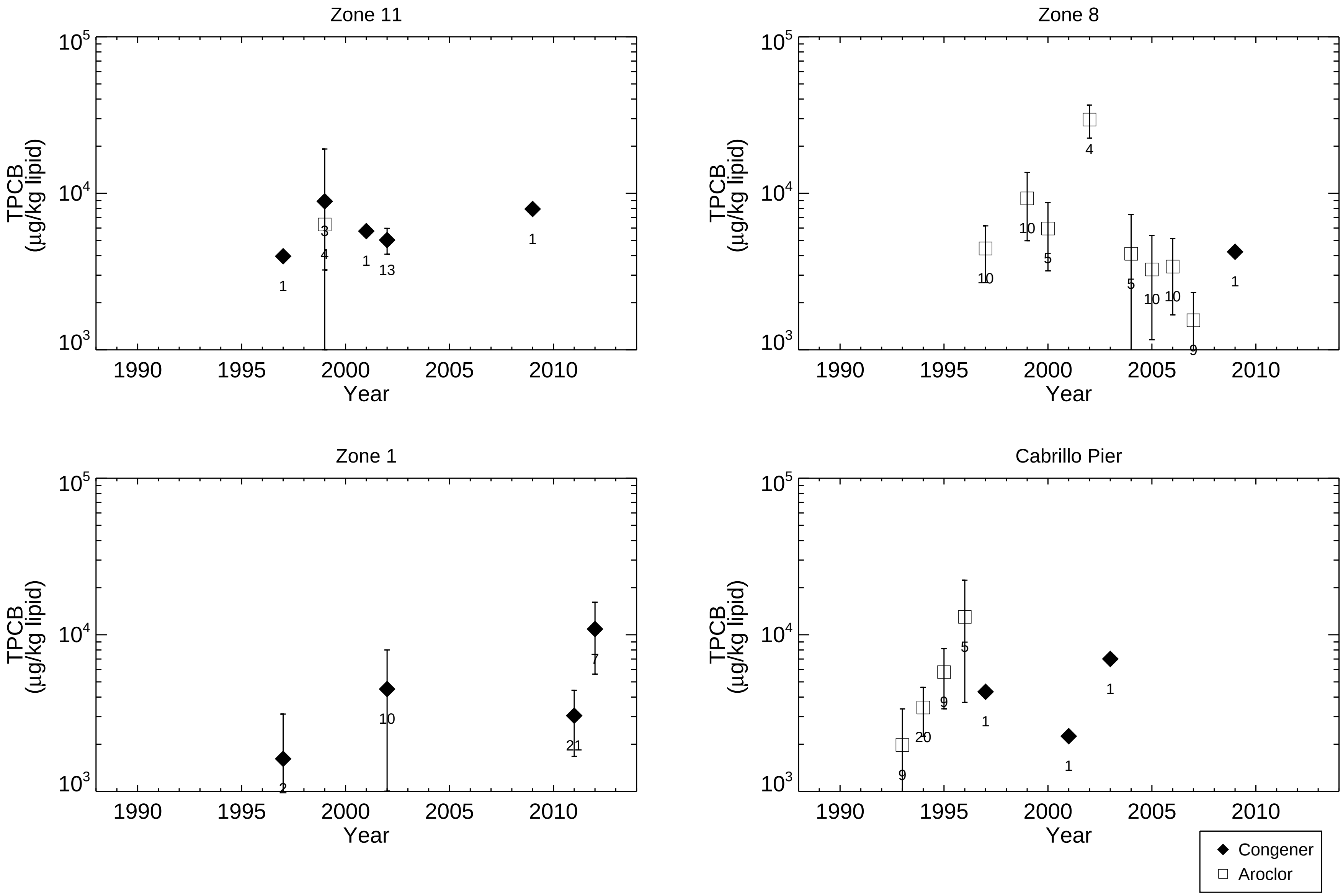

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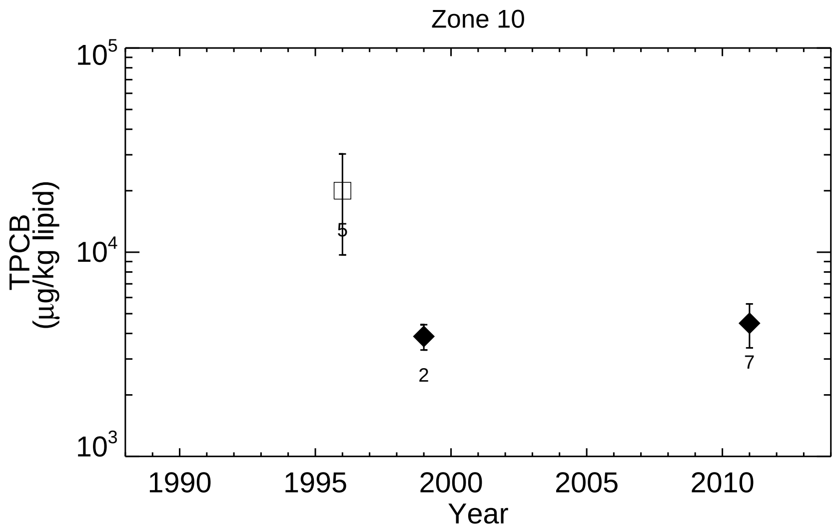
Figure 5-11b

Temporals of Lipid-Normalized TPCB Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, Fillet without skin, and Whole fish. Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist. Cabrillo Pier data are located within Zone 1 but plotted separately. 2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis. Outlier (IH5-FFF-7WC) removed due to low lipid. Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_byArea.pro Mon May 19 16:52:37 2014



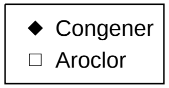


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Figure 5-11b

Temporals of Lipid-Normalized TPCB Concentrations in White Croaker

Zones delineated based on fish movement. Data shown include Fillet, Fillet with skin, Fillet without skin, and Whole fish. Points are means +/- two standard errors. Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects. Congener data are shown when paired Aroclor and Congener data exist. Cabrillo Pier data are located within Zone 1 but plotted separately. 2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis. Outlier (IH5-FFF-7WC) removed due to low lipid. Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_byArea.pro Mon May 19 16:52:37 2014

