San Diego Coastkeeper and Environmental Health Coalition
Reply Technical Comments, Rebuttal Legal Argument, and Rebuttal Evidence on the Tentative Cleanup and Abatement Order No. R9-2011-001 and Draft Technical Report for the San Diego Bay Shipyard Sediment Site

Designated Parties San Diego Coastkeeper and Environmental Health Coalition respectfully submit the following reply technical comments, rebuttal legal argument and rebuttal evidence related to the Tentative Cleanup and Abatement Order No. R9-2011-001 (the "Order") and Draft Technical Report ("DTR"). These comments hereby adopt and incorporate by reference the declaration prepared by Donald MacDonald dated June 23, 2011, attached hereto as Exhibit A. Additional evidence is also attached as exhibits to these comments and legal argument

I. The DTR Sufficiently Addressed Bioavailability of Pollutants at the Shipyard Sediment Site.

A. The DTR's approach to assessing aquatic life impairment is sufficient, despite to BAE's complaints to the contrary.

The DTR's approach to assessing aquatic-life impairment at the Site is sufficient. *See* Expert Report of Donald MacDonald, prepared March 11, 2011, §C.3.2 at 15 ("Evaluating risks to human health and aquatic-dependent wildlife using SWACs of contaminants in sediment is a scientifically valid approach that has been used in other sediment remediation projects."). The DTR's approach is similar to and in line with the approach used for the State of California's Sediment Quality Objectives (SQO's). *See* Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1. Sediment Quality, State Water Resources Control Board, 2009. In fact, as part of the DTR, twenty seven of the Triad stations were re-analyzed using the sediment quality objective framework and little difference in outcomes was found. *See* DTR Volume 2, Table 32-17 and App. 32. This demonstrates that while the DTR may have relied on a modified Weight-of-Evidence approach, its outcomes are in line with state approved guidance.

Some Designated Parties criticize the DTR for not relying on the bioavailability of chemicals at the site to assess aquatic life impairment. Bioavailability is often assessed via modeling of the ratio of the acid-volatile sulfide content of sediment versus the simultaneously extracted metal concentration (AVS-SEM). While the Exponent Report does contain AVS-SEM data, other external experts in sediment chemistry and assessment have determined that this data is "largely unusable." *See* Letter from Russell Fairey to San Diego Regional Water Quality Control Board dated June 17, 2002 SAR 065523. While bioavailability is one of many possible and useful tools used to ascertain risk to aquatic organisms, it is not the only tool. In fact, the state-approved guidelines for assessing sediments do not rely on determining bioavailability with modeling approaches like the AVS-SEM approach. *See* Water Quality Control Plan for

Enclosed Bays and Estuaries – Part 1. Sediment Quality**,** State Water Resources Control Board, 2009.

More importantly, Regional Board staff elected to rely on evidence of bioaccumulation in *Macoma nasuta,* a standard test organism used to evaluate whether chemicals in sediments can be taken up by organisms. In other words, staff chose a *direct* measurement of bioavailability – the extent to which a living organism accumulates chemicals in their tissues – as opposed to a model (AVS-SEM) to evaluate bioavailability. Dr. Allen, in his expert report for NASSCO, notes that in the Tentative Clean Up and Abatement Order "it is ***correctly*** noted that concentrations of arsenic, copper, lead, mercury, zinc, TBT, total PCBs, and high molecular weight PAHs in the Macoma nasuta [sic] tissues increase with respect to their concentrations in the sediment." Expert Report of Herbert Allen, prepared for NASSCO, dated March 11, 2011 at 19 (emphasis added). Expert Donald MacDonald also affirms that "the results for the Shipyard Sediment Site confirm that the COCs are biologically available because they accumulated in the tissues of the clam, *Macoma nasuta*." *See* Declaration of Donald MacDonald at ¶ 14. Thus, two sediment assessment experts agree that chemicals in sediments at the Shipyard Site can accumulate in tissues of organisms.

B. The DTR correctly interpreted the bioaccumulation data.

Both BAE and NASSCO criticize the DTR's use of the *Macoma* bioaccumulation data as "contrary" to San Diego Bay's narrative water quality objective for toxicity. This argument is unconvincing, irrelevant, and weak for several reasons. *See* Declaration of Donald MacDonald at ¶ 15. First, the DTR and Order address the narrative water quality objective through the evaluation of multiple lines of evidence. The *Macoma* data demonstrates that potentially harmful chemicals in the sediments at the Shipyard Site are in a form that can accumulate in tissues of organisms. *See* DTR Finding 19. This critical information <u>supplements</u> the assessments done to measure compliance with the narrative toxicity water quality standard—it is not "contrary" to it. Further, a sediment quality assessment need not be limited to collecting the information that is required to support evaluation of attainment of the water quality objectives. *See* Declaration of Donald MacDonald at ¶ 15.

C. Dr. Allen's opinions on bioaccumulation and bioavailability are weak and contain numerous flaws.

BAE relies on Dr. Allen's opinions with respect to bioaccumulation and bioavailability to criticize the DTR's approach. *See* BAE Comments dated May 26, 2011 at 7. However, the evaluation provided by Dr. Allen is weak and contains numerous flaws, as outlined by Donald MacDonald in his June 23, 2011 declaration. *See* Declaration of Donald MacDonald at ¶ 9.

For example, Dr. Allen has reached incorrect conclusions regarding the interpretation of AVS-SEM data. Using EPA guidance for AVS-SEM criteria as a his basis, Mr. MacDonald notes that "21 of 24 samples from the NASSCO site and 21 of 29 samples from the Southwest Marine Site would be classified as possibly having adverse biological effects due to divalent metals." *See* Declaration of Donald MacDonald at ¶ 9.

Similarly, Dr. Allen inappropriately applied the Biotic Ligand Model. The EPA has not developed and approved a Biotic Ligand Model for the assessment of sediments. *See* Declaration of Donald MacDonald at ¶ 9. Currently, the EPA only recommends that the Biotic Ligand Model be used to develop copper criteria for freshwater systems. *See* Declaration of Donald MacDonald at ¶ 9. Although Dr. Allen referred to a paper published by Di Toro *et al.* (2005) for the methods that he used to predict sediment metal toxicity using a sediment Biotic Ligand Model, the method has never been endorsed by EPA and the Di Toro *et al.* (2005) Biotic Ligand Model did not include mercury. *See* Declaration of Donald MacDonald at ¶ 9.

II. Natural Attenuation is Not a Viable Remedy for Addressing Issues Related to Sediment Contamination at the Site.

NASSCO and BAE have both identified "Monitored Natural Attenuation" as their preferred remedy for the Shipyard Sediment Site in San Diego Bay. However, natural attenuation is not a viable option to address contaminated sediment issues at the Shipyard Sediment Site for several reasons.

A. The contaminants at the Site are not readily degraded and, hence, are likely to persist in sediments well into the future.

The contaminants of concern at the Site are not readily amenable to natural attenuation processes. *See* Declaration of Donald MacDonald at ¶ 6. The U.S. Environmental Protection Agency indicates that the contaminants that are most appropriate for monitored natural attenuation include petroleum-related contaminants (i.e., benzene, toluene, ethylbenzene, and xylene), chlorinated solvents (e.g., trichloroethane), or inorganics that undergo sorption or oxidation-reduction reactions (e.g., certain metals and radionuclides). *See* EPA, "Use of monitored natural attenuation at Superfund, RCRA corrective action, and underground storage tank sites." (1999) Directive 9200.4-17P. Office of Solid Waste and Emergency Response. Washington, D.C. 32 pp (hereafter "EPA (1999)") *See also* Declaration of Donald MacDonald at ¶ 5.

By comparison, the contaminants of concern at the Site include organic contaminants that are not readily degraded, such as PAHs, PCBs, and TBT. *See* Tentative Cleanup and Abatement Order 2011-001 ¶ 29, Table 1, page 13. Furthermore, the metals at the Site are not degradable, have already been subject to sorption processes, and are known to bioavailable under current conditions. *See* Declaration of Donald MacDonald at ¶ 6. Passage of time is unlikely to render these contaminants less biologically available. *See* Declaration of Donald MacDonald at ¶ 6. Therefore, monitored natural attenuation is unlikely to be effective on these contaminants of concern.

B. The pollutants at the Site have the potential to migrate off site due to the nature of the activities at the Site.

Monitored natural attenuation is not appropriate for use at sites where contaminants have the potential to migrate to other areas. *See* EPA (1999); *See* Declaration of Donald MacDonald at ¶ 5. Neither NASSCO nor BAE have provided evidence to demonstrate that contaminants of concern at the Site are stable under the range of conditions that occur at the site. On the contrary, activities at the site, such as ship maintenance and repair (and associated prop wash), have the potential to remobilize sediment-associated pollutants and result in off-site transport. *See* Declaration of Donald MacDonald at ¶ 6. Likewise, storms and tidal current could exacerbate off-site contaminant transport at the Site. *See* Declaration of Donald MacDonald at ¶ 6.

C. No reliable data have been presented in the public record that demonstrate that natural attenuation is occurring at the Site.

There is no evidence in the public record that pollutant concentrations are decreasing at the site. *See* Declaration of Donald MacDonald at ¶ 6. Sediment chemistry data collected in 2001 and 2002 demonstrate that elevated concentrations of contaminants of concern occur throughout much of the site and that these contaminants pose unacceptable risks to human health and the environment. *See* DTR Volume 2.

NASSCO and BAE argue that sediment chemistry data collected at five locations in 2009 provide the necessary and sufficient evidence to demonstrate that contaminant concentrations are decreasing at the site. *See* NASSCO Comments submitted May 26, 2011 at 40; BAE Comments submitted May 26, 2011 at 26. However, five samples do not provide a data set that is sufficiently robust to characterize current contaminant concentrations at the Site. *See* Declaration of Donald MacDonald at ¶ 6.

In addition, neither NASSCO nor BAE presented evidence demonstrating that variability in contaminant concentrations is not due to sampling issues such as sampling location, sampling depth, analytical methods, or other factors. *See* Declaration of Donald MacDonald at ¶ 6. References to data collected by AMEC in 2010 are not relevant because that data is not yet a part of the administrative record. *See* BAE Comments at 26, fn 8. The Regional Board may not consider this data because San Diego Coastkeeper and Environmental Health Coalition were not provided with this data and given a full and fair opportunity to review and vet that data prior to the close of the comment and rebuttal period.

D. No evidence demonstrates that monitored natural attenuation would reduce pollutant concentrations to levels that would protect human health and the environment within a reasonable time frame.

Sediment chemistry data alone do not provide a basis for demonstrating that risks to benthic invertebrates or fish would be adequately reduced by natural attenuation. *See* Declaration of Donald MacDonald at ¶ 6. This means that even if valid sediment chemistry data existed showing reduced pollutant concentrations since 2001, such data would not be sufficient to demonstrate that monitored natural attenuation would be appropriately protective of human health and the environment. *See* Declaration of Donald MacDonald at ¶ 6. Pore-water chemistry, whole-sediment toxicity, invertebrate-tissue chemistry, and fish-tissue chemistry would also be required to demonstrate that natural attenuation is reducing exposure of ecological receptors to contaminants at the Site *See* Declaration of Donald MacDonald at ¶ 6. Neither NASSCO nor BAE has submitted data to support their claim that monitored natural attenuation would be protective of human health and the environment. *See* Declaration of Donald MacDonald at ¶ 6.

Evaluation of the available data and information indicates that conditions at the Site are sufficient to injure surface water resources (i.e., sediments) and biological resources (i.e., benthic invertebrate, fish, and wildlife communities). *See* Declaration of Donald MacDonald at ¶ 6; *See generally* DTR Volume 2. Neither NASSCO nor BAE presented evidence to demonstrate that such natural resource injuries would abate within a reasonable time frame if monitored natural attenuation was selected as the preferred remedy. On the contrary, selecting monitored natural attenuation as the preferred sediment management option will likely result in such natural resource injuries continuing well into the future. *See* Declaration of Donald MacDonald at ¶ 6. Any such impacts on natural resources would likely result in continuing beneficial use impairments in San Diego Bay. *See* Declaration of Donald MacDonald at ¶ 6.

E. Site security will not prevent benthic invertebrates, fish, or wildlife from being exposed to contaminants remaining at the Site.

Even if the Site will remain as a secured shipyard until at least 2040, security measures will not prevent humans and wildlife from being exposed to pollutants from the Site. While security measures may limit human exposure to the pollutants at the Site, they will not prevent wildlife exposure to the contaminants that occur at the Site. *See* Declaration of Donald MacDonald at ¶ 6. Securing the Site does not prevent fish or other aquatic life from swimming in and out of the site, nor does it prevent people or wildlife from catching and consuming wildlife exposed to contaminants at the Site. Therefore, people are still at risk of being exposed to pollutants remaining at the Site despite security measures at the Site.

F. NASSCO has not proven through evidence in the record its allegation that dredging would cause greater harm to human health and the environment than would natural attenuation.

NASSCO suggests argued that large-scale dredging, as described in the Order will result in greater harm to beneficial uses than leaving sediment in place and allowing contaminants to attenuate naturally. *See* NASSCO Comments dated May 26, 2011 at 43. However, NASSCO provided no quantitative assessment or other evidence to support this argument.

The assessments presented in the Order and DTR have demonstrated that conditions at the Site are currently adversely affecting human health and the environment. *See generally* DTR Volume 2, Findings 21-28. The nature, magnitude, and spatial extent of such effects are sufficient to warrant active remediation, as described in the Order. If performed correctly with adequate environmental controls, active remediation will result in substantial reductions in exposure of humans and ecological receptors to contaminants of concern at the Site. *See* Declaration of Donald MacDonald at ¶ 6; *See also* Expert Report of Donald MacDonald, prepared March 11, 2011 (already submitted into the record). As the Environmental Parties and expert Donald MacDonald have already commented, the DTR should explicitly state that measures to reduce or eliminate the transport of sediments that are resuspended during dredging must be used throughout the dredging program. *See* Expert Report of Donald MacDonald, prepared March 11, 2011 § E.2.7 at 23. Such measures may include the use of silt curtains, gunderbooms, mechanical dredge operational controls, use of a closed or environmental bucket, measures that apply to barge operation, and selected work windows. *See* Expert Report of Donald MacDonald, prepared March 11, 2011 § E.2.7 at 23-24. In addition, it is likely that benthic communities will recover within a two to four year period, resulting in enhanced benefits to the aquatic ecosystem. *See* Declaration of Donald MacDonald at ¶ 6.

G. Monitored natural attenuation cannot be considered the preferred remedial option because NASSCO and BAE have failed to prove that monitored natural attenuation would protect human health and the environmental and achieve remedial objectives within a reasonable time frame.

EPA's guidance regarding appropriate use of monitored natural attenuation as a remediation strategy emphasizes that the proponent must present convincing site-specific technical evidence that monitored natural attenuation will effectively protect human health and the environment, and that the remedial objectives will be achieved within a reasonable time frame. *See* EPA (1999); *See* Declaration of Donald MacDonald at ¶ 5. This presumption ***against*** monitored natural attenuation means that the burden of proof that monitored natural attenuation will be effective is on NASSCO and BAE. But neither NASSCO nor BAE has proven, with evidence in the record provided to all Designated Parties, that monitored natural attenuation will protect human health and the environment and achieve the remedial objectives within a reasonable time frame. For this reason, the Regional Board cannot select monitored natural attenuation as the preferred remedial alternative. *See* Declaration of Donald MacDonald at ¶ 6.

III. BAE's Criticisms of Don MacDonald's Expert Report Are Not Based on Expert Testimony and are Without Merit.

BAE's lawyers found fault with every point Don MacDonald made in his expert report, dated March 11, 2011 and deemed each expert opinion "incorrect," "invalid," "unsupported" or "premature." However, BAE's criticisms are solely argument, as they rely on unsupported assertions made by lawyers, not on measured points provided by an equally-qualified expert. After examining the particular criticisms, it is clear that they are without merit and provided merely in an attempt to confuse the Regional Board. For these reasons, BAE's criticisms of Donald MacDonald's expert opinions carry little weight and should be ignored.

All of BAE's arguments attacking Mr. MacDonald's opinions and conclusions are without merit. Below are three examples of the meritless, unsupported, and nonsensical arguments raised by BAE's lawyers.

1. BAE's lawyers claim that Mr. MacDonald's expert *opinion* that "the sampling density is insufficient to accurately characterize the nature and extent of contamination at the site" is "incorrect." They base this claim on an unsupported and un-cited assertion that sampling was "consistent with the manner in which most schemes are designed at contaminated sites." BAE Comments at 30. But BAE's lawyers provide no citations or examples to demonstrate that "most schemes" are designed with such a paltry sampling density, nor can they explain how an ***opinion*** about a subjective matter like "sufficiency" can be "incorrect."

2. BAE's lawyers characterize Mr. MacDonald's conclusion that the proposed remedial footprint "excludes polygons with composite SWAC ranking values greater than 5.5" as "invalid." *See* BAE Comments dated May 26, 2011 at 54. But the record clearly shows that the lowest SWAC ranking value included in the footprint was 5.5 and that 15 polygons with SWAC ranking values greater than 5.5 were not included in the footprint. *See* DTR Tables A33-1 and A33-2. That BAE's lawyers characterize an accurate factual summary as an "invalid" conclusion reveals their argument as nonsensical and unconvincing.

3. BAE's lawyers claim that Mr. MacDonald provided "no technical basis" for his assertion that the proposed remedial footprint "excludes polygons, like NA07, with concentrations of contaminants in sediment that likely pose higher risks to human health and aquatic-dependent wildlife than some of the polygons included in the proposed remedial

footprint." *See* BAE Comments dated May 26, 2011 at 54. BAE either ignores or fails to understand that Table 1 of Mr. MacDonald's expert report sets forth the technical basis for his conclusion that the proposed remedial footprint exclude polygons that pose higher risks to human health and aquatic-dependent wildlife than some of the polygons included in the proposed remedial footprint. *See* Expert Report of Donald MacDonald dated March 11, 2011 at Table 1.

It is clear that BAE's lawyers' arguments attacking every single opinion and conclusion Donald MacDonald offers in his expert report is a thinly-veiled attempt to force the Environmental Parties to spend their limited resources in responding to ridiculous and meritless argument. For this reason, the Environmental Parties will only provide three examples demonstrating the nonsensical, meritless nature of BAE's arguments attacking Mr. MacDonald. However, every single one of BAE's attacks on Mr. MacDonald is without merit. BAE's lawyers unfounded and unsupported arguments attacking Mr. MacDonald's credible expert report and his opinions contained in it are meritless and should be ignored.

Respectfully submitted on this 23rd day of June, 2011by:

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Jill M. Witkowski, Cal. Bar No. 270281

On behalf of San Diego Coastkeeper and
Environmental Health Coalition

SAN DIEGO COASTKEEPER AND ENVIRONMENTAL HEALTH COALITION REBUTTAL EVIDENCE

EXHIBIT A:
Declaration of Donald D. MacDonald, dated June 23, 2011

EXHIBIT B:
Davis, J.A., K. Schiff, A.R. Melwani, S.N. Bezalel, J.A. Hunt, R.M. Allen, G. Ichikawa, A. Bonnema, W.A. Heim, D. Crane, S. Swenson, C. Lamerdin, and M. Stephenson. 2011. Contaminants in Fish from the California Coast, 2009: Summary Report on Year One of a Two-Year Screening Survey. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA. http://www.sfei.org/node/3851

EXHIBIT C:
Lewison, R, et al. 2011. Chemical Analysis of Threatened and Endangered Species in San Diego: The San Diego Bay Trophic Transfer Project, Final Report to the Port of San Diego.

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DECLARATION OF DONALD D. MACDONALD

I, Donald Douglas MacDonald, declare:

1. I am the principal of MacDonald Environmental Sciences Ltd. and Canadian Director of the Sustainable Fisheries Foundation. My qualifications are set forth in detail in my expert report, entitled "Expert Report of Donald D. MacDonald Regarding the Tentative Clean-Up and Abatement Order (No. R9-2011-0001) for the Shipyard Sediment Site, San Diego Bay, San Diego, CA." That expert report was provided to all Designated Parties on March 11, 2011 and was submitted into the record by San Diego Coastkeeper and Environmental Health Coalition on May 26, 2011.

2. This declaration provides my expert opinions regarding arguments made by National Steel and Shipbuilding Company (NASSCO) and BAE Systems San Diego Ship Repair, Inc. (BAE) regarding monitored natural attenuation and bioavailability made in their May 26, 2011 submittals.

3. To prepare this declaration, I have reviewed the comments submitted by NASSCO and BAE regarding monitored natural attenuation and bioavailability, along with the expert report prepared by Herb Allen and submitted by NASSCO regarding bioavailability. I also reviewed the following reports:

- ASTM (American Society for Testing and Materials). 2010. Standard guide for determination of the bioaccumulation of sediment-associated contaminants by benthic invertebrates. E1688-00a. ASTM Annual Book of Standards Volume 11.05. West Conshohocken, Pennsylvania.

- Di Toro, D.M., J.A. McGrath, D.J. Hansen, W.J. Berry, P.R. Paquin, R. Mathew, K.B. Wu, and R.C. Santore. 2005. Predicting sediment metal toxicity using a sediment biotic ligand model: Methodology and initial application. Environmental Toxicology and Chemistry 24(10): 2410-2427.

- Exponent. 2009. Work Plan for Supplemental Triad Study. BAE and NASSCO Shipyards Site. NASSCO, BAE, City of San Diego, San Diego Gas and Electric. Exponent. Bellevue, Washington.

- U.S. Environmental Protection Agency (EPA). 1999. Use of monitored natural attenuation at Superfund, RCRA corrective action, and underground storage tank sites. Directive 9200.4-17P. Office of Solid Waste and Emergency Response. Washington, D.C. 32 pp.

- U.S. Environmental Protection Agency (EPA). 2000. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates, second edition. EPA/600/R-99/064. Washington, District of Columbia.

- U.S. Environmental Protection Agency (EPA). 2005. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: metal mixtures (cadmium, copper, lead, nickel, silver, zinc). EPA 600 R 02 011. Office of Research and Development. Washington, District of Columbia. 121 pp.

- Wenning, R.J., G.E. Batley, C.G. Ingersoll, and D.W. Moore (Editors). 2005. Use of sediment quality guidelines and related tools for the assessment of contaminated sediments. Proceedings from the Pellston Workshop. August 18 22, 2002. Fairmont, Montana. SETAC Press. Pensacola, Florida. 816 pp.

Monitored Natural Attenuation is not a Reasonable Remedial Alternative.

4. NASSCO and BAE have both identified Monitored Natural Attenuation (MNA) as their preferred remedy for the Shipyard Sediment Site (Site) in San Diego Bay.

5. The term, MNA, describes a sediment management strategy that relies on natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by more active remediation methods (EPA 1999). Such natural attenuation processes are considered to include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil (EPA 1999). EPA (1999) prefers processes that degrade or destroy contaminants, and expects that MNA will only be appropriate for sites that have low potential for contaminant migration. EPA (1999) also expects that MNA will be most appropriate when used in conjunction with other remediation measures or as a follow-up to active remediation measures that have already been implemented at a site. EPA (1999) further indicates that the proponent must present convincing site-specific technical evidence that MNA will effectively protect human health and the environment, and that the remedial objectives will be achieved within a reasonable time frame (i.e., the burden of proof that MNA will be effective is on the proponent).