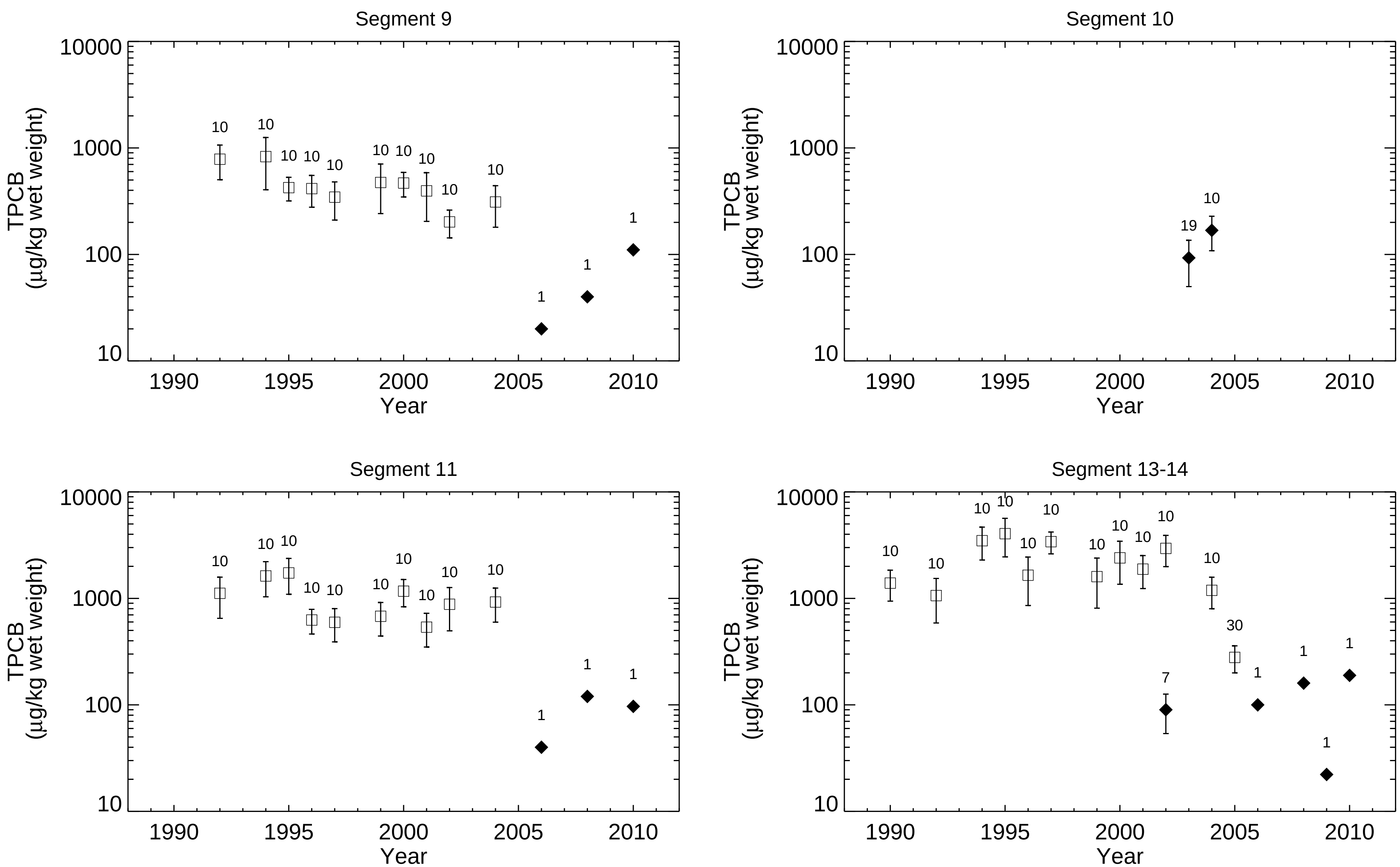

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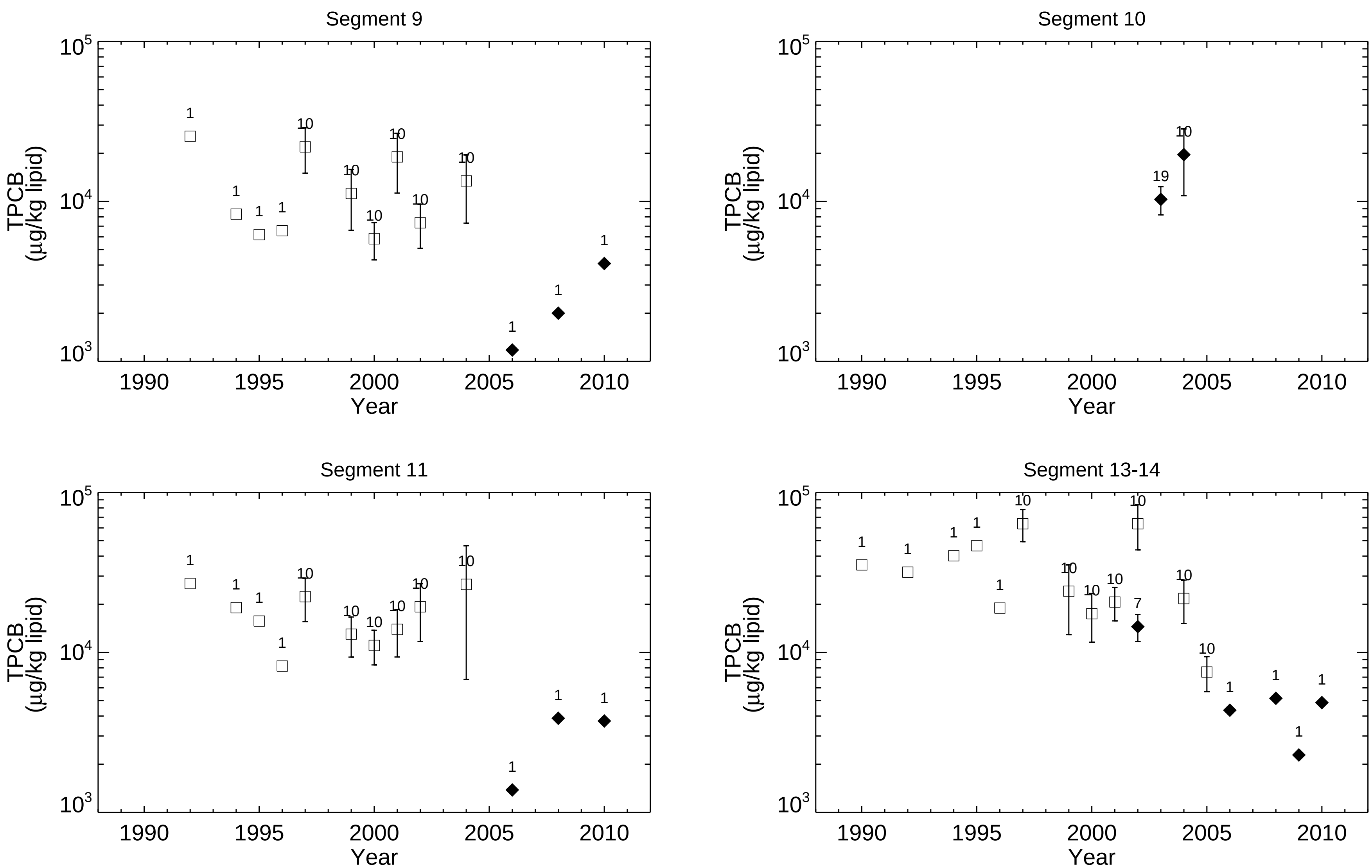
Figure 5-12a

Wet-Weight TPCB Concentrations in White Croaker from Palos Verdes Shelf

Points are means +/- two standard errors. Data counts are posted above symbols. Data shown include fillet without skin only.
Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects.
Congener data are shown when paired Aroclor and Congener data exist.
Database: AllFishData_Compile_130731.xlsx.



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◆ Congener
□ Aroclor

Figure 5-12b

Lipid-Normalized TPCB Concentrations in White Croaker from Palos Verdes Shelf

Points are means +/- two standard errors. Data counts are posted above symbols. Data shown include fillet without skin only.
Totals are calculated as sum of detected components, or half of highest detection limit if all components are non-detects.
Congener data are shown when paired Aroclor and Congener data exist.
Unique identifiers not available for pre-1996 LACSD data; data points represent annual average concentrations for these samples.
Database: AllFishData_Compile_130731.xlsx.

zw - \\nereus\d_drive\Projects\PoLAPoLB_TMDL_2012\2012-2015_TMDL_Contract_(120343-01)\Data_Analysis_Report\Natural_Recovery\naturalRecovery_fish_temporal_PVshelf.pro Mon May 19 16:41:36 2014

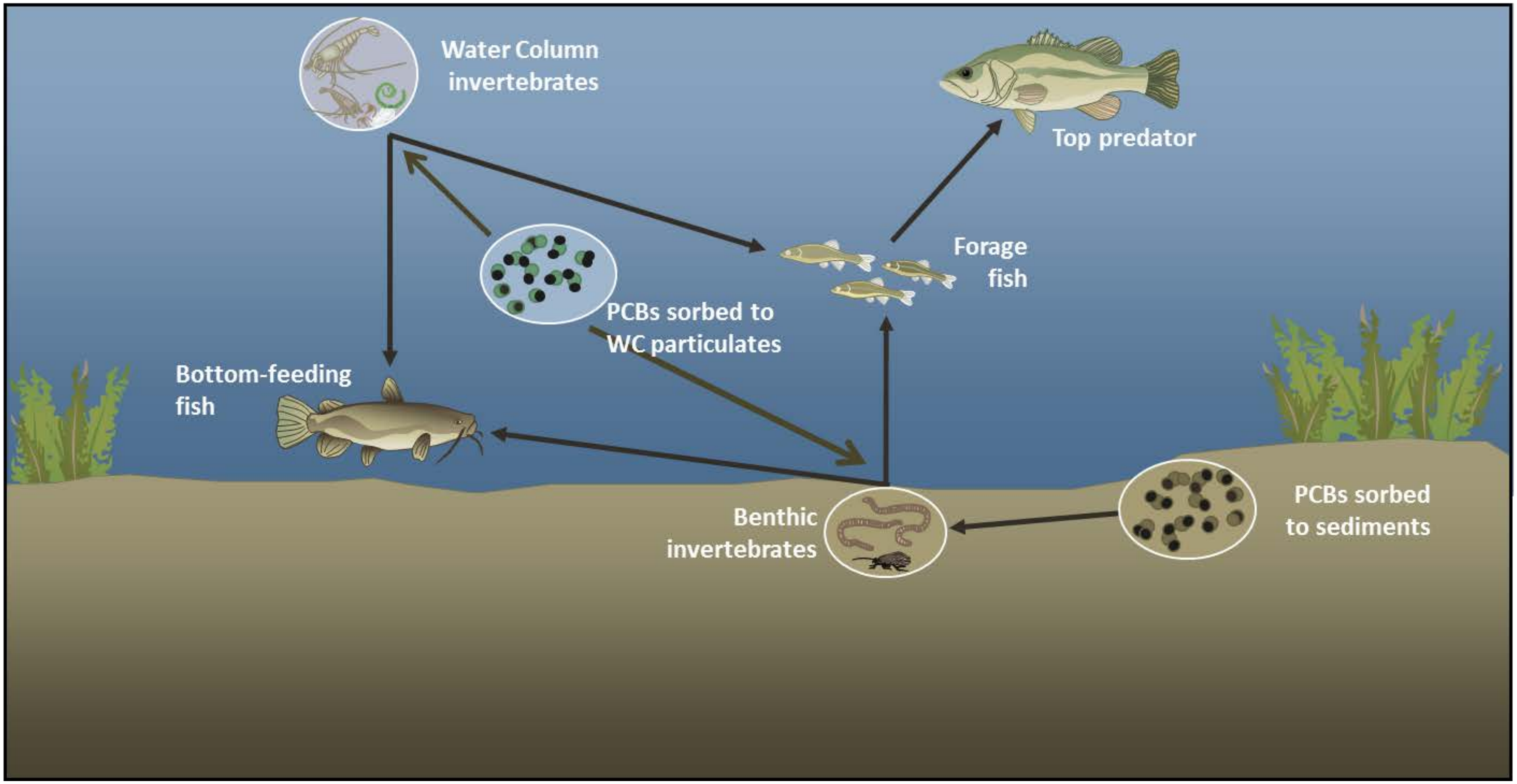

Figure 6-1
PCB Accumulation in the Food Web
Greater Los Angeles and Long Beach Harbor Waters

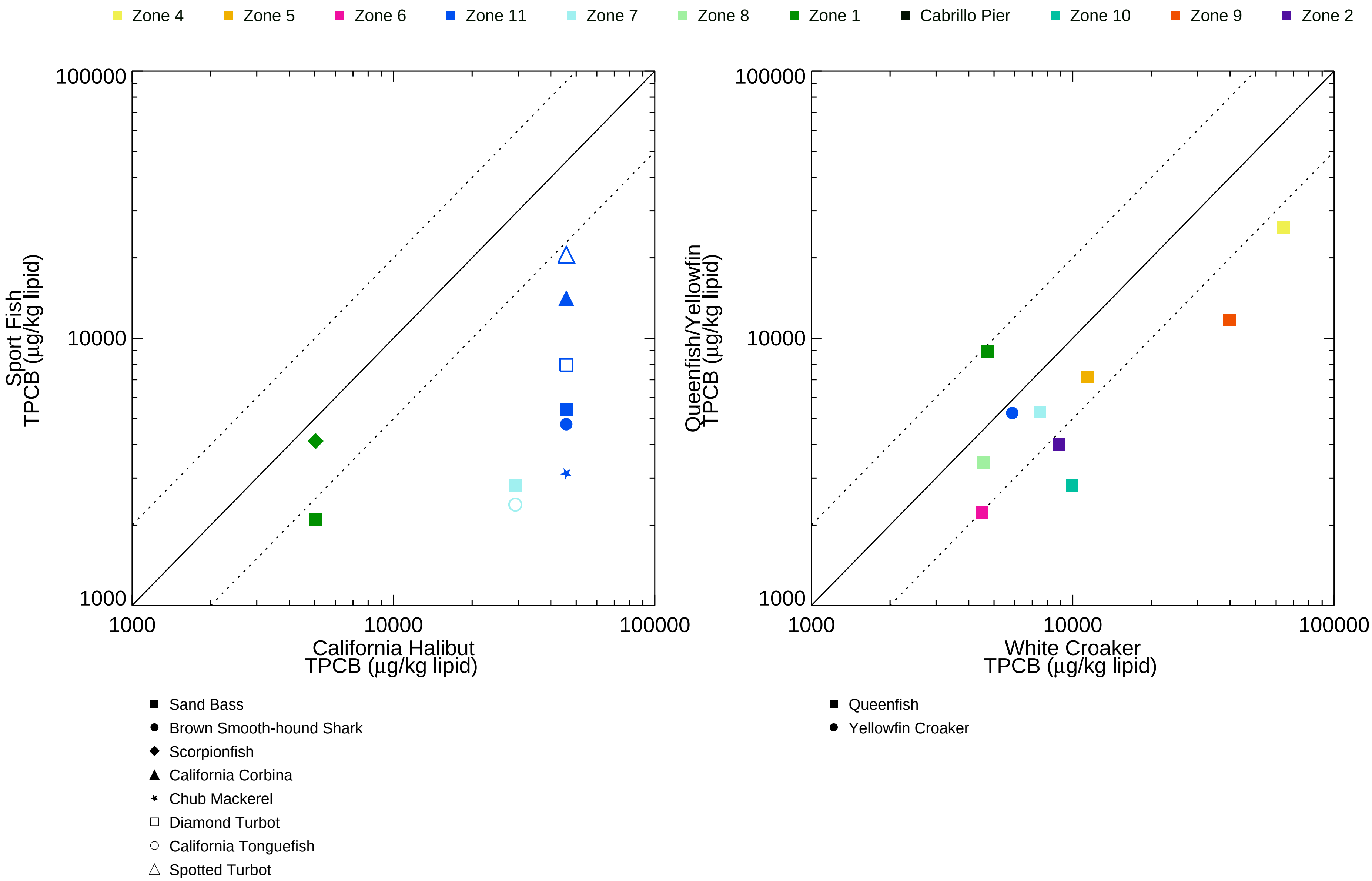

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Figure 6-2a

Lipid-Normalized TPCB Concentrations in Fish Species

ANCHOR QEA

Zones delineated based on fish movement. Data between years 1990 and 2012 included. Fish types include fillet, fillet with skin, fillet without skin, skin on scales off whole without head tail and guts, and whole fish. Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. 2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis. Congener data are used when both Aroclor and Congener data exist for the same sample. Data averaged by fish zone. Outlier removed with sample ID "IH5-FFF-7WC" due to low lipid content. Solid line is 1:1 line; dotted lines are 1:2 and 2:1 lines. Database: AllFishData_Compile_130731.xlsx.

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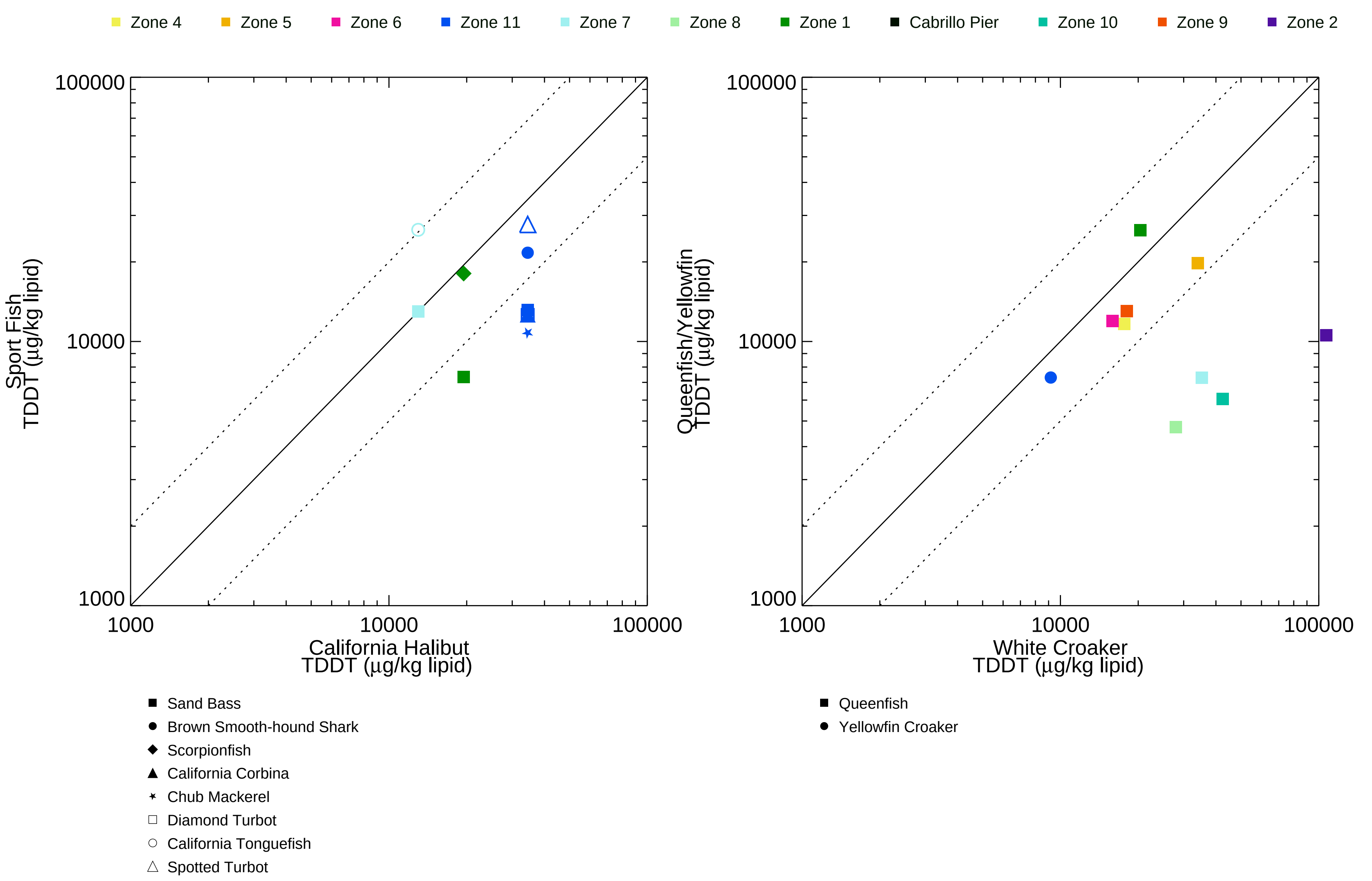

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Figure 6-2b

Lipid-Normalized TDDT Concentrations in Fish Species

ANCHOR QEA

Zones delineated based on fish movement. Data between years 1990 and 2012 included. Fish types include fillet, fillet with skin, fillet without skin, skin on scales off whole without head tail and guts, and whole fish. Totals are calculated as sum of detected components or half of highest detection limit if all components are non-detects. 2002 LA TIWRP non-detected Aroclor PCBs are removed from analysis. Congener data are used when both Aroclor and Congener data exist for the same sample. Data averaged by fish zone. Outlier removed with sample ID "IH5-FFF-7WC" due to low lipid content. Solid line is 1:1 line; dotted lines are 1:2 and 2:1 lines. Database: AllFishData_Compile_130731.xlsx.

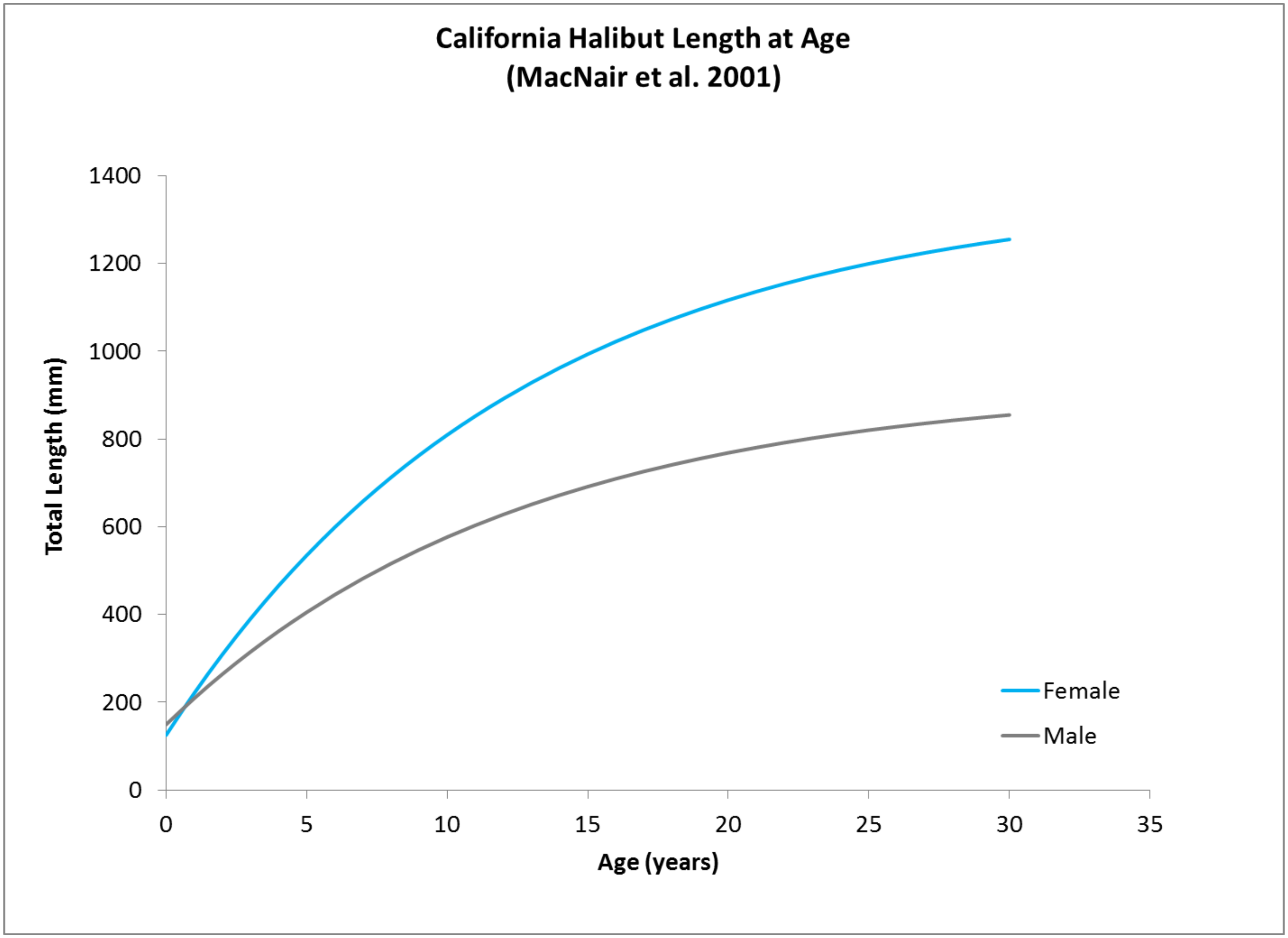
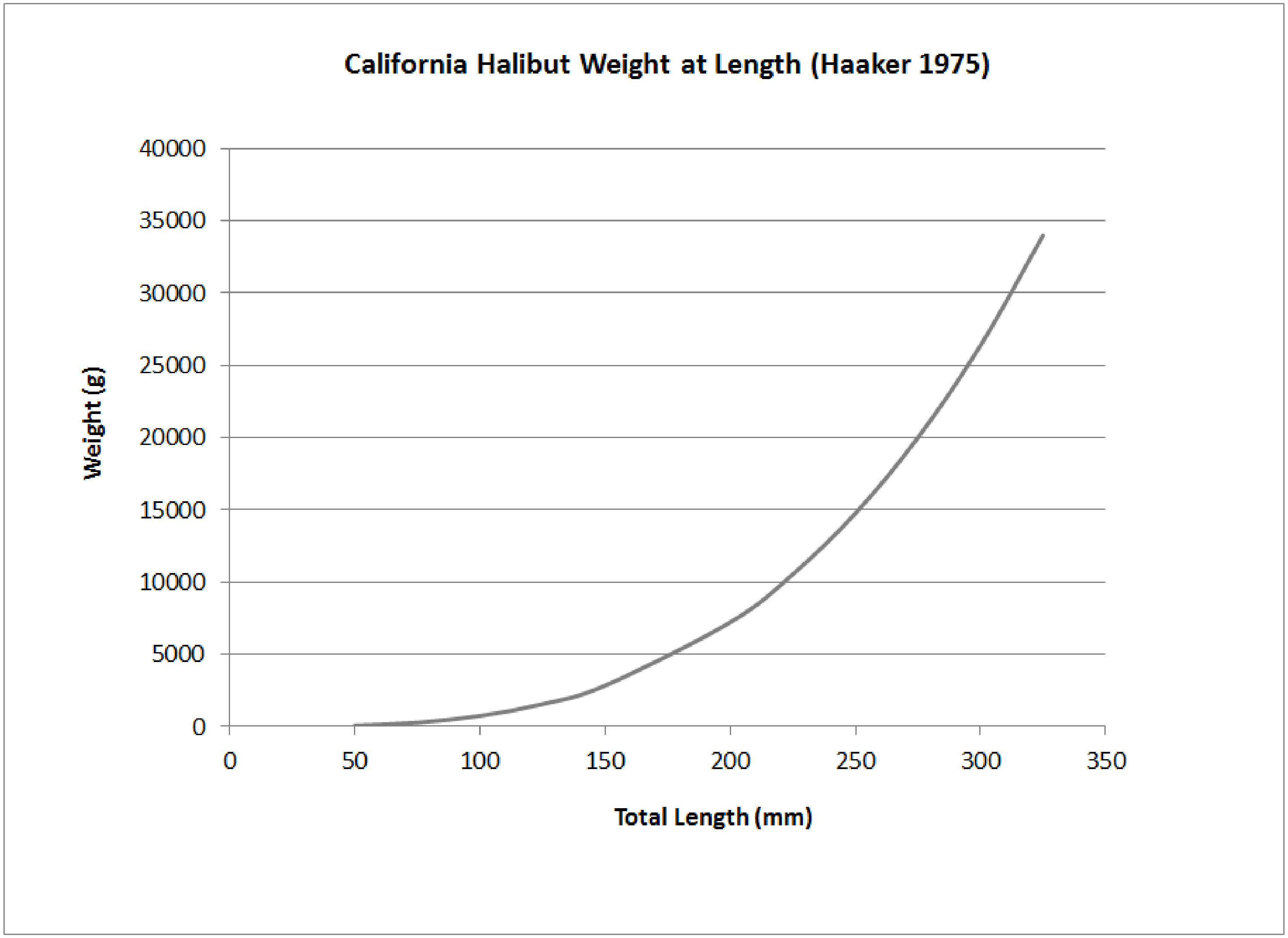