6. While NASSCO and BAE have identified MNA as the preferred remedy for the Site, in my expert opinion, MNA does not represent a reasonable alternative for the following reasons:

- The contaminants of concern (COCs) at the Site are not readily amenable to MNA processes. EPA (1999) indicates that the contaminants that are most appropriate for MNA include petroleum-related contaminants (i.e., benzene, toluene, ethylbenzene, and xylene), chlorinated solvents (e.g., trichloroethane), or inorganics that undergo sorption or oxidation-reduction reactions (e.g., certain metals and radionuclides). By comparison, the COCs at the Site include organic contaminants that are not readily degraded, such as PAHs, PCBs, and TBT. Furthermore, the metals at the Site are not degradable, have already been subject to sorption processes, and are known to be bioavailable under current conditions. Passage of time is unlikely to render these contaminants less biologically available. Hence, MNA is unlikely to be effective on these COCs;

- There is no evidence in the public record that COC concentrations are decreasing at the Site. Sediment chemistry data collected in 2001 and 2002 demonstrate that elevated concentrations of COCs occur throughout much of the Site and that these COCs pose unacceptable risks to human health and the environment. NASSCO and BAE argue that sediment chemistry data collected at five locations in 2009 provide the necessary and sufficient evidence to demonstrate that COC concentrations are decreasing at the Site (i.e., Exponent 2009). However, five samples do not provide a data set that is sufficiently robust to characterize current COC concentrations at the Site. In addition, no evidence was presented that demonstrates that the more recent data are comparable to the earlier data (i.e., that variability in COC concentrations is not related to sampling location, sampling depth, analytical methods, or other factors). References to data collected by AMEC in 2010 are not relevant because those data are not yet a part of the administrative record. See BAE Comments at 26, fn 8. Furthermore, because San Diego Coastkeeper and Environmental Health Coalition were not provided with this data, I have not had an opportunity to review and evaluate that data nor assess the conclusions that NASSCO and BAE have drawn from that data.

- NASSCO and BAE have argued that sediment chemistry data collected at the Site in 2009 provide sufficient evidence that natural attenuation is already occurring at the Site. More specifically, the proponents indicated that surface-weighted average concentrations (SWACs) for the primary COCs have decreased substantially since 2001/2002 and are now only slightly higher than the clean-up goals (i.e., post-remedial SWACs). As indicated above, the information contained in the public record is insufficient to support such a conclusion. Importantly, such a finding would not be sufficient to demonstrate that MNA would be appropriately protective of human health and the environment, even if that claim was substantiated by adequate sediment chemistry data. That is, sediment chemistry data alone (as used to calculate SWACs of selected COCs) do not provide a basis for demonstrating that risks to benthic invertebrates or fish would be adequately reduced by natural attenuation. Pore-water chemistry, whole-sediment toxicity, invertebrate-tissue chemistry, and fish-tissue chemistry would also be required to demonstrate that natural attenuation is reducing exposure of ecological receptors to COCs at the Site. The proponent has not submitted such data to support their claim that MNA would be protective of human health and the environment;

- NASSCO and BAE argued that natural attenuation represents a viable remedial alternative because the Site will remain as a secured shipyard until at least 2040 and because security measures will prevent exposure of humans and wildlife to Site COCs. While security measures may limit (but will not eliminate) human exposure to the Site COCs, they will not prevent wildlife exposure to the contaminants that occur at the Site. In other words, securing the Site does not prevent fish or other aquatic life from swimming in and out of the Site, nor does it prevent people or wildlife from catching and consuming fish or wildlife exposed to contaminants at the Site. Therefore, Site security will not mitigate risks to any ecological receptor;

- NASSCO and BAE argued that large-scale dredging, as described in the Tentative Clean-up and Abatement Order (Order), will result in greater harm to beneficial uses than leaving sediment in place and allowing contaminants to attenuate naturally. However, no quantitative assessment was presented to support this argument. Furthermore, the assessments presented in the Order and associated Draft Technical Report (DTR) have demonstrated that conditions at the Site are currently adversely affecting human health and the environment. The nature, magnitude, and spatial extent of such effects are sufficient to warrant active remediation, as described in the Order. If performed correctly with adequate environmental controls, active remediation will result in substantial reductions in exposure of humans and ecological receptors to Site COCs. In addition, it is likely that benthic communities will recover within a two to four year period, resulting in enhanced benefits to the aquatic ecosystem;

- According to EPA (1999), MNA is not appropriate for use at sites where contaminants have the potential to migrate to other areas. However, the proponents have not provided evidence to demonstrate that Site COCs are stable under the range of conditions that occur at the Site. On the contrary, activities at the Site, such as ship maintenance and repair (and associated prop wash), have the potential to remobilize sediment-associated COCs and result in off-site transport of contaminants. Storms and/or tidal currents could exacerbate off-site contaminant transport at the Site; and,

- Evaluation of the available data and information indicates that conditions at the Site are sufficient to injure surface water resources (i.e., sediments) and biological resources (i.e., benthic invertebrate, fish, and wildlife communities). No evidence has been presented by the proponents to demonstrate that such natural resource injuries would abate within a reasonable time frame if MNA was selected as the preferred remedy. On the contrary, selection of MNA as the preferred sediment management option will likely result in such natural resource injuries continuing well into the future. Any such impacts on natural resources would likely result in continuing beneficial use impairments in San Diego Bay.

7. In summary, MNA is not a viable remedy for addressing issues related to sediment contamination at the Site. Importantly, the contaminants at the Site are not readily degraded and, hence, are likely to persist in sediments well into the future. These contaminants also have the potential to migrate off site due to the nature of the activities at the Site. In addition, no reliable data have been presented in the public record that demonstrate that natural attenuation is occurring at the Site. In contrast to the arguments presented by NASSCO and BAE, institutional controls (i.e., Site security) will not mitigate exposure of benthic invertebrates, fish, or wildlife to Site COCs. Furthermore, evidence to prove that dredging (as described in the Order) would cause greater harm to human health and the environment than would natural attenuation has not been presented by NASSCO or BAE. Finally, no evidence has been presented by NASSCO or BAE that demonstrates that COC concentrations would be reduced to levels that would protect human health and the environment within a reasonable time frame. As the burden to proof is on the proponent to demonstrate that MNA would be an effective remediation strategy and neither NASSCO nor BAE have provided the necessary evidence, MNA cannot be considered as the preferred remedial option at the Shipyard Sediment Site.

Criticisms of the Bioavailability Analysis in the Order and DTR are Without Merit.

A. Allen's conclusions about metal bioavailability at the Site are based on unreliable methods and unsubstantiated assumptions. Hence, Allen's conclusions should not be relied upon to make sediment management decisions at the Site.

8. Herb Allen, in a report prepared for NASSCO, indicated that the Regional Board has incorrectly concluded that sediments at the Site are causing potential risks to aquatic life. Allen further indicated that the Regional Board has not considered the bioavailability of metals. To support his thesis, Allen presented an interpretation which he suggests shows that the concentrations of sulfide and organic matter in the sediments are sufficiently high at the Site to preclude metals from causing toxicity.

9. In my expert opinion, Allen's thesis regarding the bioavailability of metals at the Site is not supported for the following reasons.

- The Board has used data on the concentrations of total metals, in conjunction with numerical sediment quality guidelines, to estimate toxicity associated with exposure of benthic invertebrates to sediments from the Site. This approach has been demonstrated to provide an effective basis for classifying estuarine sediment samples as toxic and not toxic (See Section B below);

- The bioavailability of metals can be influenced by the concentrations of acid volatile sulfides (AVS) and total organic carbon (TOC) in sediments. To address the issue of metal bioavailability, EPA (2005) developed a guidance document to assist practitioners in evaluating metal-contaminated sediments. Two assessment tools are described in the EPA (2005) document, which are both based on evaluating the molar concentrations of simultaneously extracted divalent metals (SEM; including cadmium, copper, lead, nickel, silver, and zinc; Cd, Cu, Pb, Ni, Ag, and Zn) relative to AVS concentrations and TOC concentrations (i.e., fraction organic carbon; *f*oc). Using these tools, sediment samples are classified as follows:

1. ∑SEM-AVS of >120; ∑(SEM-AVS)/*f*oc >3000 – Adverse biological effects due to divalent metals may be expected;
2. SEM-AVS of 1.7 to 120; ∑(SEM-AVS)/*f*oc of 130 to 3000 – May have adverse biological effects due to divalent metals; and,
3. SEM-AVS <1.7; ∑(SEM-AVS)/*f*oc <130 – Low risk of adverse biological effects due to divalent metals.

- Using the criteria for ∑SEM-AVS, 21 samples from the NASSCO Site and 21 of 29 samples from the Southwest Marine Site would be classified as possibly having adverse biological effects due to divalent metals. Therefore, metal are expected to be biologically available at the Site;

- Contrary to Allen's interpretation, the EPA has not developed a biotic-ligand model (BLM) for sediments. Rather, they have recommended that the ∑SEM-AVS and ∑(SEM-AVS)/*f*oc tools be used to evaluate sediments that are contaminated by metals;

- The EPA has developed a BLM for assessing the toxicity of water-borne metals to aquatic organisms. More specifically, the BLM provides a basis for developing site-specific water quality criteria for copper. The BLM requires the following water quality input parameters: pH, DOC, alkalinity, temperature, Ca, Mg, Na, K, SO_4^{-2}, and Cl^-. Currently, the EPA only recommends that the BLM be used to develop copper criteria for freshwater systems. Therefore, Allen's use of a BLM for sediments in inappropriate;

- Allen referred to a paper published by Di Toro *et al.* (2005) for the methods that he used to predict sediment metal toxicity using a sediment BLM. It is important to note that this method has never been endorsed by EPA. In addition, mercury is not included in the Di Toro *et al.* (2005) BLM, as has been suggested by Allen. Therefore, Allen's use of a BLM for sediments in inappropriate.

In summary, Allen based his conclusions on a model that has not been approved for use by EPA for sediments. The metals interpretive tools developed by EPA are very different from Allen's, have undergone extensive peer review, and have been recommended for use in very specific applications. In addition, Allen has made several assumptions that are not necessarily appropriate for the Site. Therefore, the Board should put little weight on Allen's conclusions regarding metal bioavailability.

B. Allen's conclusion that the Board inappropriately used empirical sediment quality guidelines is not supported by the facts.

10. Allen postulated that empirical sediment quality guidelines (SQGs) are not adequate for prediction of risk. To support this thesis, Allen suggested that the bioavailability of COCs must be low because he claims that no adverse biological effects were observed at the Site. He proposed that the problem is the use of data on total metal concentrations. Finally, he evaluated the SQGs for copper in freshwater sediments. He suggested that causality-based SQGs should be used instead of empirically-based SQGs, citing EPA (2005) equilibrium partitioning sediment benchmarks (ESBs) as the appropriate methods.

11. In 2002, the Society of Environmental Toxicology and Chemistry convened a Pellston Workshop in Fairmont, Montana to identify appropriate uses of SQGs in the assessment and management of contaminated sediments. The workshop brought together 55 scientists with expertise in ecology, ecotoxicology, engineering, environmental regulation, and risk assessment. Some of the key findings that emerged from the workshop included (Wenning *et al.* 2005):

- The results of many independent laboratory toxicity studies have demonstrated a relatively low incidence of false negative errors (i.e., 0 to 21%) when low-range empirical SQGs are not exceeded. Therefore, empirically-derived SQGs provide a reliable basis for identifying sediment samples that are unlikely to be toxic to benthic invertebrates;

- Data compiled from 10 studies have demonstrated that the percentage of samples identified as adversely affected was highest (76 to 97%, based on laboratory toxicity or benthic effects) when mean SQG-quotients were highest or when many chemical concentrations exceed individual SQGs. Therefore, empirically-derived SQGs provide a reliable basis for identifying sediment samples that are likely to be toxic to benthic invertebrates;

- The results of several key studies demonstrate that there is concordance among mechanistically-based SQGs, spiked-sediment toxicity tests, and/or empirically-based SQGs. Such concordance demonstrates that empirically-derived SQGs can be used to identify chemicals that cause or substantially contribute to sediment toxicity;

- There is a growing body of evidence from several independent studies that demonstrates that impacts on estuarine benthic communities may occur at chemical concentrations below those that are associated with toxicity to amphipods in 10-day laboratory toxicity tests measuring survival. Hence, empirically-derived SQGs based on matching sediment chemistry and sediment toxicity data may not be sufficiently protective of benthic invertebrate communities utilizing estuarine habitats; and,

- The results of numerous evaluations of the predictive ability of SQGs indicate that sediment chemistry data, evaluated using empirically-derived SQGs, can be used to accurately classify sediments as toxic or not toxic.

12. Collectively, these conclusions indicate that empirical SQGs do provide an adequate basis for predicting risk to benthic invertebrates associated with exposure to contaminated sediments. Allen's thesis that bioavailability must be low because no adverse biological effects were observed is incorrect because adverse effects on benthic invertebrates were observed when the toxicity data were properly evaluated (i.e., using the reference-envelope approach). The empirical SQGs based on total metal concentrations have been found to be predictive of the presence and absence of sediment toxicity in many studies. The evaluation of the SQGs for copper in freshwater sediments is irrelevant to the Site, which is located within an estuarine ecosytem (Allen's analysis of the SQGs for copper is also biased and incorrect). Concordance between causality-based SQGs and empirically-derived SQGs confirms that the SQGs used by the Board are relevant for use at the Site. Therefore, Allen's conclusion that it is not possible to predict the effects of a chemical based solely on its total concentration is not supported by 55 scientists with expertise in the field of sediment quality assessment. Hence, Allen's conclusion that the Board inappropriately used empirical sediment quality criteria is not supported by the facts.

C. Allen's conclusions about the bioaccumulation testing are incorrect.

13. In his Summary and Conclusions, Allen indicated that bioaccumulation results for *Macoma nasuta* collected from northern California may not be applicable to organisms that occur at the Site. However, no supporting information is provided to support this claim. In my expert opinion, Allen is incorrect because indicator species, such as clams (e.g., *Macoma nasuta*) or polychaetes (e.g., *Nereis virens*) are most often used in laboratory bioaccumulation tests because they provide bioaccumulation data that are representative for a wide range conditions. Accordingly, ASTM (2010) and EPA (2000) developed standard methods for conducting such bioaccumulation tests and the results of such tests are commonly used in ecological risk assessments and natural resource damage assessments of hazardous waste sites throughout the United States.

14. Allen also dismissed the results of the bioaccumulation tests because they do not provide information on toxicity to humans, plants, and animals (i.e., do not address the narrative water quality objective for San Diego Bay). This premise is wrong for several reasons, including:

- The results of sediment bioaccumulation tests provide essential information for determining if the COCs in the sediments are bioavailable to sediment-dwelling organisms. The results for the Site confirm that the COCs are biologically available because they accumulated in the tissues of the clam, *Macoma nasuta*;

- The results of sediment bioaccumulation tests provide a basis for calculating biota-sediment accumulation factors and/or biota-sediment accumulation functions. These tools, in turn, are used to estimate the concentrations of COCs that would be expected to occur in the tissues of animals exposed to sediments throughout the Site;

- The estimated concentrations of COCs in the tissues of benthic organisms can be used directly to predict effects on sediment-dwelling organisms associated with accumulation of bioaccumulative COCs in their tissues. Such assessments are conducted using toxicity thresholds for invertebrate tissues that have been established from laboratory spiking studies and/or field studies;

- The estimated concentrations of COCs in the tissues of benthic organisms can also be used to evaluate risks to human health and aquatic-dependent wildlife associated with dietary exposure to bioaccumulative COCs.

15. Therefore, Allen's premise that "selection of chemicals based on bioaccumulation is contrary to the narrative WQO" is incorrect. And, even if his premise was correct, his point is irrelevant because a sediment quality assessment need not be limited to collecting the information that is required to support evaluation of attainment of the WQOs. Hence, Allen's argument is very weak.

I declare under penalty of perjury that the foregoing is true and correct and that this declaration was sworn on June 23, 2011 at Nanaimo, British Columbia, Canada.

____
Donald MacDonald

SWAMP
Surface Water Ambient Monitoring Program

CONTAMINANTS IN SPORT FISH FROM THE CALIFORNIA COAST, 2009: SUMMARY REPORT ON YEAR ONE OF A TWO-YEAR SCREENING SURVEY

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EXECUTIVE SUMMARY E

This summary report presents results from the first year of a coordinated two-year screening survey of contaminants in sport fish in California coastal waters. This survey was performed as part of the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP), in close collaboration with the Southern California Bight Regional Monitoring Program (Bight Program) and the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP). This statewide screening study is an initial step in an effort to evaluate the extent of chemical contamination in sport fish from California's coastal waters. This Coast Survey is one element of a new, long-term, statewide, comprehensive bioaccumulation monitoring program for California surface waters. This report provides a concise technical summary of the findings from the first year of the Coast Survey. This report is intended for agency staff charged with managing water quality issues related to bioaccumulation of contaminants in California coastal waters.

The array of species selected for sampling included the species known to accumulate high concentrations of contaminants and therefore serve as informative indicators of potential contamination problems. Contaminant concentrations in fish tissue were compared to thresholds developed by the California Office of Environmental Health Hazard Assessment (OEHHA) for methylmercury, polychlorinated biphenyls (PCBs), dieldrin, dichlorodiphenyltrichloroethanes (DDTs), chlordanes, and selenium, and a State Water Resources Control Board threshold for methylmercury in tissue that is being used for identification of impaired water bodies. Total Maximum Daily Load (TMDL) targets developed by the San Francisco Bay Regional Water Quality Control Board for San Francisco Bay also provided a basis for assessment.

The Coast Survey is a preliminary screening of contamination in sport fish. This screening study did not provide enough information for consumption guidelines – this would require a larger and more focused monitoring effort that would include a broader array of species and larger numbers of fish. Sampling in year one focused on the most urbanized regions on the coast near Los Angeles and San Francisco. Sources of contamination are generally more prevalent in urban regions, so the preliminary results from year one reflect a bias toward higher contaminant concentrations.

The Coast Survey represents a major step forward in understanding the extent of chemical contamination in sport fish in California coastal waters, and the impact of this contamination on the fishing beneficial use. In the first year of this statewide screening study, 2291 fish from 36 species were collected from 42 locations on the California coast. The survey identified high concentrations of contaminants in a few areas, and widespread moderate contamination throughout the urban coastal regions sampled. Methylmercury and PCBs are the pollutants that pose the most widespread potential health concerns to consumers of fish caught on the California coast. None of the locations had all sampled fish species below all the OEHHA thresholds. The high degree of variation observed among species within locations indicates that fish consumers can significantly reduce their exposure, and still attain the substantial nutritional benefits that fish provide, by selectively targeting species with lower concentrations of methylmercury.

At several locations, methylmercury reached concentrations high enough that OEHHA would consider recommending no consumption of the contaminated species (0.44 ppm wet weight). Overall, eight of the 42 locations surveyed had a species with an average concentration exceeding 0.44 ppm. At all but one of the locations these were sharks, which have a tendency to accumulate high levels of methylmercury worldwide. Striped bass, a very popular species sampled in San Francisco Bay, was the one other species that had an average methylmercury concentration (0.45 ppm) above 0.44 ppm. Most of the locations sampled (33 of 42) were in the moderate contamination categories (above the lowest threshold of 0.07 ppm and below 0.44 ppm). Several species had average methylmercury concentrations below all thresholds, most notably chub mackerel, which is one of the most popular sport fish species on the southern California coast.

PCB contamination was moderate but widespread. Six of the 42 locations surveyed had a species with an average concentration exceeding OEHHA's no consumption threshold of 120 ppb. San Francisco Bay and San Diego Bay stood out as having elevated concentrations. Most of the locations sampled (74%) fell in the moderate contamination categories between the lowest threshold of 3.6 ppb and the 120 ppb no consumption threshold. Only five locations from more remote areas had concentrations lower than the lowest threshold. Eleven species, including all of the rockfish species sampled, had average PCB concentrations below all thresholds. Safe eating guidelines have been in place for many years in San Francisco Bay, but guidelines for San Diego Bay have not been developed.

OEHHA has developed thresholds for four other pollutants that were analyzed in this survey: dieldrin, DDT, chlordane, and selenium. Concentrations of these contaminants in fish tissue sampled rarely exceeded any of the OEHHA Advisory Tissue Levels. The legacy pesticides, however, did frequently exceed the Fish Contaminant Goals established by OEHHA.

San Francisco Bay samples were also analyzed for dioxins, polybrominated diphenyl ethers (PBDEs), and perfluorinated chemicals (PFCs). Dioxin toxic equivalent concentrations in the Bay are several times higher than a San Francisco Bay Regional Water Board screening value and do not show obvious signs of decline. A lack of accepted thresholds constrains assessment of the concerns posed by PFCs for consumers of Bay sport fish. Only four samples had detectable perfluorooctanesulfonate (PFOS) concentrations. PBDEs were well below the newly established FCG and ATLs for PBDEs. A study performed with white croaker from San Francisco Bay found that removal of skin reduced concentrations of organic contaminants such as PCBs by 65%.

Chapter 3 of this report provides more information on the statewide results. Chapters 4 and 5 provide detailed presentations of the results from Southern California and San Francisco Bay.

SECTION 1
INTRODUCTION

This summary report presents results from the first year of a two-year statewide screening survey of contaminants in sport fish on the California coast. The survey is being performed as part of the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP). This effort marks the beginning of a new long-term, statewide, comprehensive bioaccumulation monitoring program for California surface waters.

This report provides a concise technical summary of the findings of the survey. It is intended for agency scientists that are charged with managing water quality issues related to bioaccumulation of contaminants in California surface waters.

Oversight for this project is being provided by the SWAMP Roundtable. The Roundtable is composed of State and Regional Board staff and representatives from other agencies and organizations including US Environmental Protection Agency (USEPA), the California Department of Fish and Game, and the California Office of Environmental Health Hazard Assessment (OEHHA). Interested parties, including members of other agencies, consultants, or other stakeholders also participate.

The Roundtable has formed a subcommittee, the Bioaccumulation Oversight Group (BOG) that specifically guides SWAMP bioaccumulation monitoring. The BOG is composed of representatives from each of the Roundtable groups, and in addition the Southern California Coastal Waters Research Project, and the San Francisco Estuary Institute. The members of the BOG possess extensive experience with bioaccumulation monitoring.

The BOG has also convened a Bioaccumulation Peer Review Panel that is providing evaluation and review of the bioaccumulation program. The members of the Panel are internationally-recognized authorities on bioaccumulation monitoring.

The BOG has developed and begun implementing a plan to evaluate bioaccumulation impacts on the fishing beneficial use in all California water bodies. Sampling of sport fish in lakes and reservoirs was conducted in the first two years of monitoring (2007 and 2008). In 2009 and 2010, sport fish from the California coast, including bays and estuaries were sampled. Sport fish from rivers and streams will be sampled in 2011.

THE COAST SURVEY

Management Questions for This Survey

Three management questions were articulated to guide the design of the Coast Survey. These management questions are specific to this initial screening survey; different sets of management questions will be established to guide later efforts.

Management Question 1 (MQ1)

Status of the Fishing Beneficial Use

For popular fish species, what percentage of popular fishing areas have low enough concentrations of contaminants that fish can be safely consumed?

Answering this question is critical to determining the degree of impairment of the fishing beneficial use across the state due to bioaccumulation. This question places emphasis on characterizing the status of the fishing beneficial use through monitoring of the predominant pathways of exposure – ingestion of popular fish species from popular fishing areas. This focus is also anticipated to enhance public and political support of the program by assessing the resources that people care most about. The determination of percentages mentioned in the question captures the need to perform a statewide assessment of the entire California coast. Past monitoring of contamination in sport fish on the California coast has been patchy (reviewed in Davis et al. [2007]), and a systematic statewide survey has never been performed. The emphasis on safe consumption calls for an accurate message on the status of the fishing beneficial use and evaluation of the data using thresholds for safe consumption.

The data needed to answer this question are average concentrations in popular fish species from popular fishing locations. Inclusion of as many popular species as possible is important to understanding the nature of impairment in any areas with concentrations above thresholds. In some areas, some fish may be safe for consumption while others are not, and this is valuable information for anglers. Monitoring species that accumulate high concentrations of contaminants ("indicator species") is valuable in answering this question: if concentrations in these species are below thresholds, this is a strong indication that an area has low concentrations.

Management Question 2 (MQ2)

Regional Distribution

What is the spatial distribution of contaminant concentrations in fish within regions?

Answering this question will provide information that is valuable in formulating management strategies for observed contamination problems. This information will allow managers to prioritize their efforts and focus attention on the areas with the most severe problems. Information on spatial distribution within regions will also provide information on sources and fate of contaminants of concern that will be useful to managers.

This question can be answered with different levels of certainty. For a higher and quantified level of certainty, a statistical approach is needed that includes replicate observations in the spatial units to be compared. In some cases, managers can attain an adequate level of understanding for their needs with a non-statistical, non-replicated approach. With either approach, reliable estimates of average concentrations within each spatial unit are needed.

Management Question 3 (MQ3)

Need for Further Sampling

Should additional sampling of contaminants in sport fish (e.g., more species or larger sample size) in specific areas be conducted for the purpose of developing comprehensive consumption guidelines?

This screening survey of the entire California coast will provide a preliminary indication as to whether many areas that have not been sampled thoroughly to date may require consumption guidelines. Consumption guidelines provide a mechanism for reducing human exposure in the near-term. The California Office of Environmental Health Hazard Assessment (OEHHA), the agency responsible for issuing consumption guidelines, considers a sample of 9 or more fish from a variety of species abundant in a water body to be the minimum needed in order to issue guidance. It is valuable to have information not only on the species with high concentrations, but also the species with low concentrations so anglers can be encouraged to target the less-contaminated species. The diversity of species on the coast demands a relatively large effort to characterize interspecific variation. Answering this question is essential as a first step in determining the need for more thorough sampling in support of developing consumption guidelines.

Overall Approach

The overall approach to be taken to answer these three questions is to perform a statewide screening study of bioaccumulation in sport fish on the California coast. Answering these questions will provide a basis for decision-makers to understand the scope of the bioaccumulation problem and will provide regulators with information needed to establish priorities for both cleanup actions and development of consumption guidelines.

It is anticipated that the screening study may lead to more detailed followup investigations of areas where the need for consumption guidelines and cleanup actions is indicated.

Through coordination with other programs, SWAMP funds for this survey were highly leveraged to achieve a much more thorough statewide assessment than could be achieved by SWAMP alone.

First, this effort was closely coordinated with bioaccumulation monitoring for the Southern California Bight Regional Monitoring Program. Every five years, dischargers in the Bight collaborate to perform this regional monitoring. Bioaccumulation monitoring is one element of the Bight Program. Before the present survey, however, the Bight Program had not performed regional monitoring of contaminants in sport fish. Most of the work for this most recent round of Bight monitoring was performed in 2008. The bioaccumulation element, however, was delayed to 2009 in order to allow coordination with the SWAMP survey. The Bight group wanted to conduct sport fish sampling, but lacks the infrastructure to perform sample collection. The Bight group therefore contributed approximately $240,000 worth of analytical work (analysis of PCBs and organochlorine pesticides in 225 samples) to the joint effort. This allowed more intensive sampling of the Bight region than either program could achieve independently.

The SWAMP survey was also coordinated with intensive sampling in San Francisco Bay by the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP). The RMP conducts thorough sampling of contaminants in sport fish in the Bay on a triennial basis (see Hunt et al. [2008] for the latest results). This sampling has been conducted since 1994. To coordinate with the SWAMP effort, the RMP analyzed additional species to allow for more extensive comparisons of the Bay with coastal areas and bays in other parts of the state. The RMP benefitted from this collaboration by SWAMP contributing: 1) a statewide dataset that will help in interpretation of RMP data and 2) the present statewide report that includes an assessment and reporting of Bay data and makes production of a separate report by the RMP unnecessary. The RMP effort represents $215,000 of sampling and analysis.

In addition, the Region 4 Water Board supplemented the statewide survey with another $110,000 to provide for more thorough coverage of the Southern California Bight.

In all, these collaborations more than doubled the total amount of SWAMP funding available for sampling and analysis in year 1 of the coastal waters survey. Each of the collaborating programs will benefit from the consistent statewide assessment, increased information due to sharing of resources, and efforts to ensure consistency in the data generated by the programs (e.g., analytical intercalibration).

SECTION 2 METHODS

SAMPLING DESIGN

The sampling plan was developed to address the three management questions for the project (Bioaccumulation Oversight Group 2009). In 2009, sampling was conducted at 42 locations in the San Francisco Bay region and in the Southern California Bight (Figures 2-1, 2-2, 2-3). Fish were collected from June through November. Cruise reports with detailed information on locations are available at www.waterboards.ca.gov/water_issues/programs/swamp/coast_study.shtml.

California has over 3000 miles of coastline that spans a diversity of habitats and fish populations, and dense human population centers with a multitude of popular fishing locations. Sampling this vast area with a limited budget is a challenge. The approach employed to sample this vast area was to divide the coast into 69 spatial units called “zones”. The use of this zone concept is consistent with the direction that OEHHA will take in the future in development of consumption guidelines for coastal areas. Advice has been issued on a pier-by-pier basis in the past in Southern California, and this approach has proven to be unsatisfactory. All of these zones were sampled (in other words, a complete census was performed), making a probabilistic sampling design unnecessary. The sampling focused on nearshore areas, including bays and estuaries, in waters not exceeding 200 m in depth, and mostly less than 60 m deep. These are the coastal waters where most of the sport fishing occurs. Popular fishing locations were identified from Jones (2004) and discussions with stakeholders. Zones were developed in consultation with Water Board staff from each of the nine regions, Bight Group stakeholders, and the BOG. Within each zone, sample collection was directed toward the most popular fishing locations. Locations shown in the map figures indicate the weighted polygon centroids to represent the latitudes and longitudes where the fish were actually collected (see cruise reports for details on each location).

The Sampling Plan (Bioaccumulation Oversight Group 2009) provides more details on the design (www.waterboards.ca.gov/water_issues/programs/swamp/coast_study.shtml).

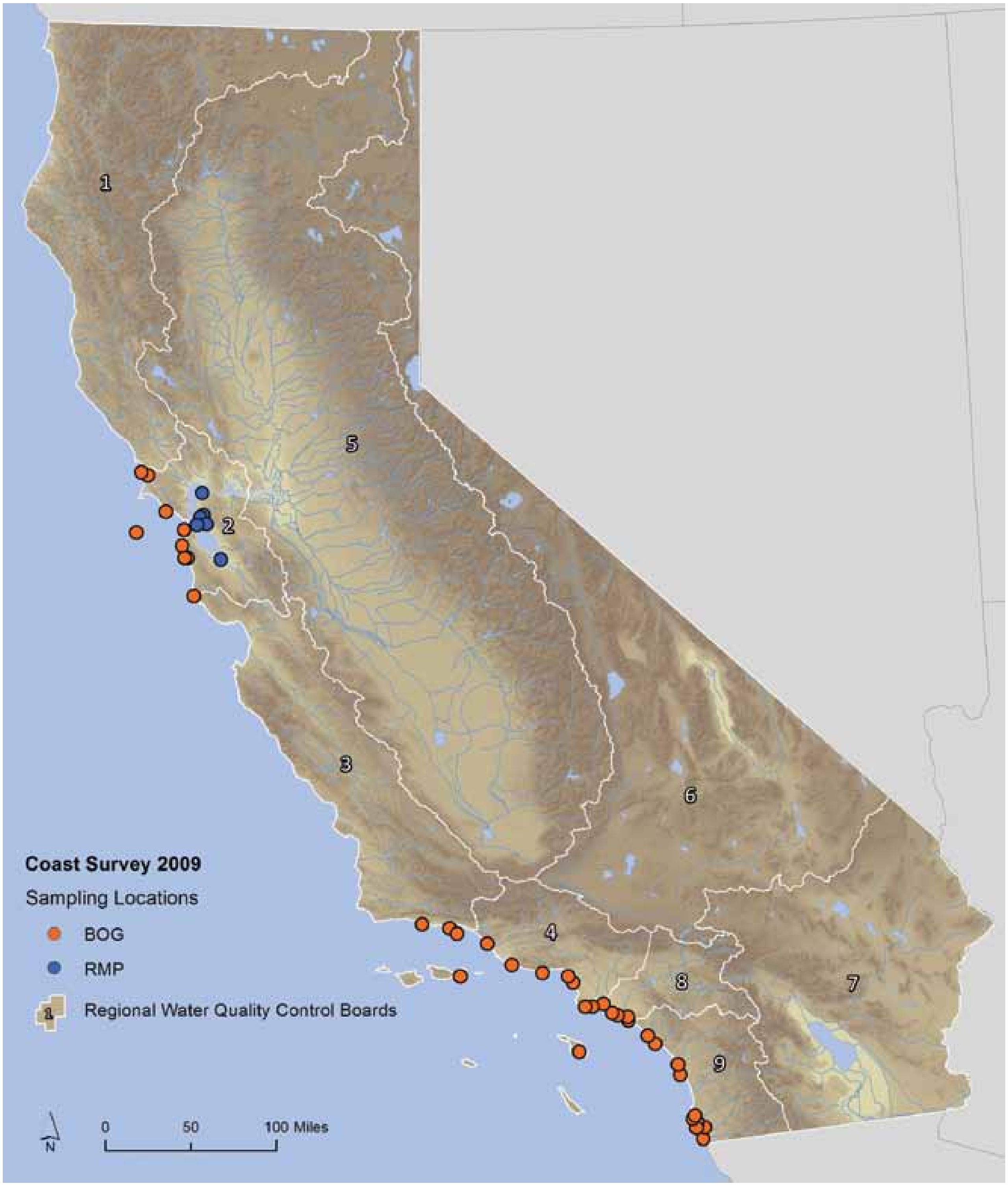


Figure 2-1. Locations sampled in 2009, the first year of the Coast Survey.

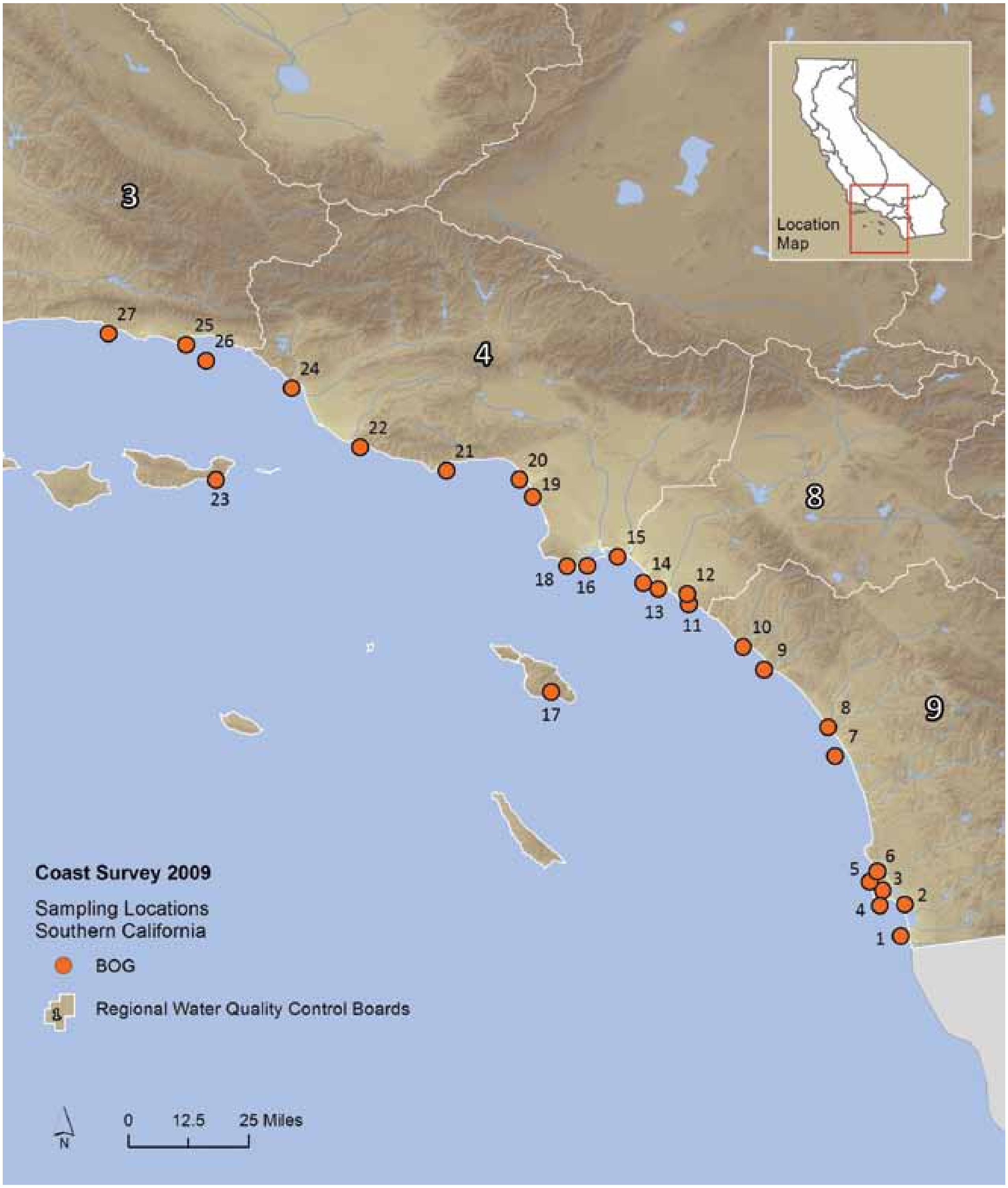


Figure 2-2. Locations sampled in 2009, the first year of the Coast Survey: Southern California. Location names are provided in Appendix 2.

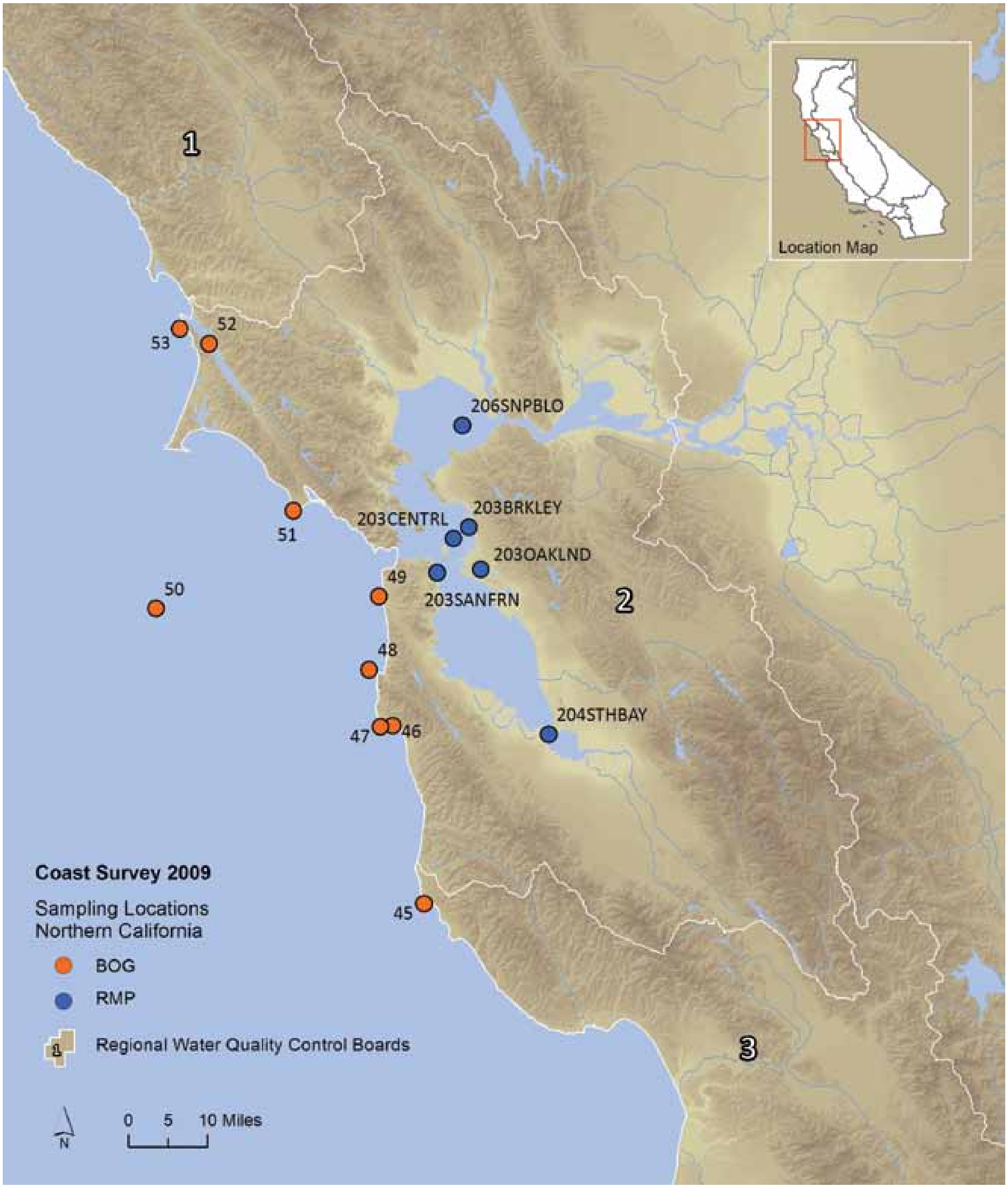


Figure 2-3. Locations sampled in 2009, the first year of the Coast Survey: Northern California. Location names are provided in Appendix 2.

TARGET SPECIES

Selecting fish species to monitor on the California coast is a complicated task due to the high diversity of species, regional variation over the considerable expanse of the state from north to south, variation in habitat and contamination between coastal waters and enclosed bays and harbors, and the varying ecological attributes of potential indicator species. The list of possibilities was narrowed down by considering the following criteria, listed in order of importance.

1. Popular for consumption
2. Sensitive indicators of problems (accumulating relatively high concentrations of contaminants)
3. Widely distributed
4. Species that accumulate relatively low concentrations of contaminants
5. Represent different exposure pathways (benthic vs pelagic)
6. Continuity with past sampling

Information relating to these criteria was presented in the Sampling Plan.

The BOG elected not to include shellfish in this survey due to the limited budget available for the survey and the lower consumption rate and concern for human health. Shellfish sampling may occur in the future if the SWAMP bioaccumulation budget is sufficient.

As recommended by USEPA (2000) in their document "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories," the primary factor considered in selecting species to monitor was a high rate of human consumption. Fortunately, good information on recreational fish catch is available from the Recreational Fisheries Information Network (RecFIN), a product of the Pacific States Marine Fisheries Commission (PSMFC). Many different taxonomic groups of fish are found on the coast (e.g., rockfish, surfperch, or sharks) and some of these groups consist of quite a diversity of species. The sampling design was based on coverage of a representative of selected groups within each zone. The popular groups varied among the three regions of the state (south, central, and north) and between coastal waters and bays and harbors.

While catch data were the primary determinant of the list of target species, some adjustments were made to ensure an appropriate degree of emphasis on sensitive indicators of contamination. Including these species is useful in assessing the issue of safe consumption (contained in MQ1) – if the sensitive indicator species in an area are below thresholds of concern then this provides an indication that all species in that area are likely to be below thresholds. Consequently, target species in this study included both high lipid species such as croaker and surfperch that are strong accumulators of organics, and predators that accumulate mercury such as sharks. A summary of basic ecological attributes of the target species was provided in the Sampling Plan.

Table 2-1
Scientific and common names of fish species collected, the number of locations in which they were sampled, their minimum, median, and maximum total lengths (mm), and whether they were analyzed as composites or individuals. Species marked as "analyzed for individuals" were analyzed as individuals for mercury only.

Family	Species Name	Common Name	Number of Fish	Number of Samples	Number of Locations Sampled	Min Length (mm)	Median Length (mm)	Max Length (mm)	Analyzed As Composite	Analyzed As Individual
Anchovies (Engraulidae)	*Engraulis mordax*	Northern Anchovy	337	9	2	65	89	126	X	
Barracudas (Sphyraenidae)	*Sphyraena argentea*	Pacific Barracuda	4	1	1	450	479	590	X	
Basses (Serranidae)	*Paralabrax nebulifer*	Barred Sand Bass	113	21	14	257	346	590	X	X
Basses (Serranidae)	*Paralabrax clathratus*	Kelp Bass	261	49	18	185	316	512	X	X
Basses (Serranidae)	*Paralabrax maculatofasciatus*	Spotted Sand Bass	63	12	4	195	327	430	X	X
Croaker (Sciaenidae)	*Cheilotrema saturnum*	Black Croaker	3	1	1	234	242	261	X	
Croaker (Sciaenidae)	*Seriphus politus*	Queenfish	4	1	1	156	165	174	X	
Croaker (Sciaenidae)	*Roncador stearnsii*	Spotfin Croaker	15	3	3	138	221	372	X	
Croaker (Sciaenidae)	*Genyonemus lineatus*	White Croaker	283	69	22	164	218	300	X	
Croaker (Sciaenidae)	*Umbrina roncador*	Yellowfin Croaker	50	10	4	121	195	376	X	
Dogfish Sharks (Squalidae)	*Squalus acanthias*	Spiny dogfish	3	1	1	995	1011	1140	X	
Hound Sharks (Triakidae)	*Mustelus henlei*	Brown Smooth-hound Shark	12	4	4	826	978	1144	X	
Hound Sharks (Triakidae)	*Mustelus californicus*	Gray Smoothhound Shark	6	2	2	616	630	685	X	
Hound Sharks (Triakidae)	*Triakis semifasciata*	Leopard shark	12	5	4	930	1153	1230	X	X
Lingcod (Hexagrammidae)	*Ophiodon elongatus*	Lingcod	7	2	2	610	671	822	X	
Mackerels (Scombridae)	*Scomber japonicus*	Chub Mackerel	290	58	20	199	240	335	X	

Family	*Species Name*	Common Name	Number of Fish	Number of Samples	Number of Locations Sampled	Min Length (mm)	Median Length (mm)	Max Length (mm)	Analyzed As Composite	Analyzed As Individual
New World Silversides (Atherinopsidae)	*Atherinops affinis*	Topsmelt	135	6	6	101	136	377	X	
Rockfish (Scorpaenidae)	*Sebastes melanops*	Black Rockfish	5	2	1	302	325	368	X	X
Rockfish (Scorpaenidae)	*Sebastes mystinus*	Blue Rockfish	23	6	5	215	270	395	X	X
Rockfish (Scorpaenidae)	*Sebastes auriculatus*	Brown Rockfish	28	6	6	205	287	392	X	
Rockfish (Scorpaenidae)	*Sebastes carnatus*	Gopher Rockfish	49	10	10	147	239	323	X	
Rockfish (Scorpaenidae)	*Sebastes atrovirens*	Kelp Rockfish	5	1	1	281	291	294	X	
Rockfish (Scorpaenidae)	*Sebastes serranoides*	Olive Rockfish	24	5	4	208	305	405	X	X
Rockfish (Scorpaenidae)	*Sebastes rosaceus*	Rosy Rockfish	5	1	1	175	196	202	X	
Rockfish (Scorpaenidae)	*Scorpaena plumieri*	Spotted Scorpionfish	10	2	2	200	290	322	X	
Rockfish (Scorpaenidae)	*Sebastes flavidus*	Yellowtail Rockfish	3	1	1	296	311	323	X	
Sand Flounder (Paralichthyidae)	*Paralichthys californicus*	California Halibut	9	3	3	580	680	730	X	
Sea Chubs (Kyphosidae)	*Girella nigricans*	Opaleye	5	1	1	194	221	230	X	
Sturgeons (Acipenseridae)	*Acipenser transmontanus*	White Sturgeon	12	5	2	1170	1270	1560	X	X
Surfperch (Embiotocidae)	*Amphistichus argenteus*	Barred Surfperch	51	8	7	122	193	363	X	X
Surfperch (Embiotocidae)	*Embiotoca jacksoni*	Black Perch	85	11	10	152	232	316	X	X
Surfperch (Embiotocidae)	*Cymatogaster aggregata*	Shiner Surfperch	478	25	15	51	111	199	X	X
Surfperch (Embiotocidae)	*Phanerodon furcatus*	White Surfperch	69	8	7	99	202	345	X	X
Temperate Basses (Moronidae)	*Morone saxatilis*	Striped Bass	18	7	2	460	600	790	X	X
Tilefishes (Malacanthidae)	*Caulolatilus princeps*	Ocean Whitefish	5	1	1	270	279	286	X	

A list of the species collected in year one of the Coast Survey is provided in Table 2-1. Table 2-1 also includes information on the number of locations sampled, fish sizes, and how the fish were processed. Statewide maps showing the locations sampled (as well as the concentrations measured) for each species can be obtained from the My Water Quality portal (www.swrcb.ca.gov/mywaterquality/safe_to_eat/data_and_trends/).