Figure 6-3a
California Halibut Length at Age
Greater Los Angeles and Long Beach Harbor Waters



ANCHOR QEA

Figure 6-3b
California Halibut Weight at Length
Greater Los Angeles and Long Beach Harbor Waters

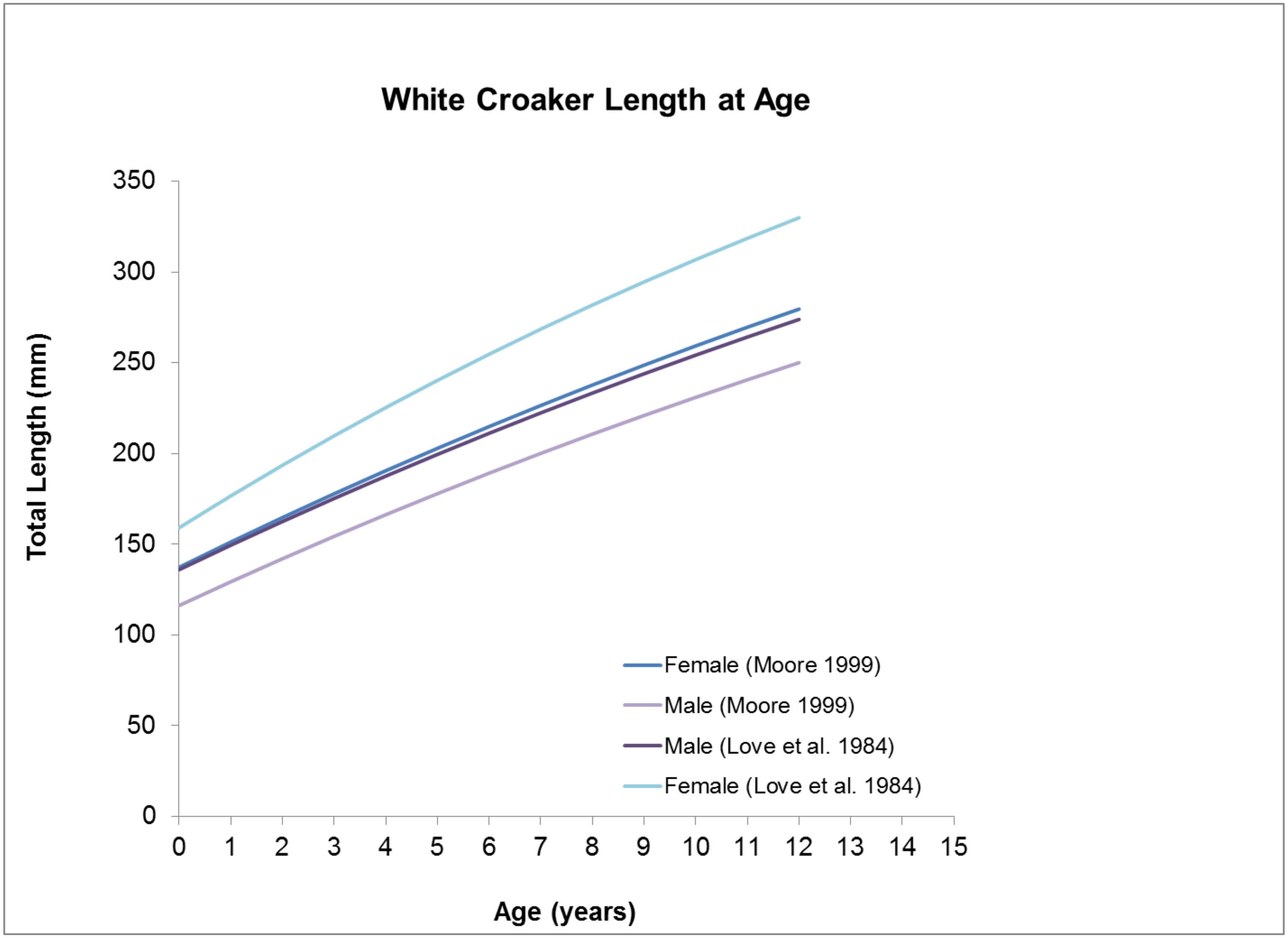


Figure 6-4a
White Croaker Length at Age
Greater Los Angeles and Long Beach Harbor Waters

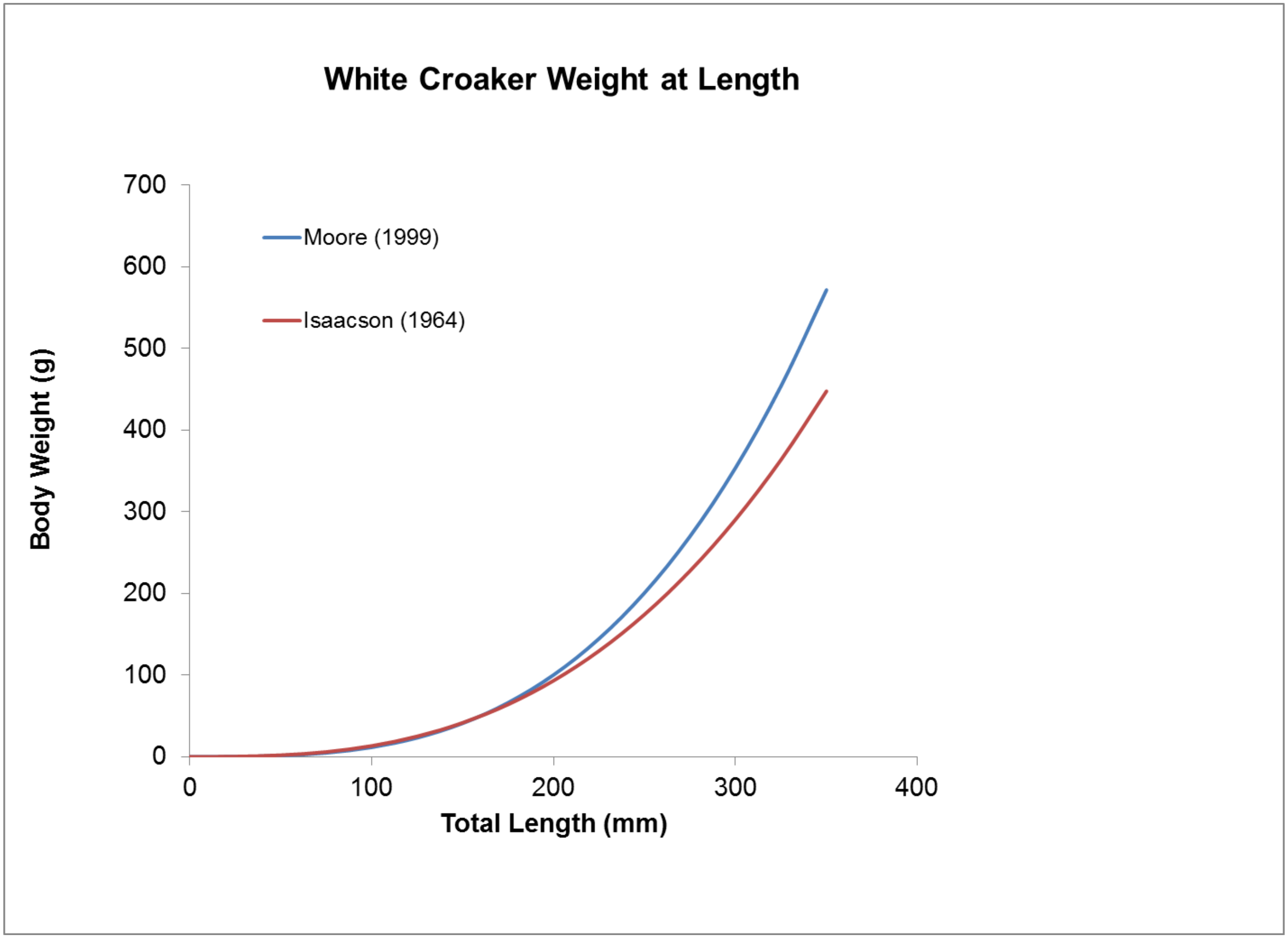


Figure 6-4b
White Croaker Weight at Length
Greater Los Angeles and Long Beach Harbor Waters

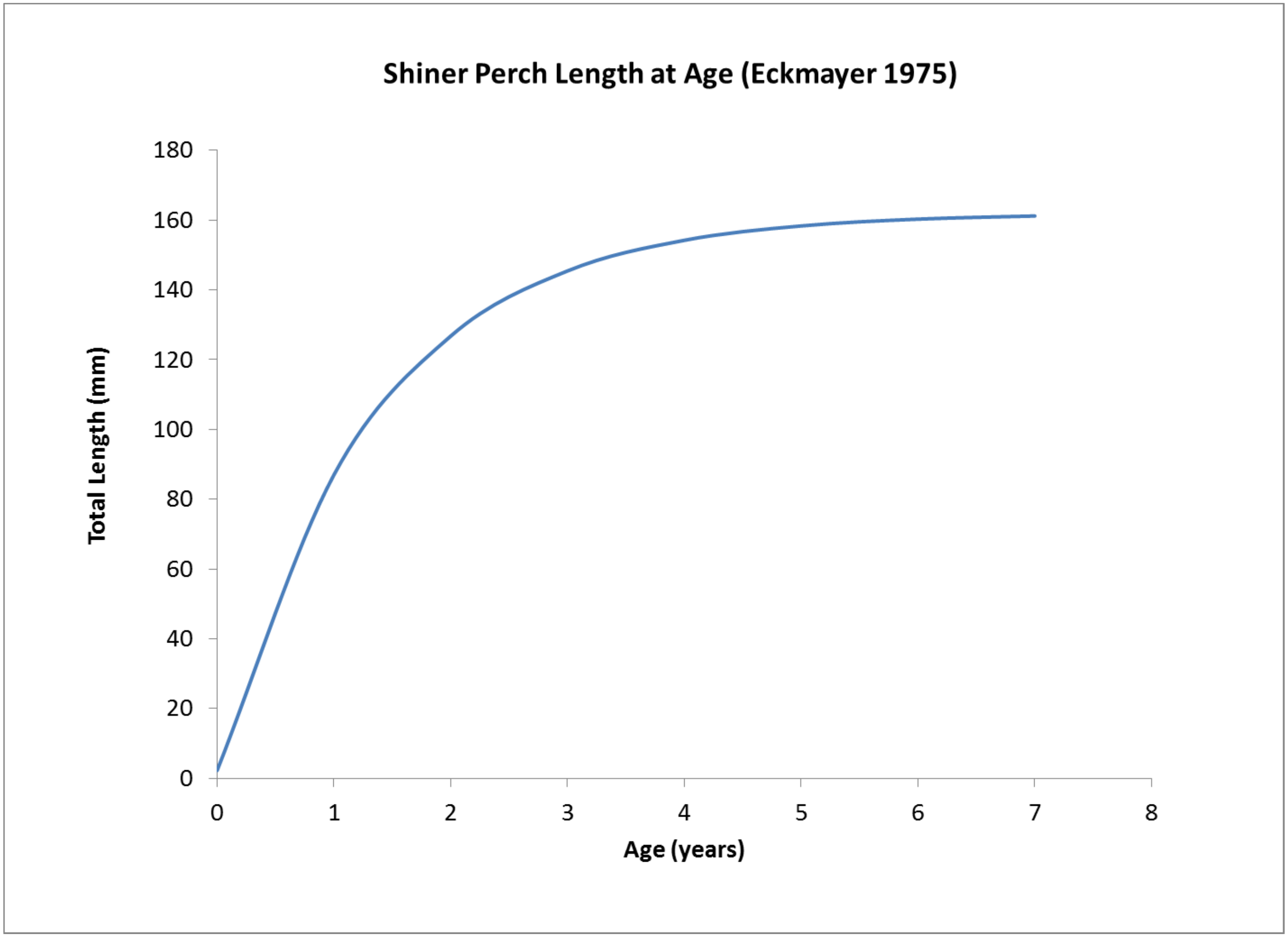
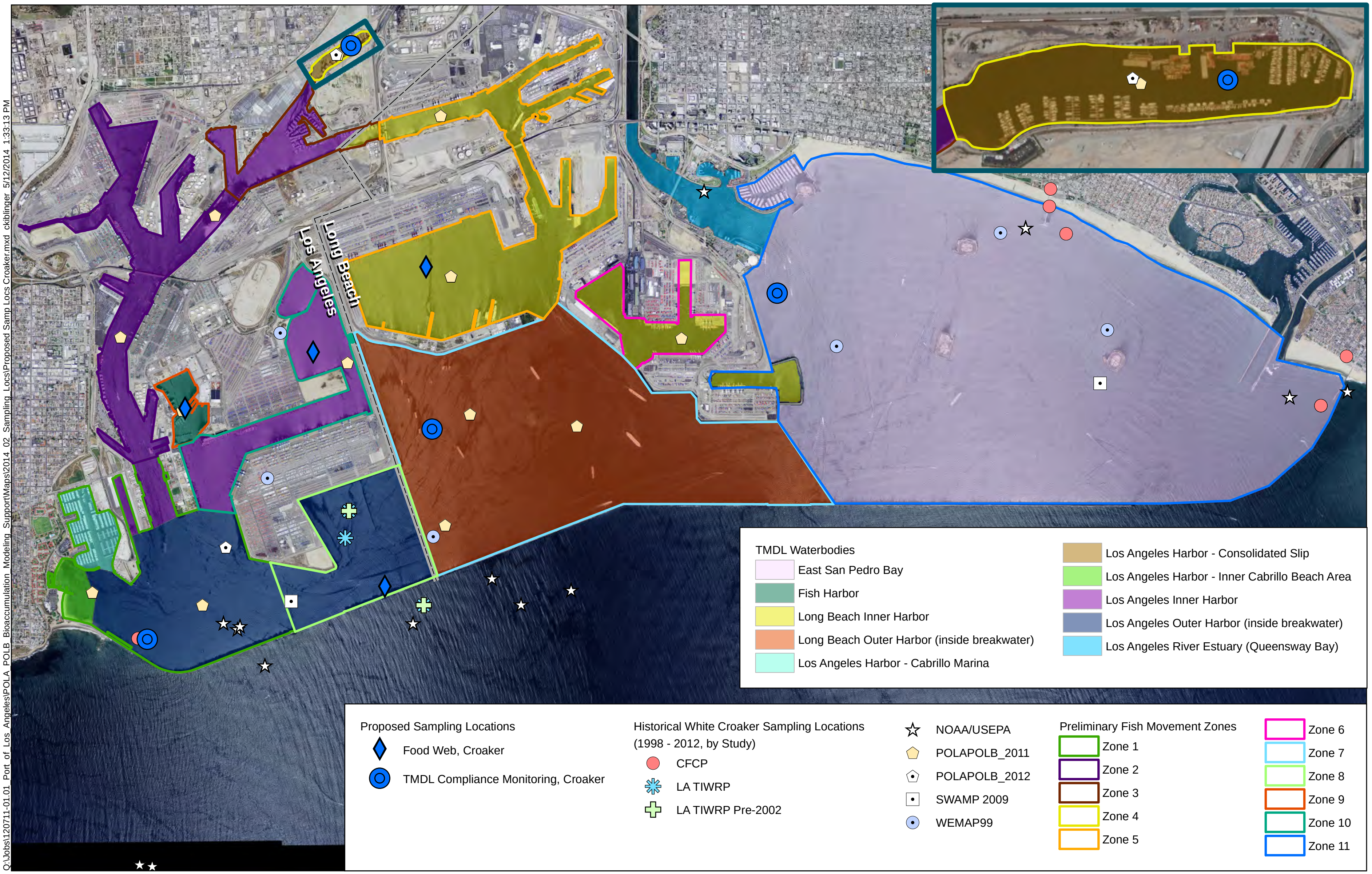


Figure 6-5a
Shiner Surfperch Length at Age
Greater Los Angeles and Long Beach Harbor Waters

Figure 6-5b
Shiner Surfperch Weight at Length
Greater Los Angeles and Long Beach Harbor Waters



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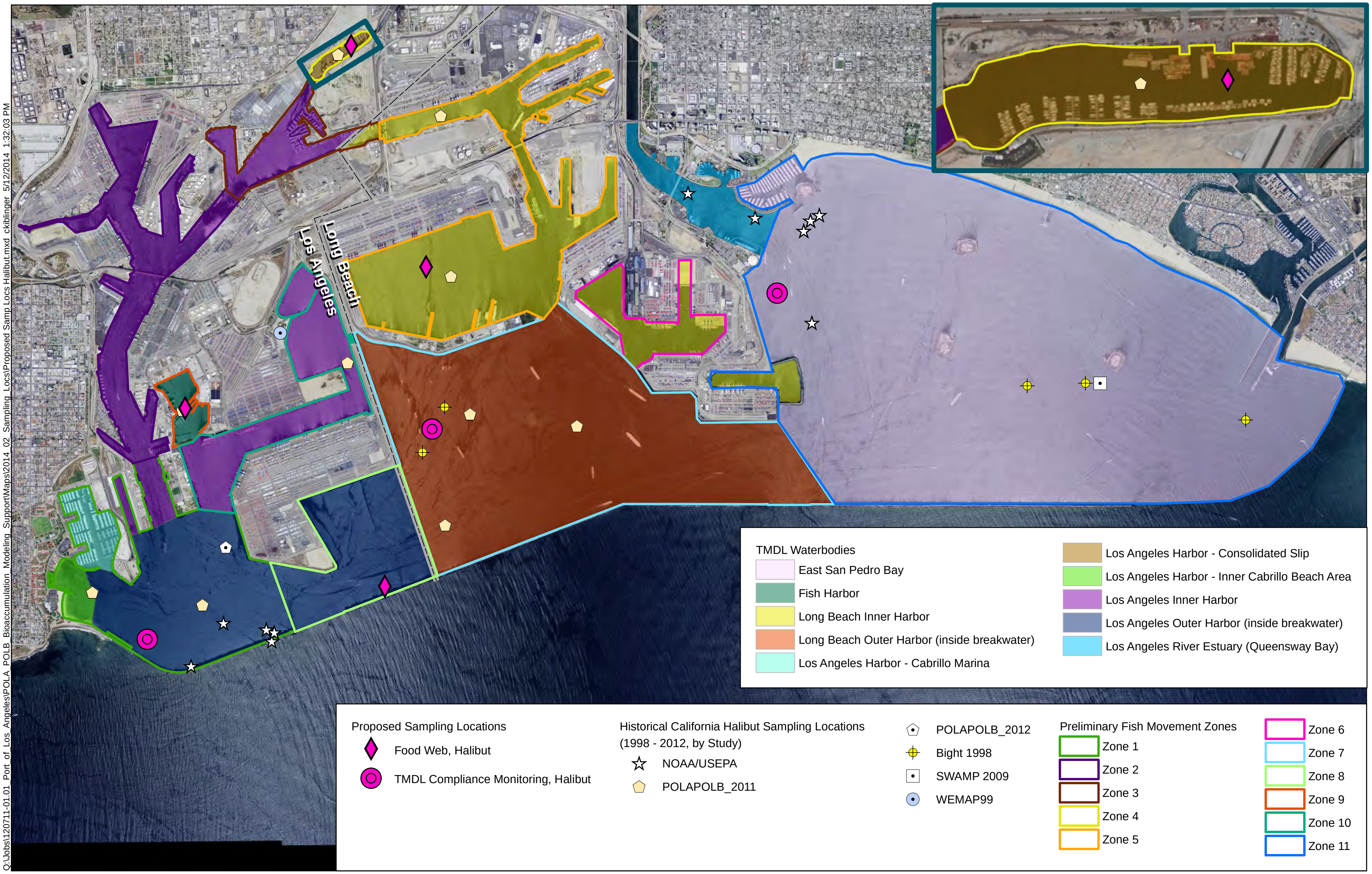
ANCHOR QEA