SAMPLE PROCESSING

Dissection and compositing of muscle tissue samples were performed following USEPA guidance (USEPA 2000). In general, fish were dissected skin-off, and only the fillet muscle tissue was used for analysis. Some species (e.g., shiner surfperch) were too small to be filleted and were processed whole but with head, tail, and viscera removed. Other exceptions are noted in the discussion of results in Sections 3 through 5.

CHEMICAL ANALYSIS

Mercury and Selenium

Nearly all (>95%) of the mercury present in fish is methylmercury (Wiener et al. 2007). Consequently, monitoring programs usually analyze total mercury as a proxy for methylmercury, as was done in this study. USEPA (2000) recommends this approach, and the conservative assumption be made that all mercury is present as methylmercury to be most protective of human health. Total mercury and selenium in all samples were measured by Moss Landing Marine Laboratory (Moss Landing, CA). Detection limits for total mercury and all of the other analytes are presented in Table 2-2. Analytical methods for mercury and the other contaminants were described in the Sampling Plan (Bioaccumulation Oversight Group 2009). Mercury was analyzed according to EPA 7473, "Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry" using a Direct Mercury Analyzer. Selenium was digested according to EPA 3052M, "Microwave Assisted Acid Digestion of Siliceous and Organically Based Matrices", modified, and analyzed according to EPA 200.8, "Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry." Mercury and selenium results were reportable for 99% of the samples analyzed.

Organics

PCBs and legacy pesticides in the Bay were analyzed by the California Department of Fish and Game Water Pollution Control Laboratory (Rancho Cordova, CA). Organochlorine pesticides were analyzed according to EPA 8081AM, "Organochlorine Pesticides by Gas Chromatography." PCBs were analyzed according to EPA 8082M, "Polychlorinated Biphenyls (PCBs) by Gas Chromatography".

PCBs are reported as the sum of 55 congeners (Table 2-2). Concentrations in many locations were near or

Table 2-2
Analytes included in the study, detection limits, number of observations, and frequencies of detection and reporting. Frequency of detection includes all results above detection limits. Frequency of reporting includes all results that were reportable (above the detection limit and passing all QA review). Units for the MDLs are ppm for mercury and selenium, parts per trillion for dioxins and furans, and ppb for the other organics.

Laboratory	Class	Analyte	Method Detection Limit	Number of Observations	Frequency of Detection (%)	Frequency of Reporting (%)
MPSL-DFG	MERCURY	Mercury	0.01	905	99%	99%
MPSL-DFG	SELENIUM	Selenium	0.15	343	99%	99%
DFG-WPCL	CHLORDANE	Chlordane, trans-	0.45	235	34%	29%
DFG-WPCL	CHLORDANE	Oxychlordane	0.47	235	6%	6%
DFG-WPCL	CHLORDANE	Chlordane, cis-	0.40	235	41%	41%
DFG-WPCL	CHLORDANE	Nonachlor, cis-	0.31	235	39%	39%
DFG-WPCL	CHLORDANE	Nonachlor, trans-	0.19	235	77%	77%
DFG-WPCL	DDT	DDT(p,p')	0.15	235	50%	50%
DFG-WPCL	DDT	DDT(o,p')	0.21	235	4%	4%
DFG-WPCL	DDT	DDE(p,p')	0.60	235	100%	99%
DFG-WPCL	DDT	DDE(o,p')	0.18	235	30%	30%
DFG-WPCL	DDT	DDD(o,p')	0.10	235	30%	30%
DFG-WPCL	DDT	DDD(p,p')	0.12	235	78%	78%
DFG-WPCL	DIELDRIN	Dieldrin	0.43	235	31%	25%
DFG-WPCL	PCB	PCB 008	0.20	235	0%	0%
DFG-WPCL	PCB	PCB 018	0.20	235	6%	6%
DFG-WPCL	PCB	PCB 027	0.20	235	0%	0%
DFG-WPCL	PCB	PCB 028	0.20	235	37%	37%
DFG-WPCL	PCB	PCB 029	0.20	235	0%	0%
DFG-WPCL	PCB	PCB 031	0.20	235	16%	16%
DFG-WPCL	PCB	PCB 033	0.20	235	2%	2%
DFG-WPCL	PCB	PCB 044	0.20	235	41%	41%
DFG-WPCL	PCB	PCB 049	0.20	235	52%	52%
DFG-WPCL	PCB	PCB 052	0.20	235	70%	70%
DFG-WPCL	PCB	PCB 056	0.20	235	6%	6%
DFG-WPCL	PCB	PCB 060	0.20	235	9%	9%
DFG-WPCL	PCB	PCB 064	0.20	235	10%	10%

Laboratory	Class	Analyte	Method Detection Limit	Number of Observations	Frequency of Detection (%)	Frequency of Reporting (%)
DFG-WPCL	PCB	PCB 066	0.20	235	61%	61%
DFG-WPCL	PCB	PCB 070	0.30	235	40%	40%
DFG-WPCL	PCB	PCB 074	0.20	235	44%	44%
DFG-WPCL	PCB	PCB 077	0.20	235	3%	3%
DFG-WPCL	PCB	PCB 087	0.30	235	43%	43%
DFG-WPCL	PCB	PCB 095	0.30	235	58%	58%
DFG-WPCL	PCB	PCB 097	0.20	235	50%	50%
DFG-WPCL	PCB	PCB 099	0.20	235	82%	81%
DFG-WPCL	PCB	PCB 101	0.34	235	82%	81%
DFG-WPCL	PCB	PCB 105	0.20	235	71%	71%
DFG-WPCL	PCB	PCB 110	0.30	235	71%	71%
DFG-WPCL	PCB	PCB 114	0.20	235	2%	2%
DFG-WPCL	PCB	PCB 118	0.32	235	82%	80%
DFG-WPCL	PCB	PCB 126	0.20	235	0%	0%
DFG-WPCL	PCB	PCB 128	0.20	235	59%	59%
DFG-WPCL	PCB	PCB 132	0.20	68	97%	97%
DFG-WPCL	PCB	PCB 137	0.20	235	20%	20%
DFG-WPCL	PCB	PCB 138	0.24	235	91%	90%
DFG-WPCL	PCB	PCB 141	0.20	235	40%	40%
DFG-WPCL	PCB	PCB 146	0.20	235	54%	54%
DFG-WPCL	PCB	PCB 149	0.20	235	77%	76%
DFG-WPCL	PCB	PCB 151	0.20	235	53%	53%
DFG-WPCL	PCB	PCB 153	0.38	235	94%	94%
DFG-WPCL	PCB	PCB 156	0.20	235	39%	39%
DFG-WPCL	PCB	PCB 157	0.20	235	9%	9%
DFG-WPCL	PCB	PCB 158	0.20	235	41%	41%
DFG-WPCL	PCB	PCB 169	0.20	235	0%	0%
DFG-WPCL	PCB	PCB 170	0.20	235	59%	59%
DFG-WPCL	PCB	PCB 174	0.20	235	40%	40%
DFG-WPCL	PCB	PCB 177	0.20	235	49%	49%
DFG-WPCL	PCB	PCB 180	0.20	235	77%	77%
DFG-WPCL	PCB	PCB 183	0.20	235	57%	57%
DFG-WPCL	PCB	PCB 187	0.20	235	76%	75%
DFG-WPCL	PCB	PCB 189	0.20	235	2%	2%

Laboratory	Class	Analyte	Method Detection Limit	Number of Observations	Frequency of Detection (%)	Frequency of Reporting (%)
DFG-WPCL	PCB	PCB 194	0.20	235	46%	46%
DFG-WPCL	PCB	PCB 195	0.20	235	19%	19%
DFG-WPCL	PCB	PCB 198	0.20	68	100%	100%
DFG-WPCL	PCB	PCB 198/199	0.20	167	1%	1%
DFG-WPCL	PCB	PCB 199	0.20	68	3%	3%
DFG-WPCL	PCB	PCB 200	0.20	235	19%	19%
DFG-WPCL	PCB	PCB 201	0.20	235	54%	54%
DFG-WPCL	PCB	PCB 203	0.20	235	41%	41%
DFG-WPCL	PCB	PCB 206	0.20	235	33%	33%
DFG-WPCL	PCB	PCB 209	0.20	235	16%	16%
AXYS	DIOXIN	TCDD, 2,3,7,8-	0.05	34	100%	100%
AXYS	DIOXIN	TCDF, 2,3,7,8-	0.06	34	100%	100%
AXYS	DIOXIN	PeCDD, 1,2,3,7,8-	0.05	34	100%	100%
AXYS	DIOXIN	PeCDF, 1,2,3,7,8-	0.05	34	91%	91%
AXYS	DIOXIN	PeCDF, 2,3,4,7,8-	0.05	34	97%	97%
AXYS	DIOXIN	HxCDD, 1,2,3,4,7,8-	0.05	34	50%	50%
AXYS	DIOXIN	HxCDD, 1,2,3,6,7,8-	0.05	34	91%	91%
AXYS	DIOXIN	HxCDD, 1,2,3,7,8,9-	0.05	34	32%	32%
AXYS	DIOXIN	HxCDF, 1,2,3,4,7,8-	0.05	34	21%	21%
AXYS	DIOXIN	HxCDF, 1,2,3,6,7,8-	0.05	34	26%	26%
AXYS	DIOXIN	HxCDF, 1,2,3,7,8,9-	0.05	34	6%	6%
AXYS	DIOXIN	HxCDF, 2,3,4,6,7,8-	0.05	34	21%	21%
AXYS	DIOXIN	HpCDD, 1,2,3,4,6,7,8-	0.05	34	94%	94%
AXYS	DIOXIN	HpCDF, 1,2,3,4,6,7,8-	0.05	34	32%	32%
AXYS	DIOXIN	HpCDF, 1,2,3,4,7,8,9-	0.05	34	3%	3%
AXYS	DIOXIN	OCDD, 1,2,3,4,6,7,8,9-	0.05	34	97%	9%
AXYS	DIOXIN	OCDF, 1,2,3,4,6,7,8,9-	0.05	34	21%	21%
AXYS	PFC	Perfluorooctanesulfonamide	2.47	21	10%	10%
AXYS	PFC	Perfluorononanoate	2.47	21	0%	0%
AXYS	PFC	Perfluorooctanoate	2.47	21	0%	0%
AXYS	PFC	Perfluorohexanoate	2.47	21	0%	0%
AXYS	PFC	Perfluoropentanoate	2.47	21	0%	0%
AXYS	PFC	Perfluorohexanesulfonate	4.93	21	0%	0%

Laboratory	Class	Analyte	Method Detection Limit	Number of Observations	Frequency of Detection (%)	Frequency of Reporting (%)
AXYS	PFC	Perfluoroheptanoate	2.47	21	0%	0%
AXYS	PFC	Perfluorooctanesulfonate	4.93	21	19%	19%
AXYS	PFC	Perfluorobutanesulfonate	4.93	21	0%	0%
AXYS	PFC	Perfluoroundecanoate	2.47	21	0%	0%
AXYS	PFC	Perfluorododecanoate	2.47	21	0%	0%
AXYS	PFC	Perfluorodecanoate	2.47	21	0%	0%
AXYS	PFC	Perfluorobutanoate	2.47	21	0%	0%

below limits of detection (Table 2-2). The congeners contributing most to sum of PCBs were detected in 70-94% of the 235 samples analyzed for PCBs. Frequencies of detection and reporting were lower for the less abundant PCB congeners that have a smaller influence on sum of PCBs. For PCBs and all of the organics presented as "sums," the sums were calculated with values for samples with concentrations below the limit of detection set to zero.

DDTs are reported as the sum of six isomers (Table 2-2). Chlordanes are reported as the sum of five compounds (Table 2-2).

Dioxins and perfluorinated chemicals (PFCs) in muscle tissue were measured by AXYS Analytical (Sidney, British Columbia, Canada). Dioxins and furans were analyzed using EPA method 1613B Mod using a high-resolution mass spectrometer coupled to a high-resolution gas chromatograph. Perfluorinated compounds were analyzed using MLA-043 Revision 07 on a high performance liquid chromatograph coupled to a triple quadrupole mass spectrometer. Dioxins are reported as dioxin toxic equivalents (TEQs) based on analysis of 17 dioxin and furan congeners (Table 2-2). Derivation of toxic equivalents is described in Section 5. The congeners contributing most to TEQs were detected in 90-100% of the 34 samples analyzed for dioxins. Frequencies of detection and reporting were lower for the less abundant congeners.

Frequencies of detection for the PFCs were low, with only one compound (perfluorooctanesulfonate) detected, and this compound was detected in only four of the 21 samples analyzed.

QUALITY ASSURANCE

The samples were analyzed in multiple batches. QAQC analyses for SWAMP Data Quality Objectives (DQOs) (precision, accuracy, recovery, completeness, and sensitivity) were performed for each batch as required by the SWAMP BOG QAPP (Bonnema 2009).

Data that meet all measurement quality objectives (MQOs) as specified in the QAPP are classified as "compliant" and considered usable without further evaluation. Data that fail to meet all program MQOs specified in the Coastal QAPP were classified as qualified but considered usable for the intended purpose. Data that are > 2X MQO requirements or the result of blank contamination were classified as "rejected" and considered unusable. Data batches where results were not reported and therefore not validated were classified as not applicable.

For the SWAMP labs (Moss Landing Marine Laboratory and the Water Pollution Control Laboratory), there were 20,946 sample results for individual constituents including tissue composites and laboratory QA/QC samples. Of these:

- 20,448 (98%) were classified as "compliant"
- 346 (1.6%) were classified as "qualified"
- 22 (0.1%) were classified as "rejected"; and
- 130 (0.6%) were classified as "NA", since the results were not reported due to high native concentrations greater than spike concentrations and could not be validated.

Classification of this dataset is summarized as follows:

- 4 results were classified as "rejected" and 10 results were classified as "qualified" due to blank contamination values.
- 6 results were classified as "qualified" due to surrogate recovery exceedances presented in Table 2 (Appendix 1).
- All results were classified as "qualified" due to recovery exceedances presented in Tables 3 and 4 (Appendix 1).
- 324 results were classified as "qualified" and 18 results were classified as "rejected" due to the precision (RPD) exceedances presented in Tables 3 and 5 (Appendix 1).
- 6 results were classified as "qualified" due to holding time exceedances.

Overall, all data with the exception of the 22 rejected results were considered usable for the intended purpose. A 99% completeness level was attained which met the 90% project completeness goal specified in the Coastal QAPP. Additional details are provided in Appendix 1.

ASSESSMENT THRESHOLDS

This report compares fish tissue concentrations to two types of thresholds for concern for pollutants in sport fish that were developed by OEHHA (Klasing and Brodberg 2008): Fish Contaminant Goals (FCGs) and Advisory Tissue Levels (ATLs) (Table 2-3).

FCGs, as described by Klasing and Brodberg (2008), are "estimates of contaminant levels in fish that pose no significant health risk to humans consuming sport fish at a standard consumption rate of one serving per

Table 2-3
Thresholds for concern based on an assessment of human health risk from these pollutants by OEHHA (Klasing and Brodberg, 2008). All values given in ng/g (ppb) wet weight. The lowest available threshold for each pollutant is in bold font. One serving is defined as 8 ounces (227 g) prior to cooking. The FCG and ATLs for mercury are for the most sensitive population (i.e., women aged 18 to 45 years and children aged 1 to 17 years).

Pollutant	Fish Contaminant Goal	Advisory Tissue Level (3 servings/week)	Advisory Tissue Level (2 servings/week)	Advisory Tissue Level (No Consumption)
Chlordanes	**5.6**	190	280	560
DDTs	**21**	520	1000	2100
Dieldrin	**0.46**	15	23	46
Mercury	220	**70**	150	440
PCBs	**3.6**	21	42	120
Selenium	7400	**2500**	4900	15000
PBDEs	310	100	210	630

week (or eight ounces [before cooking] per week, or 32 g/day), prior to cooking, over a lifetime and can provide a starting point for OEHHA to assist other agencies that wish to develop fish tissue-based criteria with a goal toward pollution mitigation or elimination. FCGs prevent consumers from being exposed to more than the daily reference dose for non-carcinogens or to a risk level greater than $1x10^{-6}$ for carcinogens (not more than one additional cancer case in a population of 1,000,000 people consuming fish at the given consumption rate over a lifetime). FCGs are based solely on public health considerations without regard to economic considerations, technical feasibility, or the counterbalancing benefits of fish consumption." For organic pollutants, FCGs are lower than ATLs.

ATLs, as described by Klasing and Brodberg (2008), "while still conferring no significant health risk to individuals consuming sport fish in the quantities shown over a lifetime, were developed with the recognition that there are unique health benefits associated with fish consumption and that the advisory process should be expanded beyond a simple risk paradigm in order to best promote the overall health of the fish consumer. ATLs provide numbers of recommended fish servings that correspond to the range of contaminant concentrations found in fish and are used to provide consumption advice to prevent consumers from being exposed to more than the average daily reference dose for non-carcinogens or to a risk level greater than $1x10^{-4}$ for carcinogens (not more than one additional cancer case in a population of 10,000 people consuming fish at the given consumption rate over a lifetime). ATLs are designed to encourage consumption of fish that can be eaten in quantities likely to provide significant health benefits, while discouraging consumption of fish that, because of contaminant concentrations, should not be eaten or cannot be eaten in amounts recommended for improving overall health (eight ounces total, prior to cooking, per week). ATLs are but one component of a complex process of data evaluation and interpretation used by OEHHA in the assessment and communication of fish consumption risks. The nature of the contaminant data or omega-3 fatty acid concentrations in a given species in a water body, as well as risk communication needs, may alter strict application of ATLs when developing site-specific advisories. For example, OEHHA may recommend that consumers eat fish containing low levels of omega-3 fatty acids less often than the ATL table would suggest based solely on contaminant concentrations. OEHHA uses ATLs as a framework, along with best professional judgment, to provide fish consumption guidance on an ad hoc basis that best combines the needs for health protection and ease of communication for each site." For methylmercury and selenium, the 3 serving and 2 serving ATLs are lower than the FCGs.

Consistent with the description of ATLs above, the assessments presented in this report are not intended to represent consumption advice.

For methylmercury, results were also compared to a 0.3 ppm threshold that was used by the State and Regional Water Boards in the most recent round of 303(d) listing.

The results for San Francisco Bay were also compared to thresholds developed for the Bay by the San Francisco Bay Regional Water Quality Control Board. These thresholds are described in Section 5.

SECTION 3
STATEWIDE ASSESSMENT

In 2009, the first year of this statewide screening study, 2291 fish from 36 species were collected from 42 locations on the California coast (Figures 2-1, 2-2, 2-3, Table 2-1). A concise tabulated summary of the data for each location is provided in Appendix 2. Data in an untabulated format are provided in Appendices 3-5. Excel files containing these tables are available from SFEI (contact Jay Davis, jay@sfei.org). All data collected for this study are maintained in the SWAMP database, which is managed by the data management team at Moss Landing Marine Laboratories (http://swamp.mpsl.mlml.calstate.edu/). The complete dataset includes QA data (quality control samples and blind duplicates) and additional ancillary information (specific location information, fish sex, weights, etc). The complete dataset from this study will also be available on the web at http://www.ceden.org/. Finally, data from this study are available on the web through the California Water Quality Monitoring Council's "My Water Quality" portal (http://www.waterboards.ca.gov/mywaterquality/). This site is designed to present data on contaminants in fish and shellfish from SWAMP and other programs to the public in a nontechnical manner, and allows mapping and viewing of summary data from each fishing location.

This section presents a preliminary statewide assessment of the year one results, which represent the most urbanized portions of the California coast. A more thorough analysis and discussion of results for the entire coast will be presented in the report on the complete dataset, including the less urbanized stretches of coast sampled in 2010, which will be available in spring of 2012.

METHYLMERCURY

Comparison to Thresholds

Based on results from the first year of the statewide survey, methylmercury and PCBs are the pollutants that pose the most widespread potential health concerns to consumers of fish caught in urbanized regions of the California coast.

Considering the complete dataset (including shark species) for the year one sampling, methylmercury occasionally reached concentrations high enough that OEHHA would consider recommending no consumption of the contaminated species (0.44 ppm wet weight). Overall, eight of the 42 locations surveyed (19%) had a species with an average concentration exceeding 0.44 ppm (Figures 3-1 and 3-2). The 95% confidence interval for this estimate was 7 – 31% (Figure 3-2). Most of the locations sampled (33 of 42, or 79%) were in the moderate contamination categories (above 0.07 ppm and below 0.44 ppm). Thirteen of 42 locations had a species with an average above the State Board's 0.30 ppm 303(d) listing threshold.