Miles
0 0.5 1

Figure 7-1
Proposed White Croaker Sampling Locations, Food Web Sampling Program
Greater Los Angeles and Long Beach Harbor Waters



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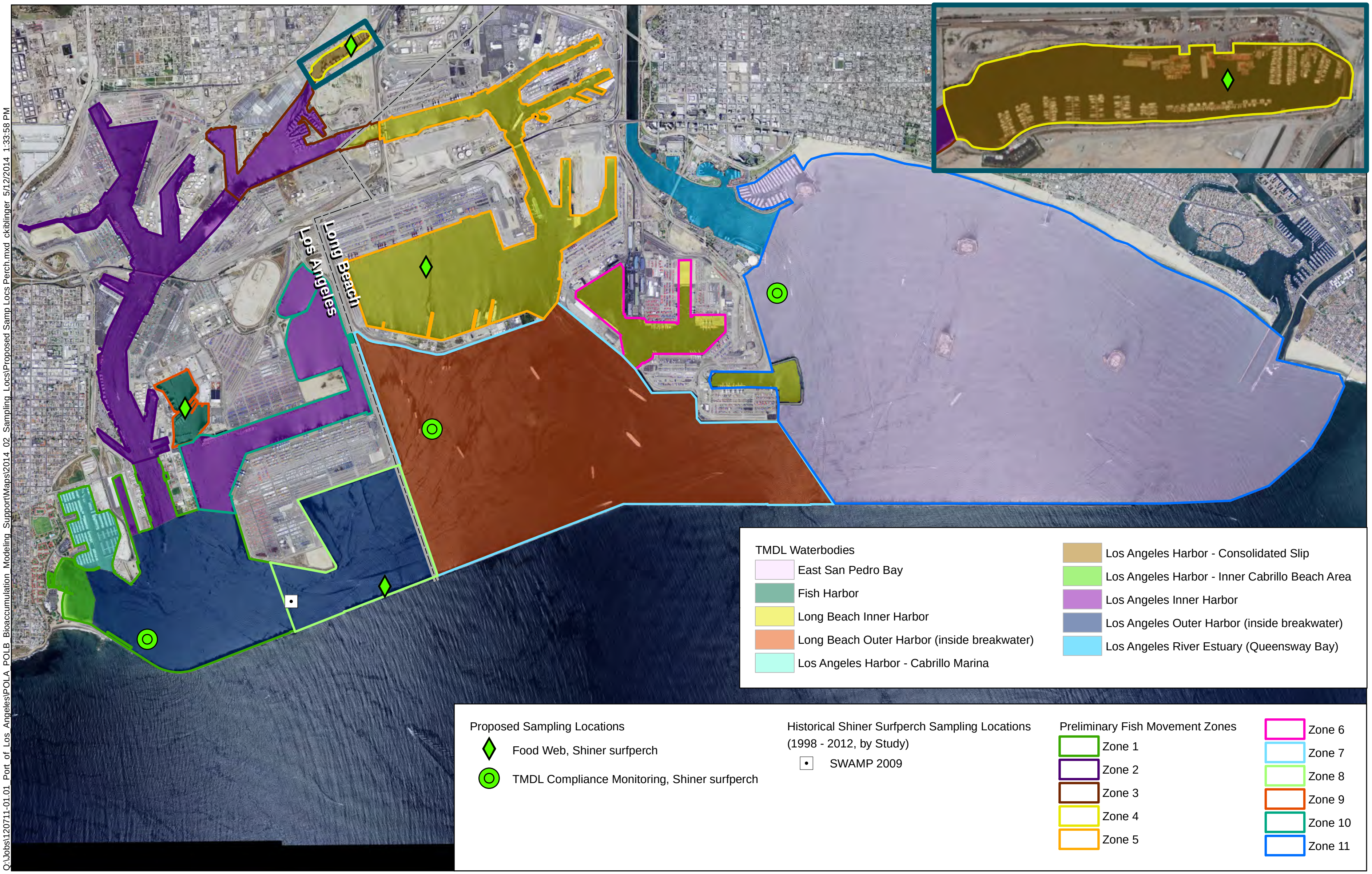
ANCHOR QEA

Miles
0 0.5 1

Figure 7-2
Proposed California Halibut Sampling Locations, Food Web Sampling Program
Greater Los Angeles and Long Beach Harbor Waters



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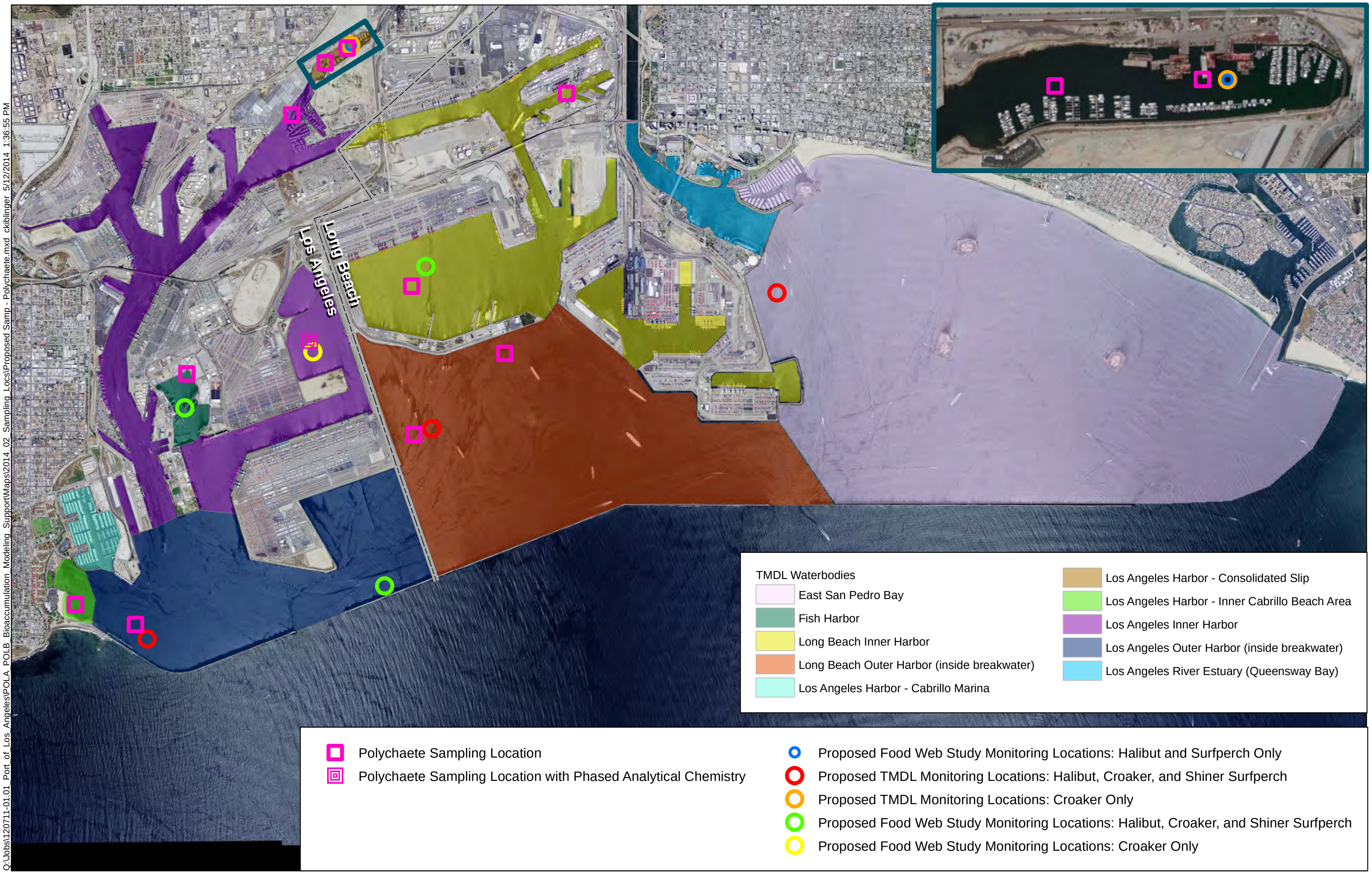
ANCHOR QEA

Miles
0 0.5 1

Figure 7-3
Proposed Shiner Surfperch Sampling Locations, Food Web Sampling Program
Greater Los Angeles and Long Beach Harbor Waters