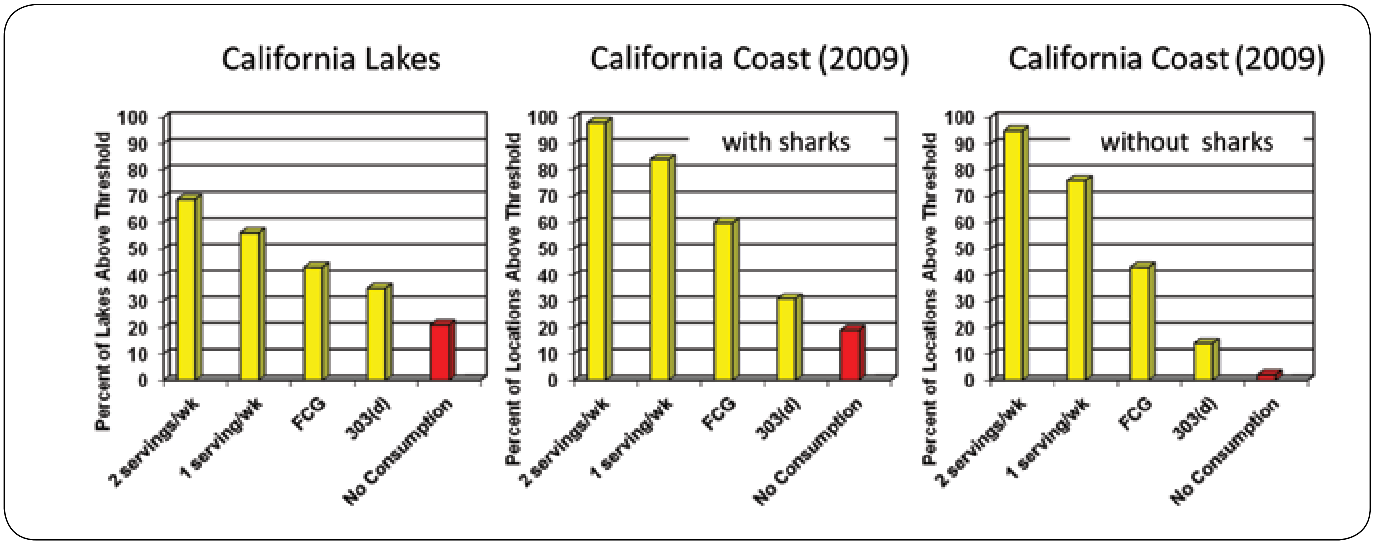


Figure 3-1. Percentages of lakes or coastal sampling locations above various methylmercury thresholds. Based on the highest species average concentration for each lake or location.

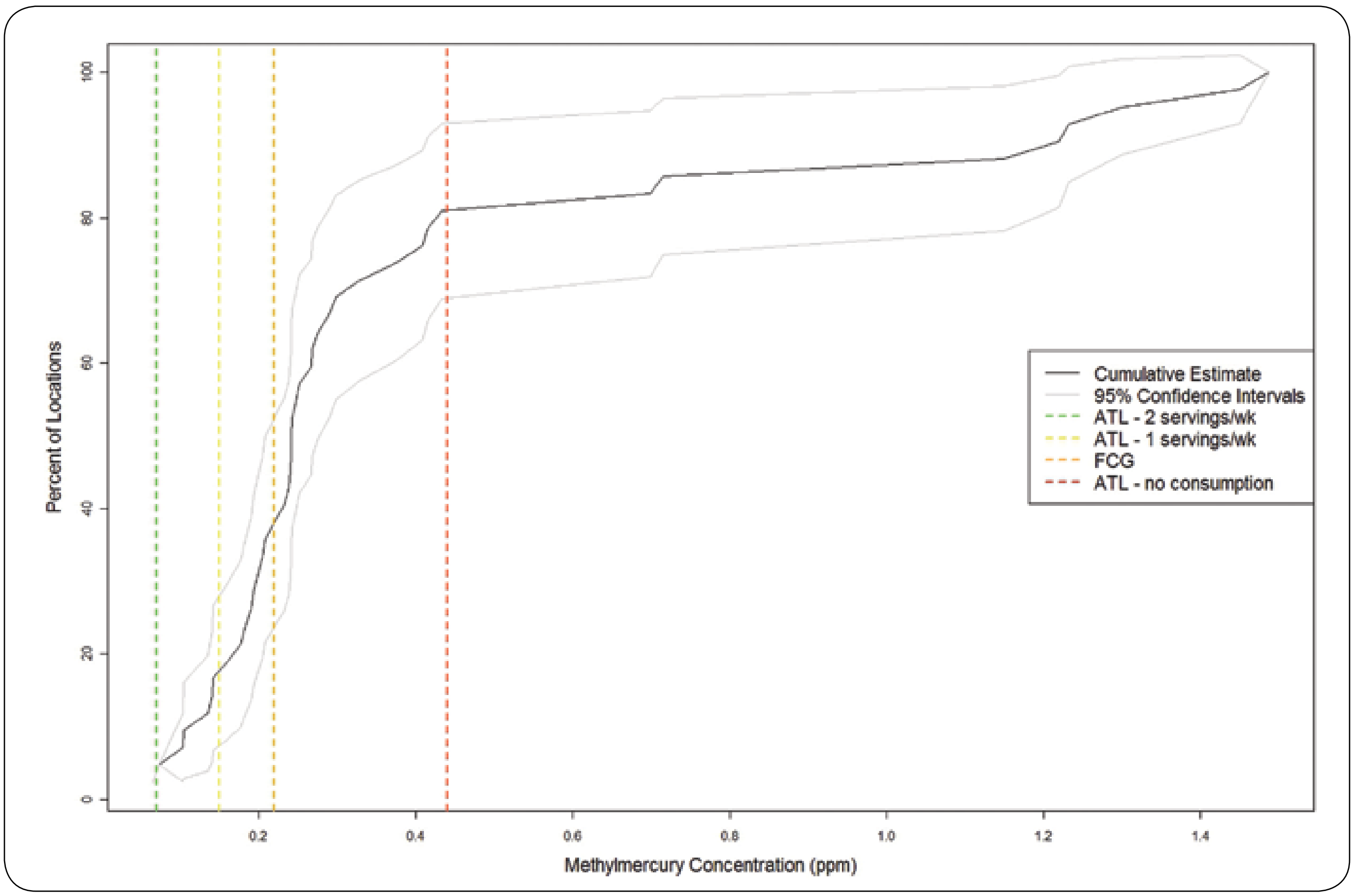


Figure 3-2. Cumulative distribution function (CDF) plot for mercury at locations sampled in 2009, shown as percent of locations sampled. Based on the highest species average concentration (ppm) for each location. Vertical lines are threshold values.

The degree of methylmercury contamination observed in the urban coastal areas sampled in 2009 was comparable to that observed in the two-year Lakes Survey (Davis et al. 2010) (Figure 3-1). Relative to the lakes results, the year one coast sampling found higher proportions of locations exceeding the lower OEHHA thresholds (the FCG of 0.22 ppm, the 1 serving per week ATL of 0.15 ppm, and the 2 serving per week ATL of 0.07 ppm). Another way of expressing this is that there was a higher proportion of water bodies below all thresholds for lakes (32%) than for the year one coast locations (2%).

One major factor behind this difference between the lakes results and the year one coast results is the focus of the initial coastal sampling on urban areas. Another important factor is the significant proportion of lakes where trout were the most abundant predator species. Trout generally occupy a lower trophic position than predatory fish species in other California water bodies (such as the coastal locations sampled in this survey), and also tend to have lower methylmercury concentrations due to the widespread presence of hatchery transplants that have been shown to have lower concentrations in previous studies (Grenier et al. 2007). Another factor was the broader spectrum of species present in coastal waters and sampled in this survey, which made it more likely to include a higher trophic level representative with higher concentrations. Finally, the urban focus of the 2009 sampling may have also been a factor.

Shark species in California and in other parts of the world often accumulate exceptionally high concentrations of methylmercury (Davis et al. 2006) (Figure 3-3). The reason for the unusually high concentrations observed in some shark species is not known. Trophic position is an important factor explaining variation among some shark species, but trophic position does not explain why some shark species have much higher concentrations than other co-located species with a similar or higher trophic position. A prime example of this is with leopard shark and striped bass in San Francisco Bay (discussed further in Section 5). Most of the year one locations with methylmercury concentrations above 0.44 ppm fell in that category because of a shark species. If the shark data are excluded, the apparent severity of methylmercury problem on the coast is considerably less (Figure 3-1), with only 2% (one of 42 locations) exceeding 0.44 ppm. Excluding shark species did not greatly affect the percentages in the lower concentration categories.

Variation Among Species

Several shark species accumulated higher methylmercury concentrations than other species sampled in year one of the survey (Figure 3-3). Average concentrations above 0.44 ppm were observed for three shark species: spiny dogfish (1.30 ppm), leopard shark (1.28 ppm), and brown smoothhound shark (0.92 ppm). The fourth shark species sampled, gray smoothhound, had a lower average of 0.29 ppm.

Striped bass, collected only in San Francisco Bay, was the one other species that had an average methylmercury concentration (0.45 ppm) above 0.44 ppm. Other species with relatively high methylmercury concentrations included black croaker (0.41 ppm), California halibut (0.22 ppm), gopher rockfish (0.25

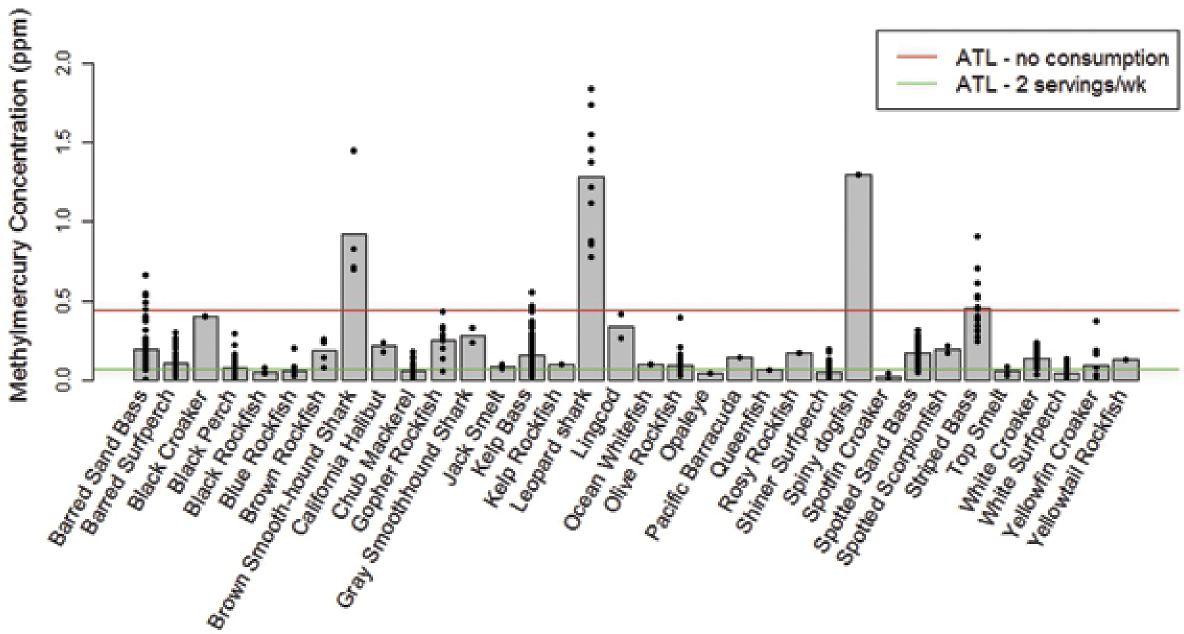


Figure 3-3. Methylmercury concentrations (ppm) in sport fish species on the California coast, 2009. Bars indicate average concentration. Points represent individual samples (either composites or individual fish). Note that the averages for some species (e.g., spiny dogfish) are based on only one sample.

ppm), and lingcod (0.34 ppm). However, the number of samples analyzed for these species was small, except for gopher rockfish (n = 10 composites).

Several species had average methylmercury concentrations below all thresholds, including black rockfish (0.05 ppm), blue rockfish (0.06 ppm), chub mackerel (0.06 ppm), opaleye (0.05 ppm), queenfish (0.07 ppm), shiner surfperch (0.05 ppm), spotfin croaker (0.02 ppm), topsmelt (0.05 ppm), and white surfperch (0.04 ppm). The estimate for chub mackerel is particularly robust, based on measurements in 58 composite samples. This is a positive outcome as chub mackerel is one of the most popular sport fish species on the southern California coast.

Spatial Patterns

Methylmercury concentrations at locations sampled in year one did not exhibit distinct variation on a regional scale (Figure 3-4). For the complete dataset (including sharks), the distribution of locations in the highest concentration category (above 0.44 ppm) was primarily a function of whether sharks were obtained. Seven of the locations in this category had a shark species with an average concentration above 0.44 ppm.

Excluding the shark species highlights spatial patterns among the other species (Figure 3-5). The one location with a species average above 0.44 ppm was San Pablo Bay in northern San Francisco Bay (striped bass at 0.47 ppm). Five locations had a species average between 0.30 ppm and 0.44 ppm, including (from

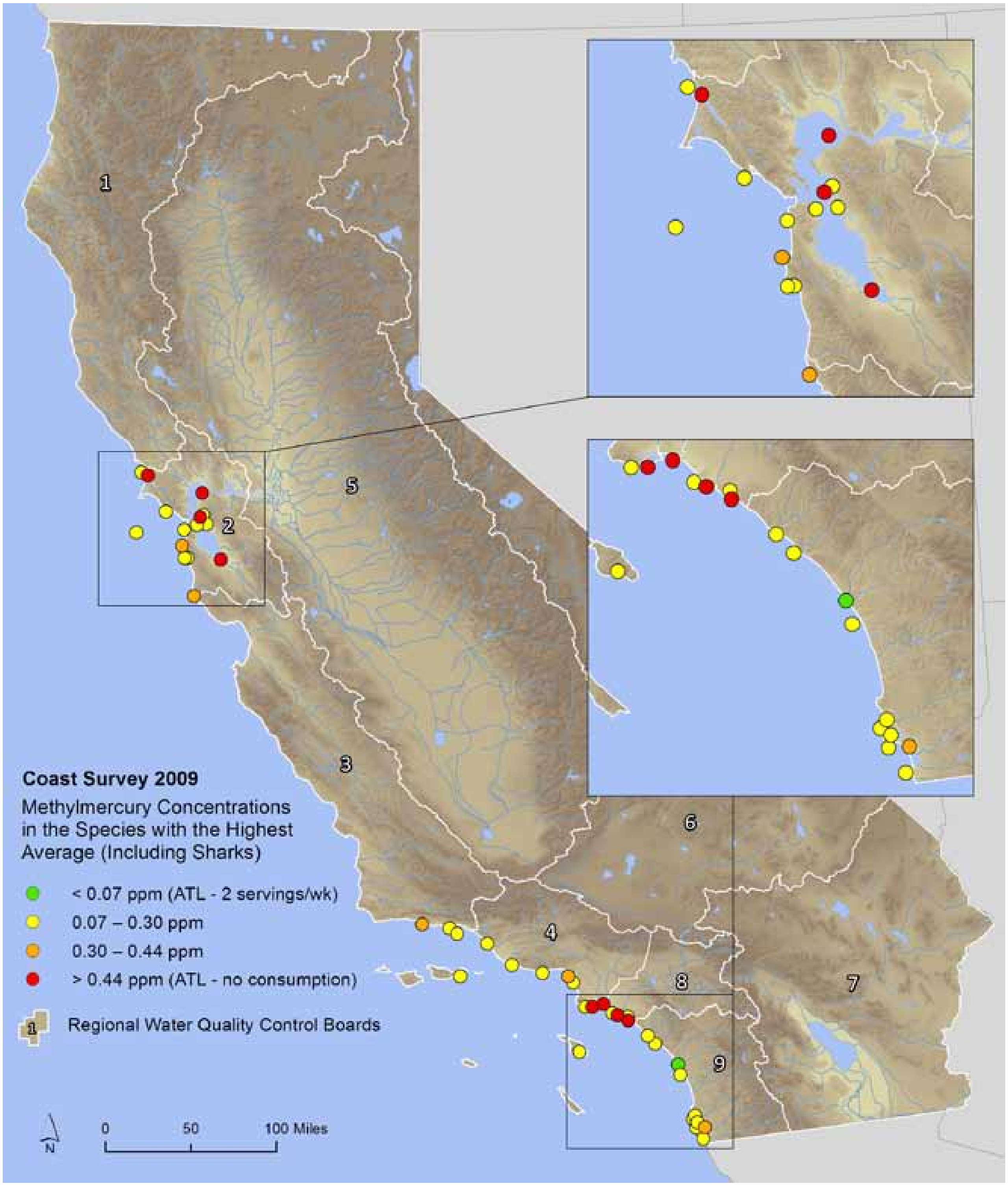


Figure 3-4. Spatial patterns in methylmercury concentrations (ng/g wet weight) among locations sampled in the Coast Survey, 2009. Each point represents the highest average methylmercury concentration among the species sampled at each location (including sharks). Concentrations based on location composites and individual fish.

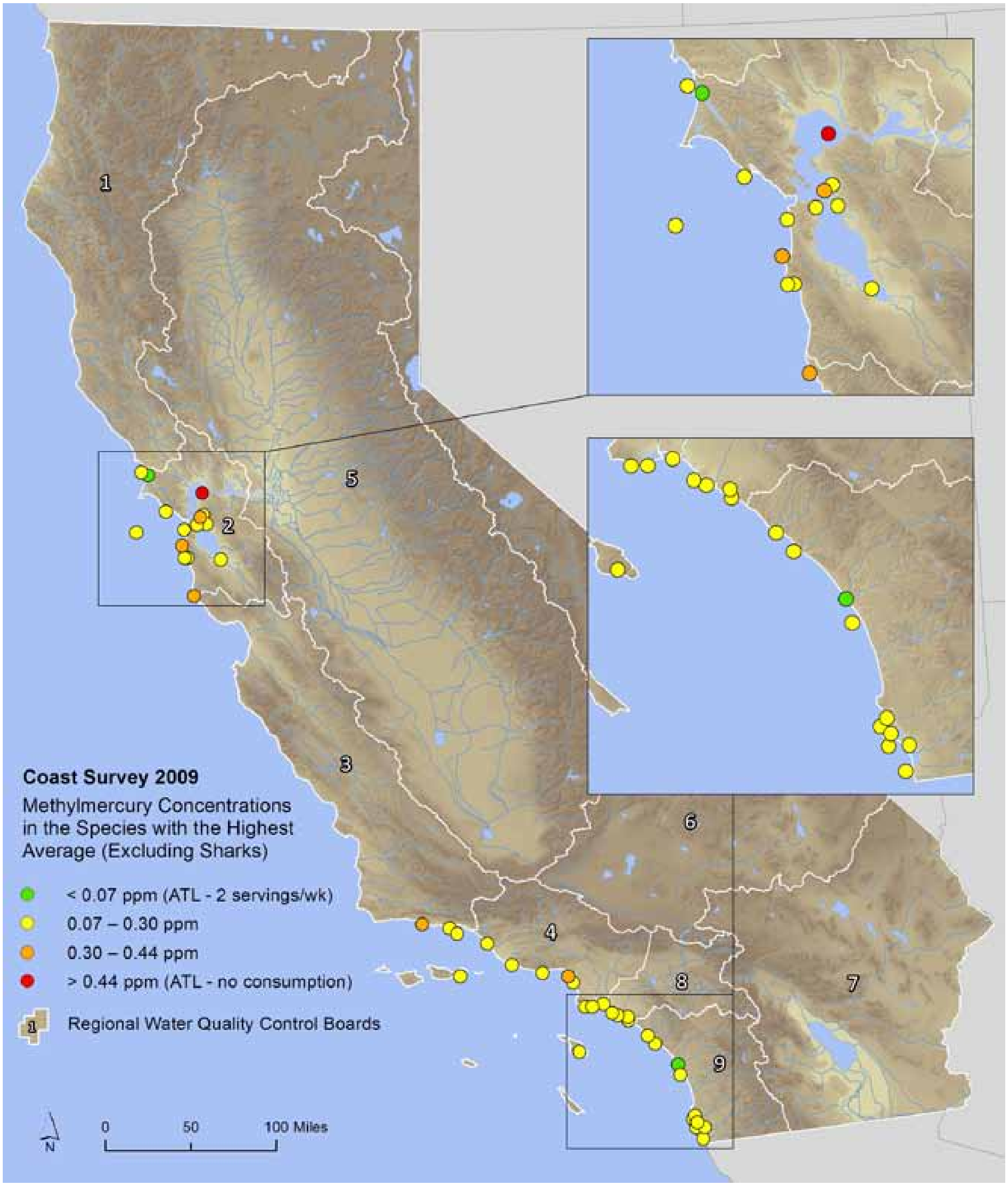


Figure 3-5. Spatial patterns in methylmercury concentrations (ng/g wet weight) in locations sampled in the Coast Survey, 2009. Each point represents the highest average methylmercury concentration among the species sampled at each location (excluding sharks). Concentrations based on location composites and individual fish.

north to south) Central Bay in San Francisco Bay (striped bass at 0.43 ppm), Pacifica Coast on the west side of the San Francisco Peninsula (lingcod at 0.42 ppm and gopher rockfish at 0.34 ppm), San Mateo Coast at the boundary between Water Board regions 2 and 3 (gopher rockfish at 0.43 ppm), near Goleta in the southern end of Region 3 (gopher rockfish at 0.33 ppm), and Middle Santa Monica Bay in Region 4 (black croaker at 0.41 ppm). Only two locations had average mercury concentrations below all thresholds: Tomales Bay, where the highest non-shark species had an average of 0.068 ppm (shiner surfperch), and Oceanside Harbor in Region 9, where the highest species (queenfish) had an average of 0.065 ppm. It should be noted that when sharks were included Tomales Bay fell into the greater than 0.44 ppm category due to concentrations of 1.22 ppm in leopard shark and 0.83 ppm in brown smoothhound shark.

Overall, whether the sharks are included or not, the magnitude of contamination was similar in the northern and southern regions sampled in year one of the Survey. In both regions, concentrations in fish from most locations were between 0.07 ppm and 0.30 ppm. Both regions had a few locations above 0.44 ppm (with sharks included), a few locations between 0.30 and 0.44 pppm, and only one location below 0.07 ppm.

Priorities for Further Assessment

One location, San Francisco Bay, stands out as having high concentrations that are not driven by the apparently anomalous high values observed in sharks. However, San Francisco Bay is being routinely and thoroughly assessed every three years under the Regional Monitoring Program, and the consumption guidelines for the Bay are being updated in 2011. This situation is in contrast to that observed for lakes, where many water bodies were found to have concentrations above 0.44 ppm and advisories are not currently in place. This highlights the need for sufficient monitoring of methylmercury in lakes to support development of safe eating guidelines and cleanup plans.

PCBs

Comparison to Thresholds

PCBs (measured as the sum of 55 congeners – Table 2-2) were comparable to methylmercury in reaching fish tissue concentrations posing potential health concerns to consumers of fish caught from the locations sampled in year one of the Coast Survey.

Similar to methylmercury, PCBs at several locations reached concentrations high enough that OEHHA would consider recommending no consumption of the contaminated species (120 ppb wet weight). Overall, six of the 42 locations surveyed (14%) had a species with an average concentration exceeding 120 ppb (Figures 3-6 and 3-7). The 95% confidence interval for this estimate was 2 – 24% (Figure 3-7). Another nine locations (21%) were between the 1 serving ATL of 42 ppb and 120 ppb. Most of the locations sampled (53%) fell in the moderate contamination categories between the FCG of 3.6 ppb and the 1 serving ATL of 42 ppb.