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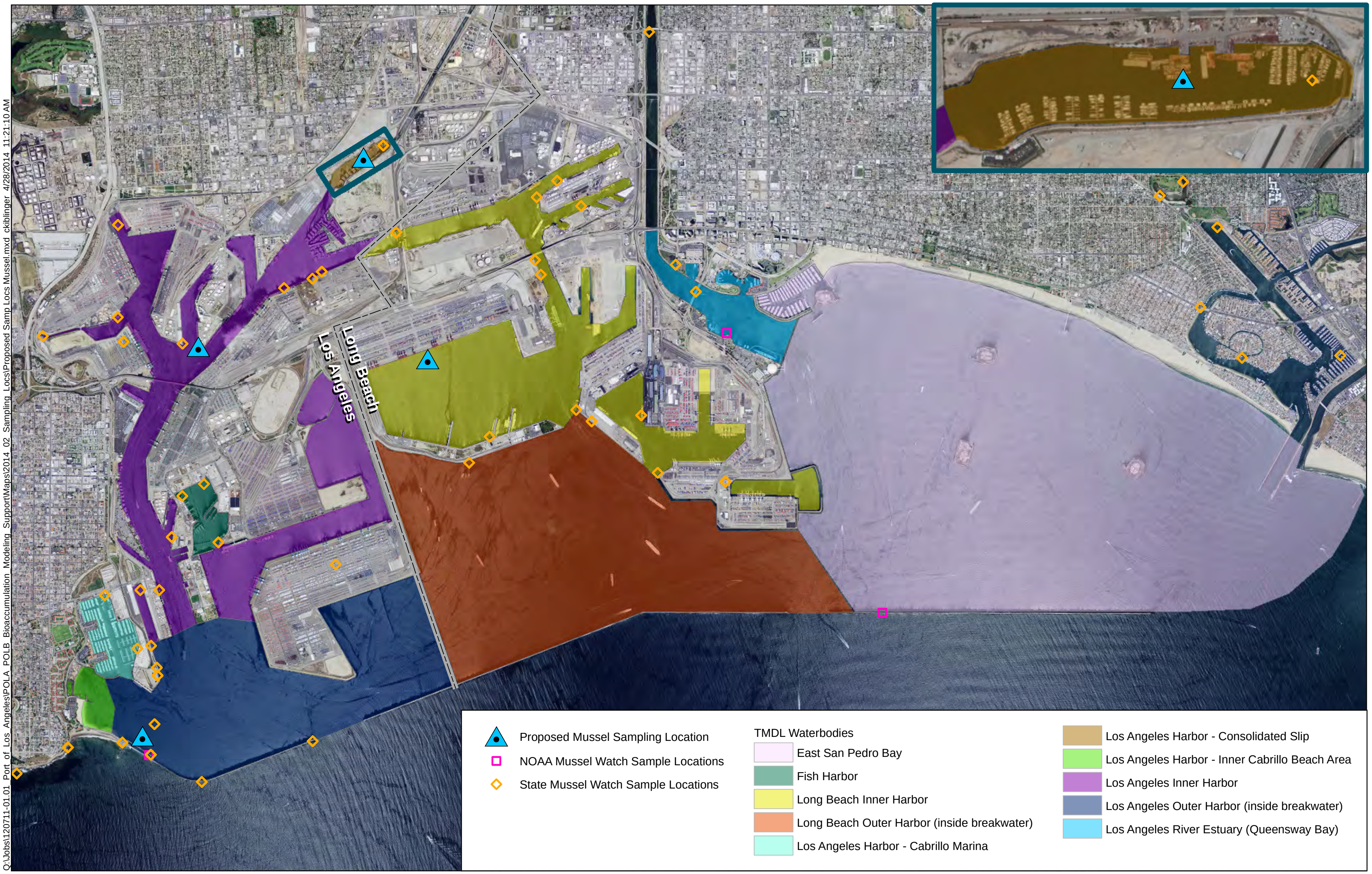
ANCHOR QEA

Miles
0 0.5 1

Figure 7-4
Proposed Polychaete Worm Sampling Locations, Food Web Sampling Program
Greater Los Angeles and Long Beach Harbor Waters



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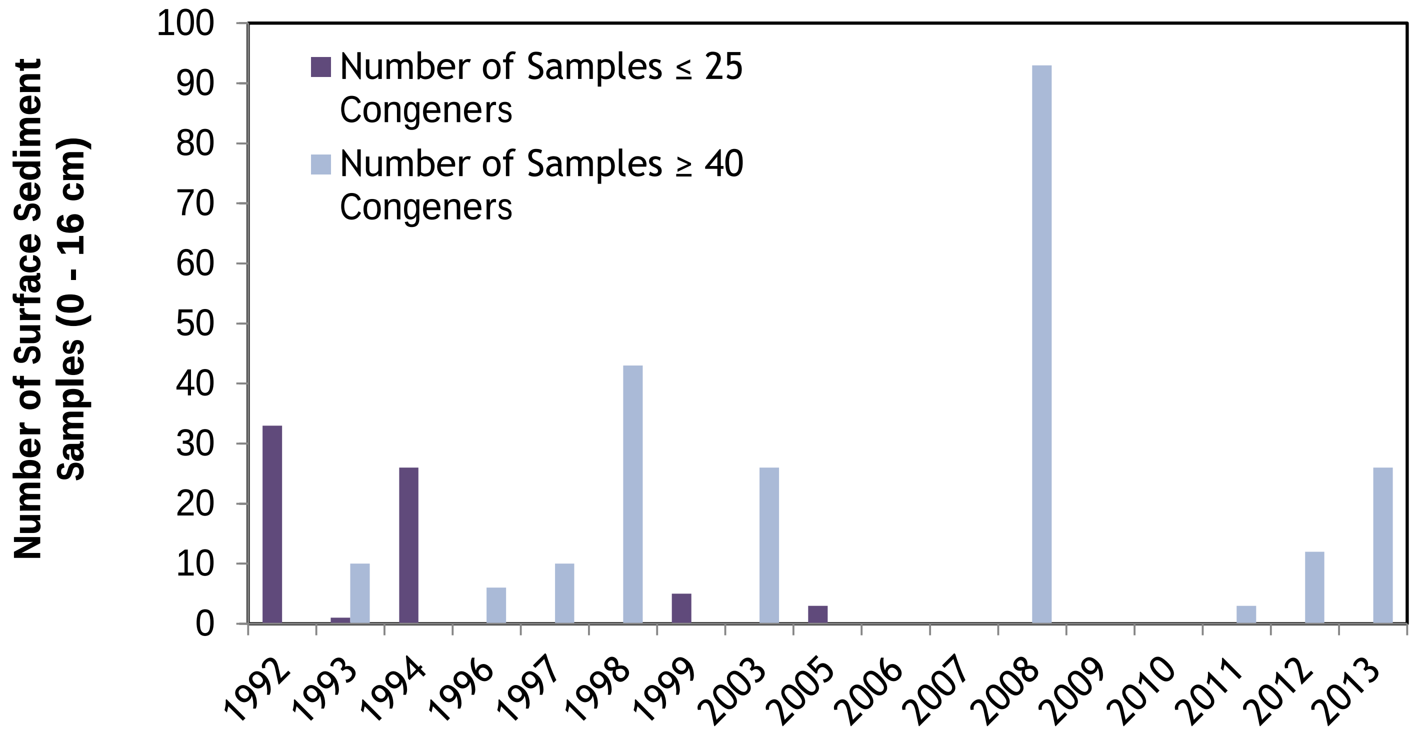
Miles
0 0.5 1

Figure 7-5
Proposed Mussel Sampling Locations, Food Web Sampling Program
Greater Los Angeles and Long Beach Harbor Waters



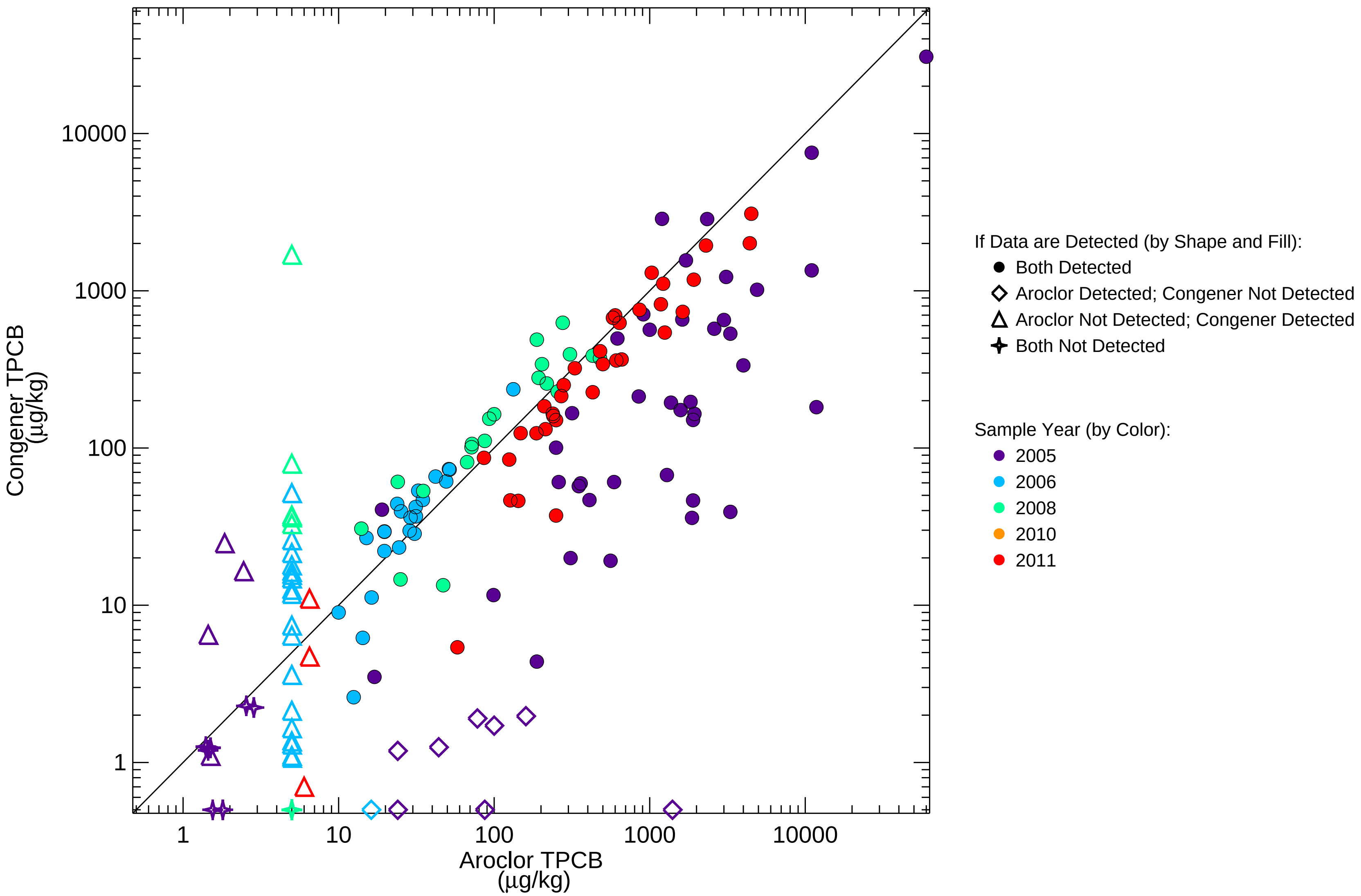
Notes:

Data are from LA/LB Harbor and Eastern San Pedro Bay.

Bight 2013 data counted for samples with provided coordinates. Not all laboratory results available yet.