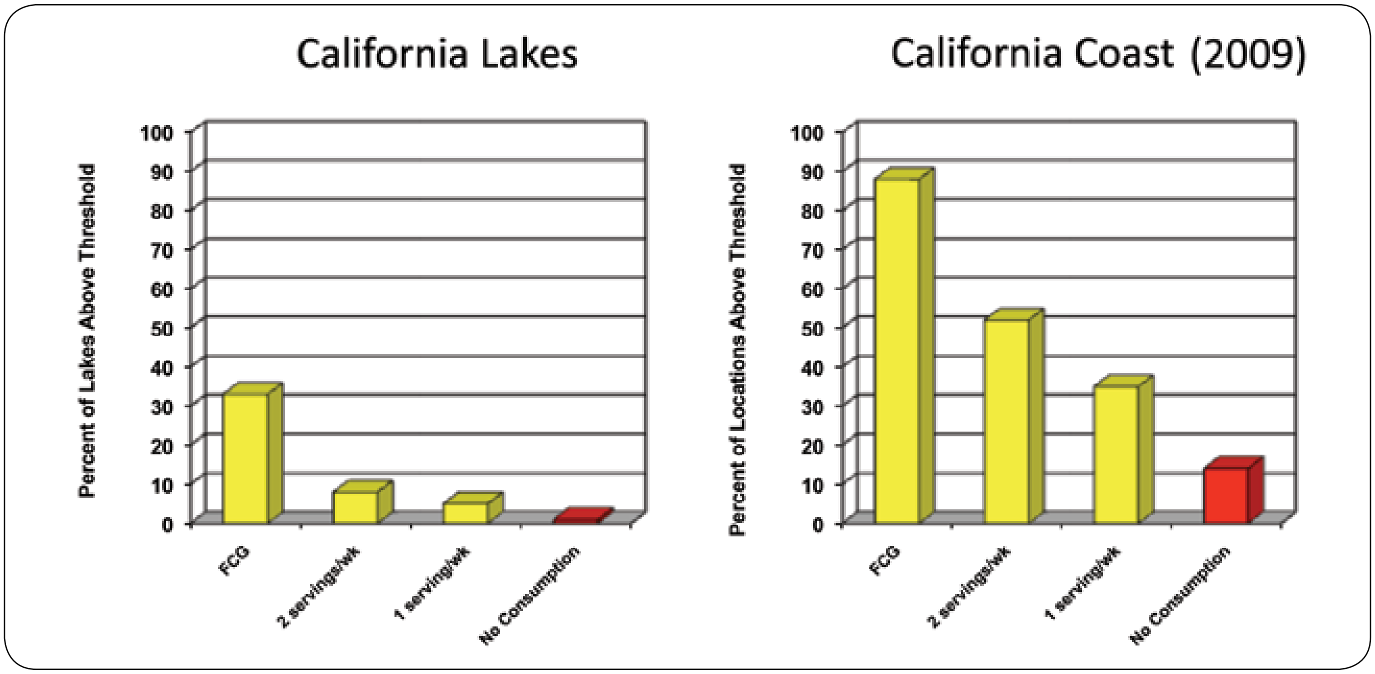


Figure 3-6. Percentages of lakes or coastal sampling locations above various PCB thresholds. Based on the highest species average concentration for each lake or location.

The degree of PCB contamination at the locations sampled in year one of the Coast Survey was substantially greater than that observed in the two-year Lakes Survey (Davis et al. 2010) (Figure 3-6). Much higher proportions of the year one coastal locations fell into each threshold category. For example, 37 of 42 locations (88%) were above the lowest PCB threshold (the 3.6 ppb FCG), in contrast to only 33% of the 272 lakes found to be above this value. One primary cause of this difference is likely the geographic focus on the major urban areas of the state in the year one coast sampling. The lakes survey concluded that PCB concentrations were higher around the urbanized regions in Los Angeles and the San Francisco Bay Area (Davis et al. 2010). Another factor contributing to this difference, as for methylmercury, is the prevalence of lakes where trout species were the primary bioaccumulation indicators. The generally lower trophic position of trout and the possibly the abundance of hatchery fish are factors that could lead to lower PCB concentrations as seems likely for methylmercury. It will be interesting to reevaluate the PCB frequency distribution when the complete two-year coastal dataset is available.

Variation Among Species

Spiny dogfish was the only species in the year one sampling that had an average PCB concentration (296 ppb) above the 120 ppb no consumption ATL (Figure 3-8). Only one sample was collected for this species though (from San Pedro Bay), so this value may not be representative for the species more generally.

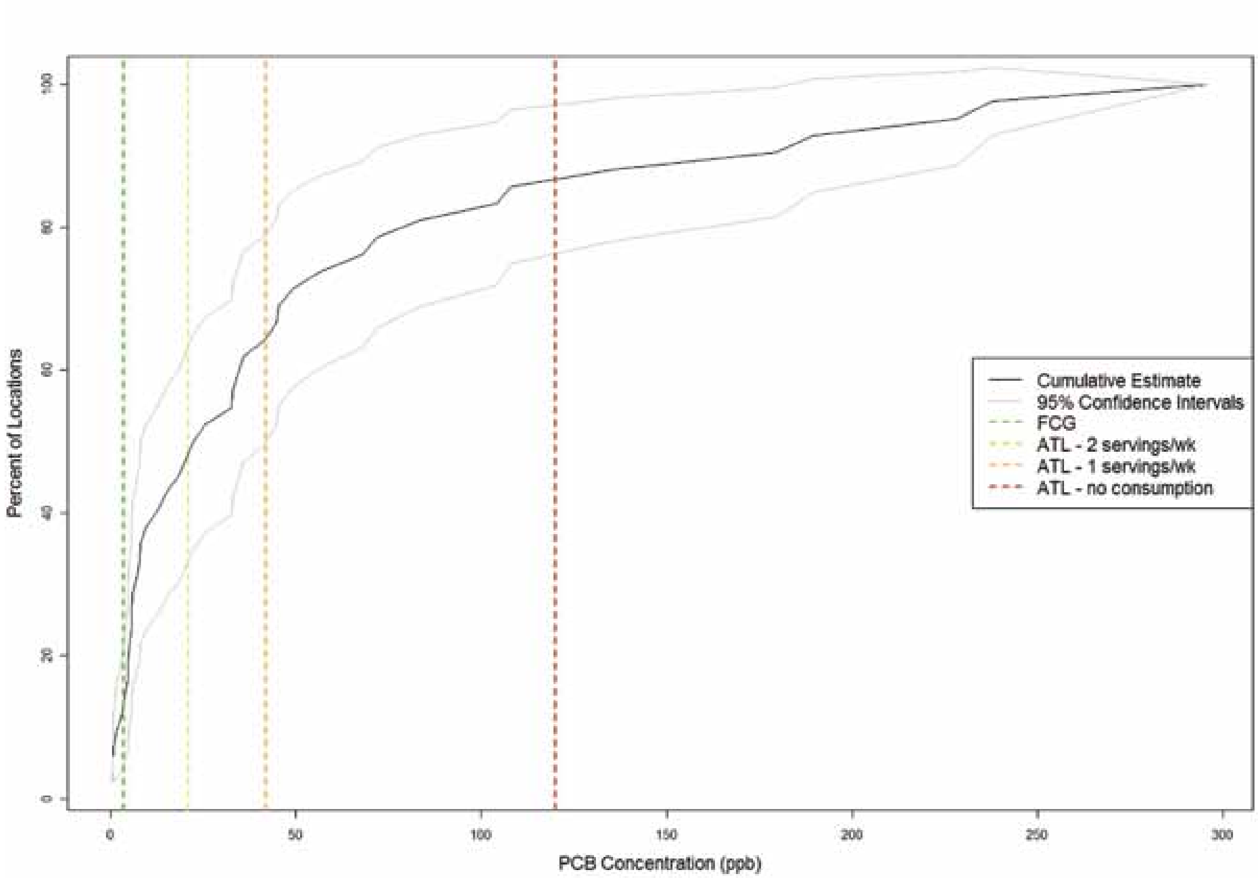


Figure 3-7. Cumulative distribution function (CDF) plot for PCBs at locations sampled in 2009, shown as percent of locations sampled. Based on the highest species average concentration (ppb) for each location. Vertical lines are threshold values.

Overall, 24 of 36 species (66%) had an average PCB concentration between the FCG of 3.6 ppb and the no consumption ATL of 120 ppb.

San Francisco Bay suffers from a relatively high degree of PCB contamination. Two species sampled extensively in the Bay, northern anchovy and shiner surfperch, had average concentrations approaching 120 ppb. Northern anchovy are a species sampled by the RMP that are not a target for human consumption, but they are collected in the sport fish trawls and analyzed as an indicator of wildlife exposure. They accumulate high concentrations of PCBs and other organic contaminants in spite of their small size (9 cm, or 3.5 in) and low trophic position. Their high lipid content and their analysis as whole body samples (including high lipid internal organs) are factors contributing to the high accumulation. The nine composite samples of northern anchovy (all from the Bay) averaged 118 ppb.

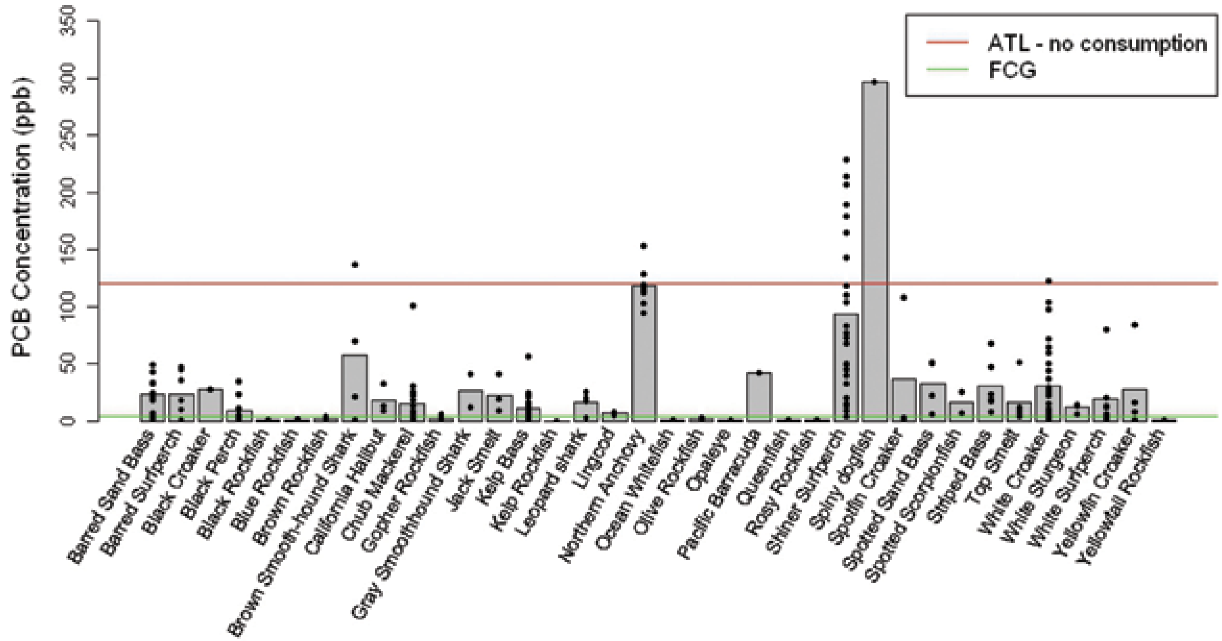


Figure 3-8. PCB concentrations (ppb) in sport fish species on the California coast, 2009. Bars indicate average concentration. Points represent individual samples (either composites or individual fish). Note that the averages for some species (e.g., spiny dogfish) are based on only one sample. Also note that northern anchovy are not a sport fish species – they are an important wildlife prey species that is collected in the surveys in San Francisco Bay and analyzed as whole fish.

Shiner surfperch are a species that are also not processed as fillets (they are processed whole with head, viscera, and tail removed due to their small size - typically 11 cm, or 4.3 in), but these fish are caught and consumed by anglers. Shiner surfperch had a year one statewide average PCB concentration of 93 ppb. Three locations (two in San Francisco Bay and one in San Diego Bay) had average concentrations in shiner that were above 120 ppb (discussed further below). Shiner surfperch have high site fidelity and are an excellent indicator of spatial patterns. Their sensitivity as a spatial indicator is evident from the 70-fold range in average concentrations observed – from a high of 216 ppb in Oakland Harbor to a low of 3 ppb in Tomales Bay.

Average PCB concentrations in other species were considerably lower. The only other species with an average concentration above the 42 ppb 1 serving ATL was brown smoothhound (57 ppb).

Eleven species had average PCB concentrations below all thresholds, including black rockfish (0.3 ppb), blue rockfish (0.3 ppb), brown rockfish (1.4 ppb), gopher rockfish (1.2 ppb), kelp rockfish (not detected), ocean whitefish (0.7 ppb), olive rockfish (1.4 ppb), opaleye (0.2 ppb), queenfish (0.8 ppb), rosy rockfish (0.7 ppb), and yellowtail rockfish (0.5 ppb). All of the rockfish species sampled were below all thresholds; however, these averages were generally based on very small sample sizes (Table 2-1).

Spatial Patterns

PCB concentrations at locations sampled in year one had a similar spatial distribution in the north and south (Figure 3-9). Five locations had a species averaging greater than 120 ppb. Three of these locations were in urban embayments with the average observed in shiner surfperch (San Francisco – 162 ppb, Oakland – 216 ppb, and San Diego South – 190 ppb) (Figure 3-10). This species has high site fidelity and is a reliable indicator of the degree of contamination at these locations. Two of the five locations fell into the greater than 120 ppb category due to concentrations measured in shark species: the spiny dogfish sample from San Pedro Bay (296 ppb) and a brown smoothhound sample from the area between Crystal Cove and the Santa Ana River (136 ppb). These shark species are mobile and may not be representative of the precise locations where they were collected.

Five locations had average PCB concentrations lower than the lowest PCB threshold – the 3.6 ppb FCG. These five locations were all in more remote, less urbanized areas, including three offshore locations.

The remaining 32 locations had concentrations between the FCG and the no consumption ATL. Overall, PCB contamination at the year one sampling locations was moderate but widespread, and this pattern was observed both in the north and the south.

A clearer picture of spatial variation can be obtained by examining spatial patterns in two species that accumulate high PCB concentrations and that were collected across multiple locations in the north and south. As mentioned above, shiner surfperch can accumulate high PCB concentrations and is a reliable indicator of spatial patterns. This species was collected at 14 locations, from Tomales Bay in the north to San Diego Bay in the south (Figure 3-10), with concentrations ranging from 216 ppb at Oakland to 3 ppb in Tomales Bay. The shiner surfperch results highlight the relatively high degree of PCB contamination in San Francisco Bay and San Diego Bay, as well as other locations with moderate contamination at San Pedro Bay (50 ppb) and Dana Point Harbor (49 ppb). On the other hand, the shiner surfperch data indicate that Tomales Bay was quite low in PCBs.

White croaker is another species that accumulates relatively high PCB concentrations and that was collected across much of the area sampled in 2009. Concentrations in white croaker were not as high as in shiner surfperch, but spatial variation in this species was also quite distinct (Figure 3-11). Long Beach had the highest average concentration in white croaker (104 ppb). Other species collected at this location also had relatively high concentrations, including topsmelt (51 ppb) and barred sand bass (49 ppb). White croaker from Oakland (63 ppb) and South Bay (36 ppb) in San Francisco Bay had the second and third highest average concentrations. Other areas with moderately elevated concentrations included three other locations near Long Beach (South Santa Monica Bay – 29 ppb; Palos Verdes – 22 ppb; and San Pedro Bay – 29 ppb) and two locations in the San Diego region (Point Loma – 25 ppb, and near Tijuana – 23 ppb). The white croaker results indicate that many other locations (Southern Marin Coast, Pillar Point Harbor, Santa Barbara Channel Oil Platform, Point Dume to Oxnard, Dana Point Harbor, and Oceanside Harbor) were quite low in PCBs (all below the 3.6 ppb FCG).

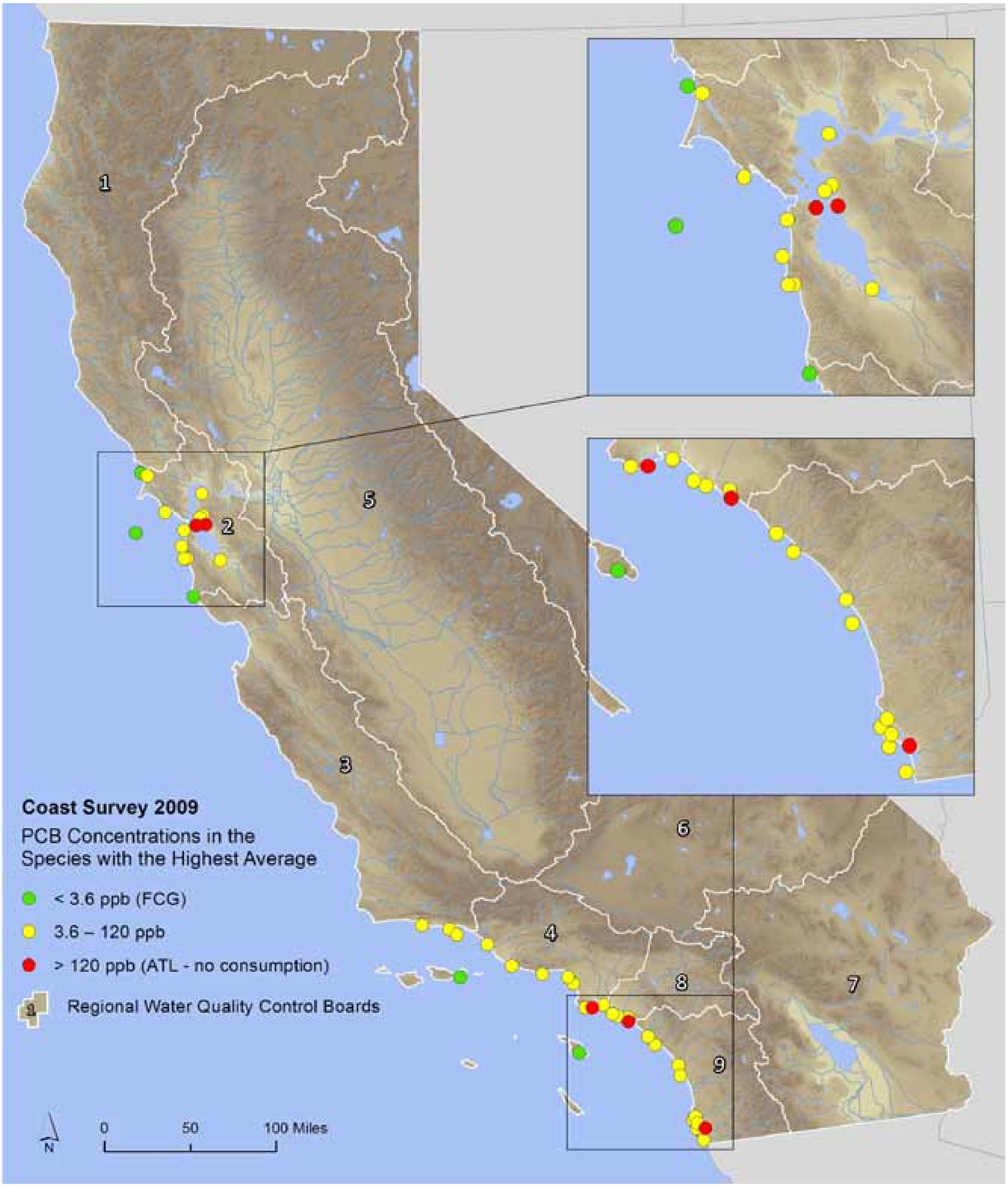


Figure 3-9. Spatial patterns in PCB concentrations (ppb) among locations sampled in the Coast Survey, 2009. Each point represents the highest average PCB concentration among the species sampled at each location. Concentrations were measured in composite samples.

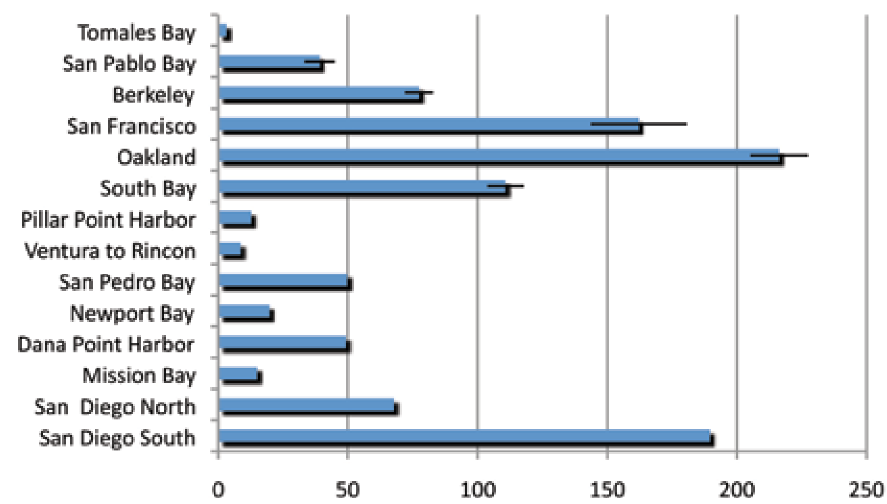


Figure 3-10. Average PCB concentrations in shiner surfperch samples on the California coast, 2009. Standard error is shown where replicate samples were analyzed.

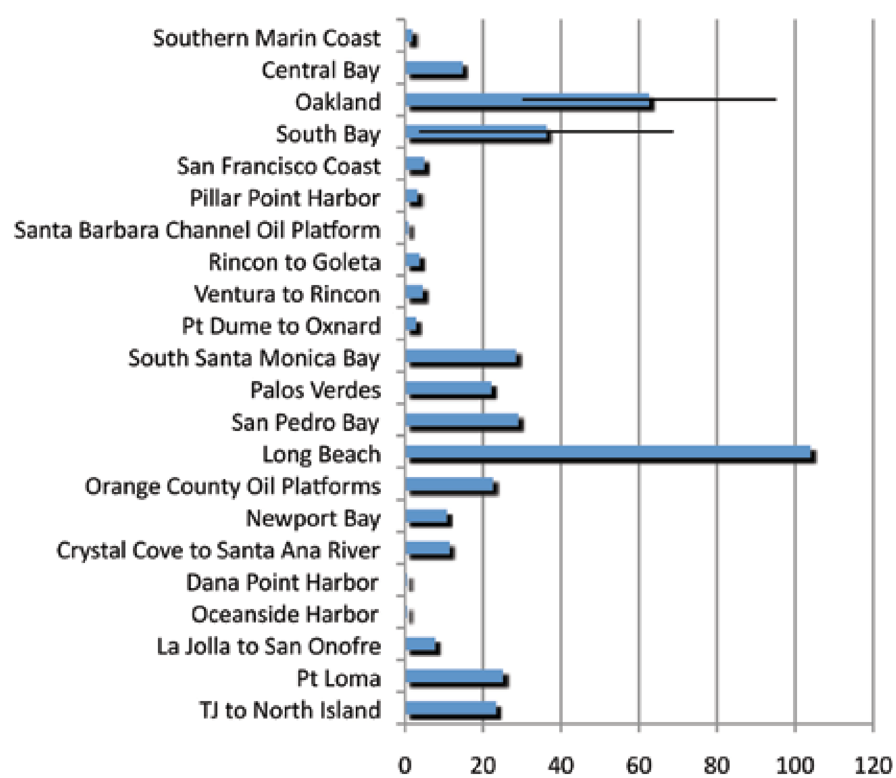


Figure 3-11. PCB concentrations in white croaker samples on the California coast, 2009. Standard error is shown where replicate samples were analyzed.

Priorities for Further Assessment

San Francisco Bay and San Diego Bay stand out as having high PCB concentrations. As mentioned above in the methylmercury section, San Francisco Bay is being routinely and thoroughly assessed every three years under the Regional Monitoring Program, and the consumption guidelines for the Bay are being updated in 2011. Consumption guidelines are in place for the region with moderately elevated PCB concentrations around Long Beach. Consumption guidelines for San Diego Bay have not been developed. Acquiring the data needed to support development of consumption guidelines for San Diego Bay appears to be a high priority.

OTHER POLLUTANTS WITH THRESHOLDS

OEHHA (Klasing and Brodberg 2008) has developed thresholds for four other pollutants that were analyzed in this survey: dieldrin, DDT, chlordane, and selenium. Concentrations of these pollutants did not exceed any of the no consumption ATLs, and rarely exceeded any ATL. The organic pollutants, however, did frequently exceed the FCGs.

Results for these pollutants are briefly summarized below.

DDTs

The maximum species averages for DDTs were below the lowest threshold (the 21 ppb FCG) in 50% of the 42 locations sampled (Figure 3-12). Twenty of the locations fell between the FCG and the next lowest threshold (the 520 ppb 2 serving ATL). One location was above 520 ppb: San Pedro Bay with the spiny dogfish sample at 1077 ppb. The highest concentrations were found primarily in three regions: San Francisco Bay, near the Palos Verdes Peninsula, and near San Diego and the Mexican border.

Dieldrin

The maximum species averages for dieldrin were below the lowest threshold (the 0.46 ppb FCG) in 63% of the 42 locations sampled (Figure 3-13). Fifteen of the locations fell between the FCG and the next lowest threshold (the 15 ppb 2 serving ATL). The highest concentration measured was 3.0 ppb in a shiner surfperch sample from Dana Point Harbor. As for DDTs, the highest concentrations were found primarily in three regions: San Francisco Bay, near the Palos Verdes Peninsula, and near San Diego and the Mexican border.

Chlordanes

The maximum species averages for chlordanes were below the lowest threshold (the 5.6 ppb FCG) in 76% of the 42 locations sampled (Figure 3-14). Ten of the locations fell between the FCG and the next lowest threshold (the 190 ppb 3 serving ATL). The highest concentration measured was 42 ppb in the spiny dogfish sample from San Pedro Bay. The highest concentrations were found in San Francisco Bay and near the Palos Verdes Peninsula.

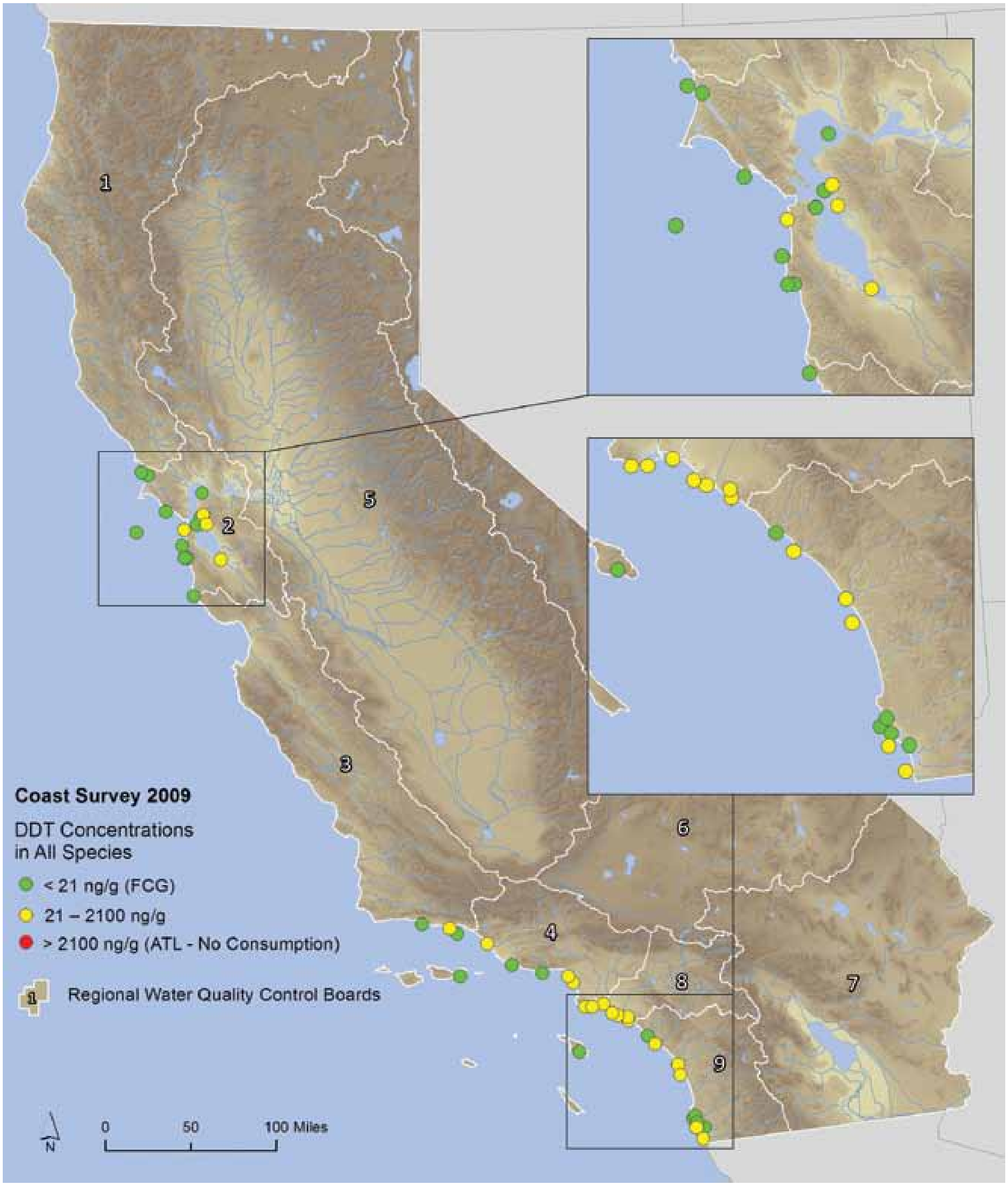


Figure 3-12. Spatial patterns in DDT concentrations (ppb) among locations sampled in the Coast Survey, 2009. Each point represents the highest average DDT concentration among the species sampled at each location. Concentrations were measured in composite samples.

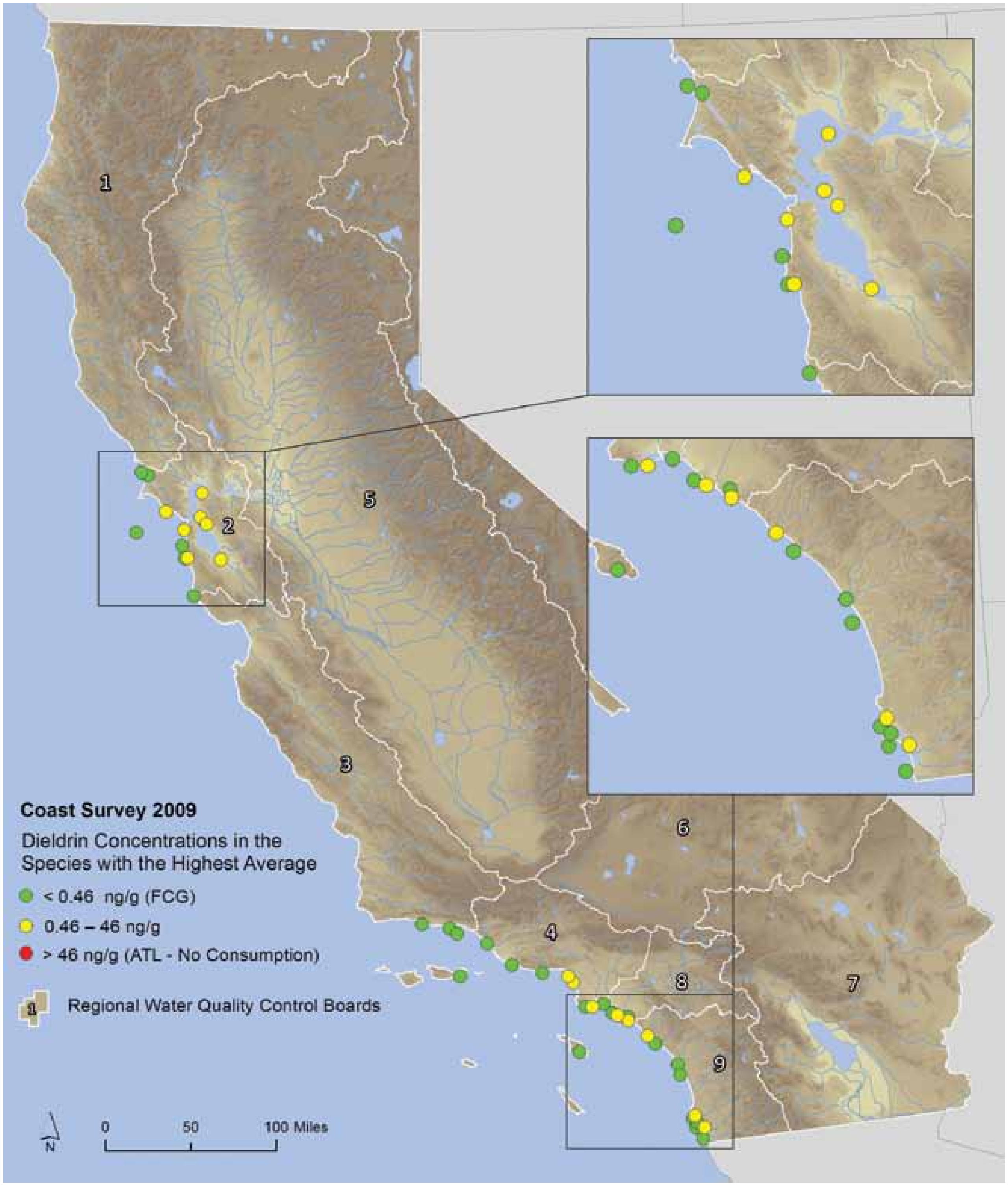


Figure 3-13. Spatial patterns in dieldrin concentrations (ppb) among locations sampled in the Coast Survey, 2009. Each point represents the highest average dieldrin concentration among the species sampled at each location. Concentrations were measured in composite samples.

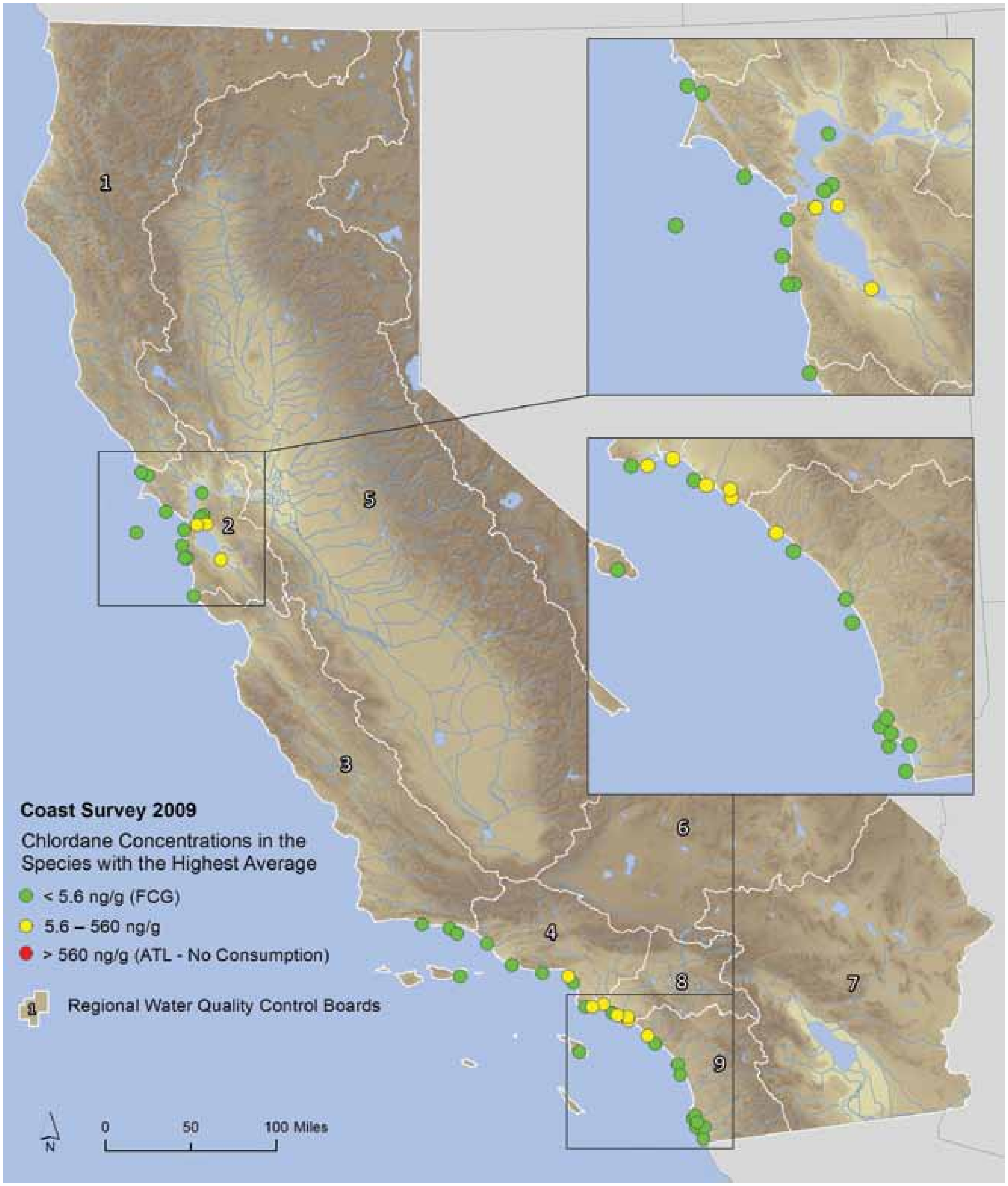


Figure 3-14. Spatial patterns in chlordane concentrations (ppb) among locations sampled in the Coast Survey, 2009. Each point represents the highest average chlordane concentration among the species sampled at each location. Concentrations were measured in composite samples.

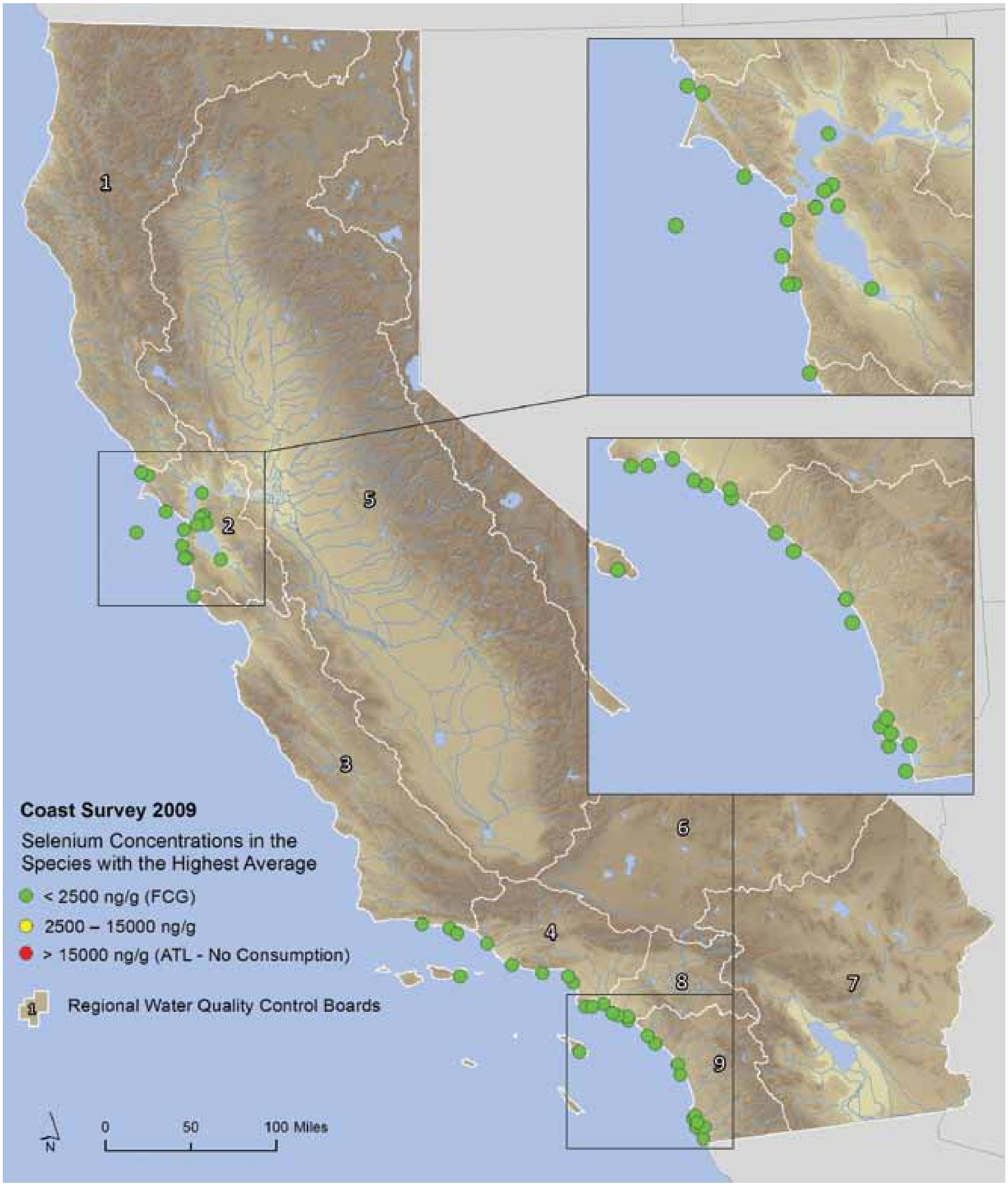


Figure 3-15. Spatial patterns in selenium concentrations (ppb) among locations sampled in the Coast Survey, 2009. Each point represents the highest average selenium concentration among the species sampled at each location. Concentrations were measured in composite samples.

Selenium

The maximum species averages for selenium were below the lowest threshold (the 2.5 ppm 3 serving ATL) in 100% of the 42 locations sampled (Figure 3-15). The highest average or composite concentration measured was 2.4 ppm in a barred sand bass sample from San Pedro Bay.

SECTION 4
THE SOUTHERN CALIFORNIA BIGHT

INTRODUCTION

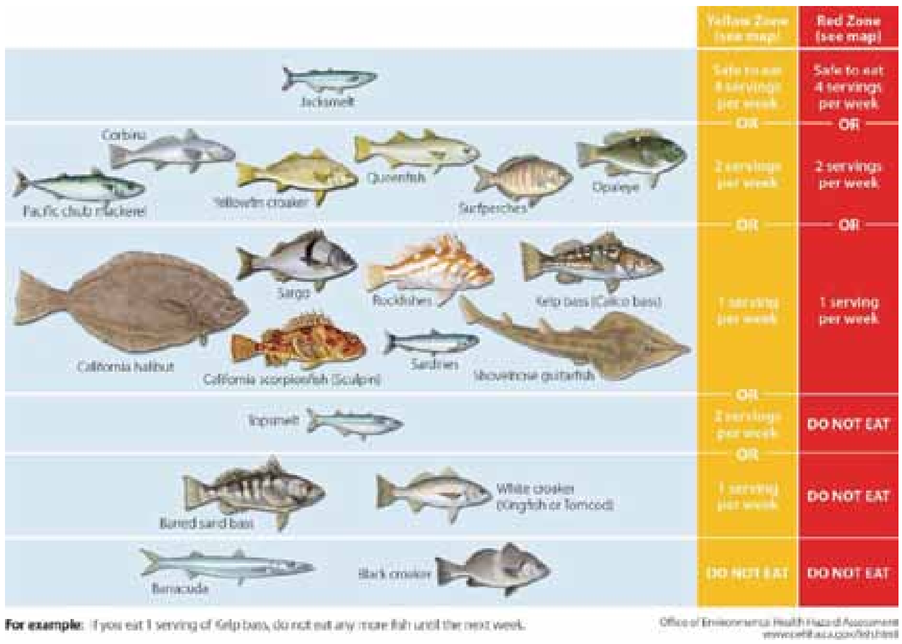
The Office of Environmental Health and Hazard Assessment (OEHHA) has developed a health advisory and safe eating guidelines for fish from the Southern California Bight (Figure 4-1) (Klasing et al. 2009). The advisory, which extends from Ventura Harbor to San Mateo Point, warns fishers against eating specific species from some or all locations. OEHHA's safe eating guidelines also identifies fish species with low contaminant levels that are safe to eat frequently (once a week or more). Sufficient numbers of fish were collected to provide consumption advice for barracuda, barred sand bass, black croaker, corbina, California halibut, California scorpionfish (also known as "sculpin"), jacksmelt, kelp bass, opaleye, Pacific chub mackerel, queenfish, rockfishes, sardines, sargo, shovelnose guitarfish, surfperches, topsmelt, white croaker, and yellowfin croaker. Because sport fish were collected from such a large geographic area, OEHHA divided the advisory and safe eating guidelines into regions based on highly variable contaminant levels found in some species: 1) Ventura Harbor to Santa Monica Pier, 2) Santa Monica Beach south of Santa Monica Pier to Seal Beach Pier, and 3) South of Seal Beach Pier to San Mateo Point.

This chapter on the Southern California Bight has a regional focus on a subset of species collected in the statewide survey. These species include kelp bass, Pacific chub mackerel, white croaker, yellowfin croaker, barred sand bass, and spotted sand bass. These species were most frequently caught in the Bight and provide our best opportunity to illustrate spatial comparisons across the region.

The five species selected for this region are all secondary or tertiary carnivores in the Southern California marine food web structure (Allen et al. 2006). Yellowfin and white croaker are benthic secondary carnivores, feeding largely on invertebrates (i.e., clams, worms, crustaceans) living in or on sea bottom sediments. The primary difference between the croakers is their preferred benthic habitats; yellowfin croaker prefers embayment habitats, while white croaker can be found in large bays and near coastal open ocean habitats. Kelp bass are secondary carnivores that prefer rocky reef habitats, feeding on smaller kelp bed fishes (i.e., perch and wrasses). Pacific chub mackerel are pelagic secondary carnivores, meaning they prefer water column habitats either near or far from the coast, feeding on smaller midwater fishes (i.e., anchovy and sardine). Spotted sand bass are tertiary benthopelagivores. That is, spotted sand bass are near the top of the food web, preferring bay/estuarine habitats, feeding on a large variety of prey including flatfish (e.g., diamond turbot), baitfish (e.g., slough anchovy), perches (e.g., shiner surfperch), and other assorted benthic fishes (longjaw mudsuckers, Pacific staghorn sculpin, bay pipefish). Therefore, the combination of target species sampled during this study covers a wide variety of habitats ranging from bays to offshore, from the sea bottom to the surface, and focuses largely on the upper end of the food web.