ANCHOR QEA

Figure 7-6
Counts of Surface Sediment Congener TPCB Data per Year
Greater Los Angeles and Long Beach Harbor Waters



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ANCHOR QEA

Figure 7−7

Comparison Between Congener and Aroclor PCBs in Sediment

Only samples from 1998 to 2012 (at all depths) are shown
Totals were calculated as the sum of detected components, or if all components were non−detects, half of the highest method detection limit was used as the total and shown as open symbols. Data from LA/LB Harbor and Dominguez Channel.
Database: Sed_DB_comb_ND_half_MDL__totals_20140229.bin

BG − \\socal2\Disneyland\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_crossplot_TPCBC_vs_TPCBA.pro Mon May 19 12:25:05 2014

Proposed Sediment Sampling Locations
- Sediment Only
- Sediment and Polychaete

Historical TPCB Sampling Locations (Sample Year)
- 2003
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013

TMDL Waterbodies
- East San Pedro Bay
- Fish Harbor
- Long Beach Inner Harbor
- Long Beach Outer Harbor (inside breakwater)
- Los Angeles Harbor - Cabrillo Marina
- Los Angeles Harbor - Consolidated Slip
- Los Angeles Harbor - Inner Cabrillo Beach Area
- Los Angeles Inner Harbor
- Los Angeles Outer Harbor (inside breakwater)
- Los Angeles River Estuary (Queensway Bay)

Miles
0 1 2

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ANCHOR QEA

Figure 7-8
Proposed Sediment Sampling Locations Overview
Greater Los Angeles and Long Beach Harbor Waters

APPENDIX A
NOAA CHARTS OF SAN PEDRO BAY

UNITED STATES - WEST COAST
CALIFORNIA
LOS ANGELES AND LONG BEACH HARBORS
Scale 1/12000
SOUNDINGS IN FEET
AT MEAN LOWER LOW WATER
N.A. 1927
CAUTION
Improved Channels
The side limits of the improvement are shown by broken lines. The legend gives the controlling depth through the channel ascertained on the date stated. Because of possible shoaling, particularly at the edges, it must not be inferred that the depth stated existed throughout the entire width of the improvement on the date of the examination unless so stated, or that it has not since decreased in places across the entire width.
CAUTION
Temporary changes affecting
Lights, Buoys and Day Beacons
Aids which have been destroyed or removed, but which will be reestablished and are temporarily replaced by aids of different characteristics, are indicated in red by the following abbreviations.
D Destroyed, to be reestablished.
T R B Temporarily replaced by a red buoy.
T B B Temporarily replaced by a black buoy.
T F B Temporarily replaced by a fixed white light buoy.
T F R B Temporarily replaced by a fixed red light buoy.
T FL B Temporarily replaced by a flashing white light buoy.
T FL R B Temporarily replaced by a flashing red light buoy.
AUTHORITIES
Surveys to 1934
Surveys by U. S. Engineers to 1934
Surveys by local authorities to 1934
HEIGHTS in feet above high water
WILMINGTON
LONG BEACH
SAN PEDRO
TERMINAL ISLAND
SMITH ISLAND
MORMON I.
EAST SAN PEDRO
SAN PEDRO BAY
OUTER HARBOR
Cerritos Channel
Diversion Channel
TURNING BASIN
FISH HARBOR
LOS ANGELES HARBOR AIRPORT
SEASIDE PARK
West Basin
East Basin
WATCHORN BASIN
Berth Numbers
The numbers on land along the waterfront are the berth numbers.
TIDES
	Long Beach Inner Harbor	Los Angeles Outer Harbor	Los Angeles Harbor Mormon Id.
High water interval	9h 26m	9h 22m	9h 30m
Higher high water height	5.6 ft.	5.4 ft.	5.4 ft.
Lowest tide	−2.5 ft.	−2.5 ft.	−2.5 ft.
ABBREVIATIONS
Lights: F. fixed, FL. flashing, Occ. occulting, W. white, R. red, G. green, Alt. alternating, Gp. group, Sec. sector, m. miles, min. minutes, sec. seconds, ev. every, vis. visible
Color white unless otherwise indicated. AERO. aeronautical light
Buoys: C. can, N. nun, S. spar, W. white.
Day beacons: ▲ black, ▲ red, △ white unless otherwise indicated
R.Bn. radiobeacon
N.R.C. Naval radio direction finder station
M. mud, S. sand, Sh. shells, hrd. hard, sft. soft, rky. rocky, stk. sticky, bk. black, yl. yellow, gy. gray, gn. green, br. brown,
P.D. position doubtful. E.D. existence doubtful.
RADIOBEACON SIGNALS
For schedule of operations see Light List and for changes see Notice to Mariners.
Stations Signals
Los Angeles Harbor Lighthouse ..... Gp 1 dot and 2 dashes for 5 min.

No. 5147 PRICE 75 CENTS

Published at Washington, D. C., Oct. 1943
BY THE U. S. COAST AND GEODETIC SURVEY

NATIONAL ARCHIVES OF THE UNITED STATES

LIGHTS, BEACONS, BUOYS, AND DANGERS CORRECTED FOR INFORMATION RECEIVED TO DATE OF ISSUE

(Los Angeles and Long Beach Harbors) U.S.C.&G.S. 51
PRICE 75 CENTS

No. 5147

Published at Washington, D.C., Oct. 1943 (6th Edition)


1st Ed., Oct. 1934
Nautical Chart Catalog No. 2, Panel R
UNITED STATES - WEST COAST
CALIFORNIA
LOS ANGELES AND LONG BEACH HARBORS
Mercator Projection
Scale 1:12,000 at Lat. 33°44′
SOUNDINGS IN FEET
AT MEAN LOWER LOW WATER
NATIONAL OCEAN SURVEY
NOTE A
Navigation regulations are published in Chapter 2, U.S. Coast Pilot 7, or weekly Notice to Mariners which include new or revised regulations. Information concerning the regulations may be obtained at the Office of the District Engineer, Corps of Engineers in Los Angeles, Calif.
Anchorage regulations may be obtained at the Office of the Commander, 11th Coast Guard District in Long Beach, Calif.
Refer to section numbers shown with area designation.
NOTE B
The Restricted Harbor Entrance Area regulations are contained in City of Long Beach Tariff No. 3 (August 1, 1965). Consult Board of Harbor Commissioners Port of Long Beach.
NOTE C
CAUTION
Vessels are cautioned to keep clear of the 500-foot wide Los Angeles Main Channel during the passage of deep-laden tankships to and from Berths 45-47, and large bulk ore carriers from Berths 48-50. These vessels, because of their deep draft, must remain in the channel. Vessels not carrying a Los Angeles pilot may obtain information on the movement of such vessels by contacting the Los Angeles Pilot Station on VHF Channel 14 (156.7 MHz), call letters KMB-466; on VHF Channel 16 (156.8 MHz); or by telephone 832-7241 or 7513 and 775-3231.
CAUTION
Submerged Pipelines
Uncharted submerged pipelines may exist in the vicinity of oil well structures, and between such structures and the shoreline. Mariners should use caution when anchoring.
WARNING
The prudent mariner will not rely solely on any single aid to navigation, particularly on floating aids. See U.S. Coast Guard Light List and U.S. Coast Pilot for details.
NEW CHART NUMBERING SYSTEM
The National Ocean Survey, in cooperation with the Defense Mapping Agency Hydrographic Center, is in the process of adopting a new national chart numbering system. See Notice to Mariners No. 19, May 11, 1974, or Nautical Chart Catalog for cross references of old and new chart numbers.
AIDS TO NAVIGATION
Consult U.S. Coast Guard Light List for supplemental information concerning aids to navigation.
NOTE D
Traffic lanes and Pilot Areas established at approaches to Los Angeles and Long Beach Harbors are shown on Charts 18746, 18740, and 18720.
The normal Pilot Cruising Areas are outlined by trapezoidal purple bands. Mariners are advised to exercise extreme care in navigating within these areas.
NOTE E
A precautionary area has been established in the Los Angeles-Long Beach area. Large vessels are maneuvering to embark or disembark pilots, and to enter or depart the traffic separation system. It is recommended vessels proceed with extreme caution in this area.
OVHD. POWER CABLES
AUTH. CL. 155 FT. JAN. 1957
Nautical Mile
Yards
LOGARITHMIC SPEED SCALE
To find SPEED, place one point of dividers on nautical miles run and the other on minutes run. Without changing divider spread, place right point on 60 and left point will then indicate speed in knots. Example: with 4.0 miles run in 15 minutes, the speed is 16.0 knots.
HEIGHTS
Heights in feet above Mean High Water.
AUTHORITIES
Hydrography and topography by the National Ocean Survey (formerly the Coast and Geodetic Survey) with additional data from the Corps of Engineers, Department of the Navy, City of Los Angeles and U.S. Coast Guard.
STORM WARNINGS
The National Weather Service displays storm warnings at the following approximate locations:
Pilot Station, Long Beach (33°44.8′-118°12.9′)
Fish Harbor, Terminal Island (33°43.9′-118°15.8′)
Wilmington (33°45.9′-118°15.0′)
San Pedro (33°43.2′-118°16.2′)
NOTE E
Seaplanes operate in this area on regular scheduled runs.
NEON SIGN "76"
CAUTION
Improved channels shown by broken lines are subject to shoaling, particularly at the edges.
CAUTION
Temporary changes or defects in aids to navigation are not indicated on this chart.
RACING BUOYS
Racing buoys within the limits of this chart are not shown hereon. Information may be obtained from the U.S. Coast Guard District Offices as racing and other privately maintained buoys are not all listed in the Coast Guard Light List.
SUPPLEMENTAL INFORMATION
Consult U.S. Coast Pilot 7 for important supplemental information.
ANCHORAGE AREAS
110.1, 110.100, and 110.214 (see note A)
Limits and designations of anchorage areas are shown in purple.
A C D GENERAL
A2 YACHTS AND SMALL CRAFT
B QUARANTINE
E NAVAL
F G H NON-ANCHORAGE
STACK
WILMINGTON
LOS ANGELES
LONG BEACH
TERMINAL ISLAND
SAN PEDRO
SAN PEDRO BAY
INNER HARBOR
MIDDLE HARBOR
WEST BASIN
EAST BASIN
TURNING BASIN
FISH HARBOR
SOUTHEAST BASIN
LONG BEACH OUTER HARBOR
OUTER HARBOR
MAIN CHANNEL
LONG BEACH CHANNEL
MIDDLE BREAKWATER
SAN PEDRO BREAKWATER
LONG BEACH BREAKWATER
Flood Control Channel
PRECAUTIONARY AREA (see note E)
LOS ANGELES PILOT AREA
LONG BEACH PILOT AREA
PROHIBITED DUMPING GROUND
Island Grissom
Island White
Island Freeman
Amusement Park
Municipal Auditorium
CITY HALL
FEDERAL BLDG
Dominguez Channel
(CONTINUED ON CHART 18746)