A Guide to Eating Fish Caught from Vetura Harbor to San Mateo Point

Women 18-45, especially those who are pregnant or breastfeeding, and children 1-17



Map of Yellow and Red Zones for fish caught from Ventura Harbor to San Mateo Point

Figure 4-1. Current health advisories for fish consumption in the southern California Bight (OEHHA 2009).

METHYLMERCURY

Comparison to Thresholds

In the Southern California Bight, more samples exceeded fish contaminant thresholds for methylmercury than any other contaminant for the six species examined in this study (Figure 4-2). Average concentrations of fish caught in embayments, open coastal areas, and the Channel Islands all exceeded OEHHA's 1 serving ATL (0.15 ppm). Six samples (5%) exceeded OEHHA's no consumption ATL of 0.44 ppm.

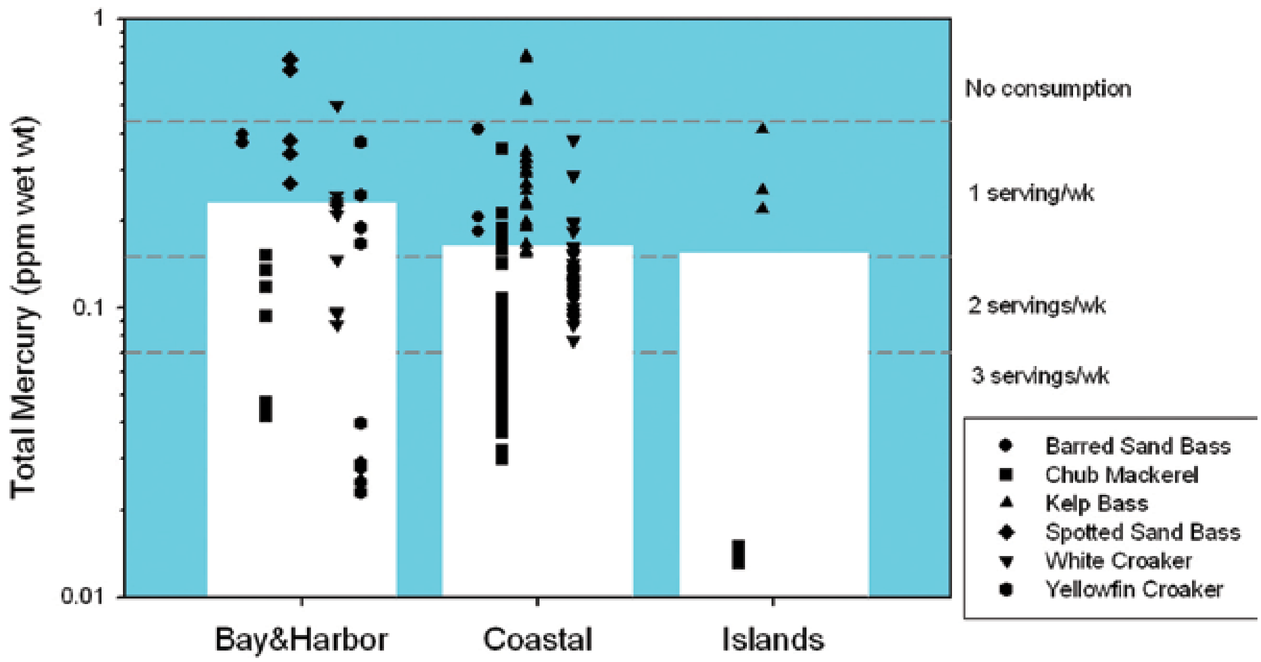


Figure 4-2. Concentrations of methylmercury (ppm) in fish composites from three different habitats in the Southern California Bight. Bars represent the average of all species for each habitat. Symbols represent the concentration of each composite sample arranged by species.

Variation Within and Among Species

The average concentration of methylmercury was greater in spotted sand bass (0.16 ± 0.04 ppm) than any other species from the Southern California Bight (Figure 4-2). This was followed by kelp bass (0.15 ± 0.05 ppm), white croaker (0.13 ± 0.05 ppm), yellowfin croaker (0.10 ± 0.10 ppm), and Pacific chub mackerel (0.06 ± 0.03 ppm). Spotted sand bass are the highest trophic position predator sampled in the Bight. In addition, spotted sand bass prefer embayment habitats known to have greater mercury concentrations in sediment than offshore habitats (Maruya and Schiff 2009). Kelp bass, which prefer open coastal habitats, are perhaps the longest-lived of the six species sampled (up to 30 yrs). The combination of high trophic position and long lifespan are known to contribute to methylmercury accumulation in fish (Wiener et al. 2007). This likely contributes to the increased average methylmercury concentrations in these species.

Spatial Patterns

There was no clear spatial trend in average methylmercury tissue concentrations along the open coast of the Southern California Bight (Figure 4-3). Average methylmercury concentrations exceeded OEHHA's 2 serving ATL (0.07 ppm) in every one of the 19 fishing locations for kelp bass. Five of the 19 fishing locations also exceeded OEHHA's 1 serving ATL (0.15 ppm) for kelp bass, but these were not the locations typically known

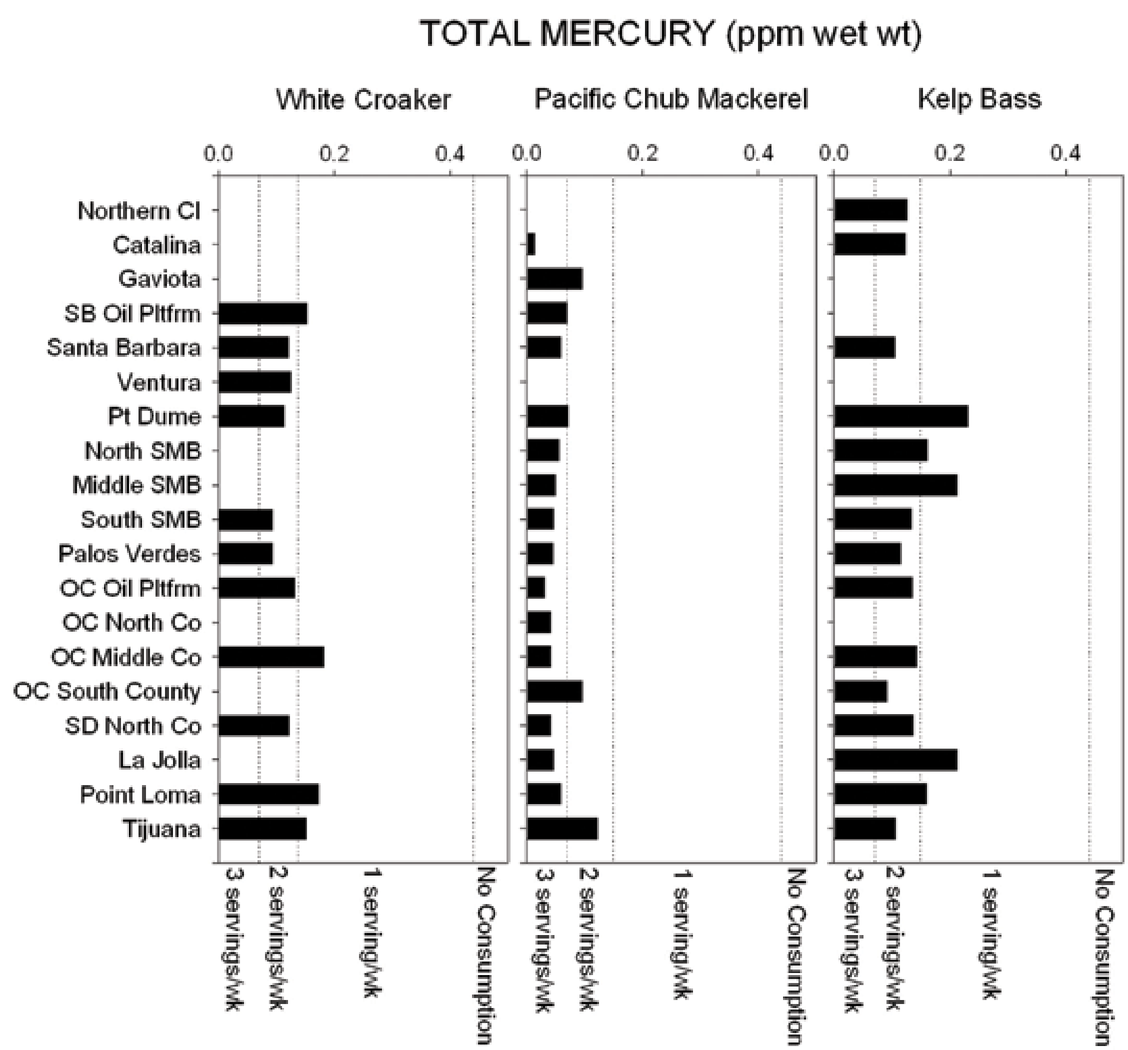


Figure 4-3. Average methylmercury concentrations (ppm) by fishing zone for three commonly occurring species in the Southern California Bight.

for mercury contamination sources. These five locations, which include Point Dume and Point La Jolla, are headlands with relatively robust kelp bass populations (Pondella et al. in press).

Pacific chub mackerel was the species with the lowest average methylmercury tissue concentrations in this study. In contrast to kelp bass, Pacific chub mackerel exceeded OEHHA's lowest threshold, the 2 serving ATL, in only four of the 19 fishing locations. Like the observations for kelp bass, the fishing locations with the highest Pacific chub mackerel tissue methylmercury concentrations, places like Gaviota and south Orange County, are not associated with known sources of mercury.

Temporal Trends

There have been few studies of methylmercury concentrations in recreationally-caught fishes from the Southern California Bight. The most prominent study available for comparison was conducted in 2002 and used for the existing fish advisory in the Los Angeles area (NOAA 2007). After constraining the samples from this study to the same geographic area as NOAA (2007), the ranges of methylmercury tissue concentrations between the two surveys were similar (Table 4-1). This implies that tissue concentrations have remained steady, at least on the Los Angeles margin, between 2002 and 2009.

Table 4-1
Comparison of methylmercury concentration ranges (ppm) among species from the Los Angeles margin.

Species	Methylmercury (range, ppm wet weight)	
	2009 (This Study)	2002 (NOAA 2007)
Kelp Bass	0.115-0.231	0.118-0.321
White Croaker	0.093-0.131	0.027-0.196
Pacific chub Mackerel	0.031-0.056	0.080-0.086

Management Implications

This is the first regional scale assessment of methylmercury in edible tissues of marine sport fishes of the entire Southern California Bight. The widespread exceedance of OEHHA's lowest 2 serving ATL for open coastal fish species such as kelp bass is new information. Less than a half-dozen composite kelp bass samples exceeded OEHHA's no consumption threshold of 0.44 ppm and no fishing location exceeded 0.44 ppm on average.

Local land-based sources of mercury appeared to have little impact on fish tissue concentrations in the Southern California Bight. For example, kelp bass tissue concentrations had no strong spatial gradient and did not peak near large urban centers where land-based inputs of mercury have historically been the greatest. The tissue concentrations of methylmercury were greater in embayments than open coastal habitats. This may be a reflection of localized land-based sources and in-situ biogeochemical cycling of mercury, but sample sizes were too limited to compare embayments for different levels of tissue contamination. Instead of spatial relationships, the fish species highest in the food web and with the longest life span appeared to have the greatest tissue concentrations of total mercury.

Priorities for Further Assessment

Fishing locations with samples greater than OEHHA's no consumption ATL should be prioritized for further assessment because many of these locations were not included in OEHHA's current fish tissue advisory. These investigations should focus on species higher in the food web and with the longest life spans, since these species tended to accumulate the greatest concentrations within a habitat.

A second consideration for further investigation would be deciphering sources of mercury that contribute to tissue contamination. There have been a number of studies documenting total mercury in sediments of the Southern California Bight (Maruya and Schiff 2009, Schiff 2000). However, two data gaps remain. First, too few tissue samples were collected in embayments where sediment processes might play a role in bioaccumulation. Embayments are particularly important since these habitats support some of the most intensive fishing pressure in the Southern California Bight. The second data gap is the role of additional mercury sources where sediments are not the primary source. These locations would include open coastal and offshore island habitats. Especially for heavily-fished species such as kelp bass that live in rocky habitat, non-sediment sources including atmospheric deposition may be implicated.

PCBs

Comparison to Thresholds

Approximately one-third (36%) of the samples from the Southern California Bight exceeded OEHHA's 2 serving ATL (21 ppb) for PCBs in this study (Figure 4-4). Average PCB concentrations of fish caught from embayments exceeded OEHHA's 1 serving ATL (42 ppb). Average PCB concentrations of fish caught from open coastal areas exceeded OEHHA's 2 serving ATL (21 ppb). Average PCB concentrations of fish caught from the Channel Islands were below the 1 serving ATL. Five samples (3%) exceeded OEHHA's no consumption ATL (120 ppb), all of which came from embayment habitats. No samples from the Channel Islands exceeded the 2 serving ATL (21 ppb).

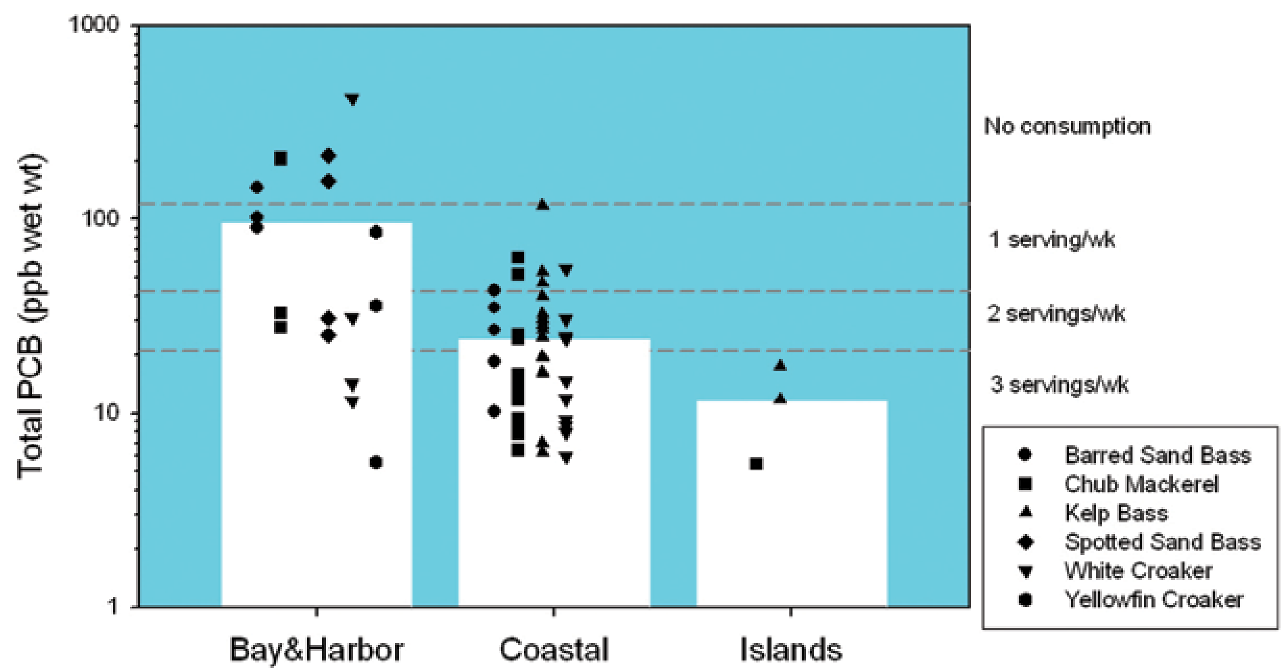


Figure 4-4. Concentrations of PCBs (ppb) in fish composites from three different habitats in the Southern California Bight. Bars represent the average of all species for each habitat. Symbols represent the concentration of each composite sample arranged by species.

Variation Among Species

The average concentration of PCBs was similar among species. Average concentrations varied by less than a factor of three among the five species sampled. The greatest average PCB concentration was measured in spotted sand bass (35 ± 21 ppb). The lowest average PCB concentration was measured in kelp bass (15 ± 13 ppb). Species that feed on or near sediments, especially those located in embayments (white croaker, yellowfin croaker, spotted sand bass), had greater concentrations than those species that feed in the water column along the open coast (kelp bass and Pacific chub mackerel).

Spatial Patterns

There was a clear spatial trend in PCB concentrations along the open coast of the Southern California Bight (Figure 4-5). Peak concentrations occurred in fishing locations near the urban centers of Los Angeles and San Diego. Minimum concentrations occurred in fishing locations distant from urban centers such as Santa Barbara/Gaviota or south Orange/north San Diego Counties. Four of the 18 fishing locations with kelp bass samples exceeded OEHHA's 2 serving ATL (21 ppb); a single location located just north of the US-Mexico international border exceeded the 1 serving ATL (42 ppb). Five of the 11 fishing locations with white croaker samples exceeded the 2 serving ATL (21 ppb). Again, samples generally nearest the urban centers of Los

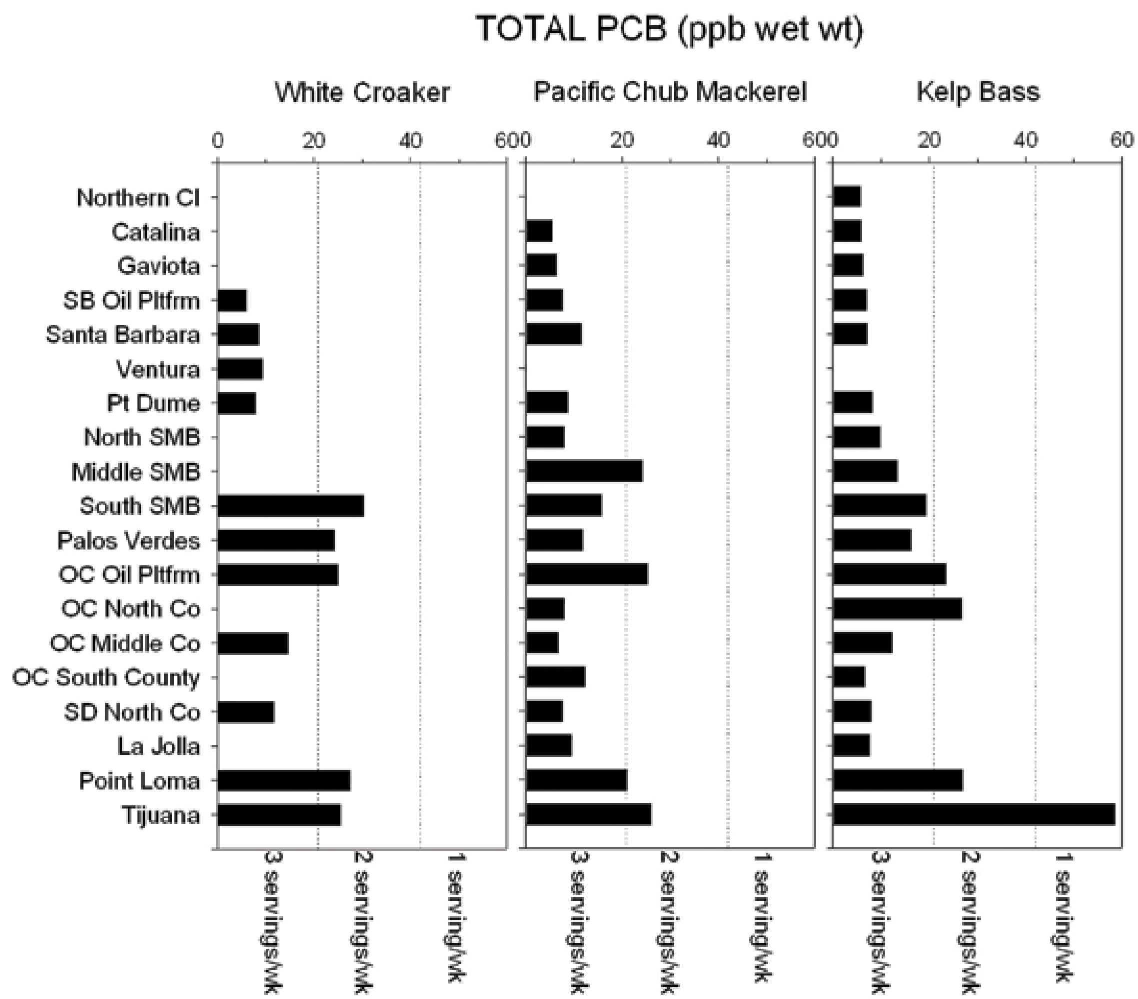


Figure 4-5. Average PCBs (ppb) by fishing zone for three commonly occurring species in the Southern California Bight.

Angeles and San Diego had the greatest PCB concentrations. Three of the 17 fishing locations with Pacific chub mackerel samples exceeded 21 ppb. Yet again, samples generally nearest the urban centers of Los Angeles and San Diego had the greatest PCB concentrations. Samples furthest from Los Angeles and San Diego had the lowest average PCB concentrations in Pacific chub mackerel.

The urban centers near Los Angeles and San Diego have the greatest sediment concentrations of PCBs found in the Southern California Bight (Maruya and Schiff 2009, Schiff 2000). PCBs are a known persistent bioaccumulative organic contaminant. Food web transfer of PCBs has been well-documented in the Southern California Bight (Young et al. 1976, 1977) and elsewhere (Suedel et al. 1994). In fact, sediment concentrations have been well correlated with tissue levels in sediment-associated fishes (Schiff and Allen 2001). Even pelagic (water column) forage fishes have been shown to contain higher concentrations of PCBs near to, compared to distant from, urban centers in the Southern California Bight (Jarvis et al. 2007).

Temporal Trends

No long-term studies of PCBs in sport fish have been conducted in the Southern California Bight.

Management Implications

While regional scale assessments of PCBs in marine fishes have been conducted previously in the Southern California Bight, they were focused on either liver or whole-body tissues rather than edible fillets consumed by most anglers. Livers, which typically have PCB concentrations 10-fold greater than muscle tissue, are good for projects addressing trends because higher concentrations enhance detection of differences over time. However, livers are not typically consumed by anglers. Similarly, whole-body samples may have greater concentrations than muscle tissue, but do not provide the best index of human exposure. Whole-body samples are valuable for studies focused on environmental risk since most predators consume their prey whole. Therefore, comparing studies that measure different tissue types (livers, whole-body, and muscle fillets) is problematic.

PCBs appear to be a problem nearest urban centers in the Southern California Bight. The inputs of PCBs near urban centers of the Southern California Bight have been well-studied (Schiff et al. 2001). The historical inputs of PCBs have been greatest (up to 98% of total emissions) from treated wastewater discharges. These inputs, estimated to be 9 metric tons/yr in 1971, have been below detection limits for the last two decades. However, large quantities still exist in sediments near outfalls and in embayments of the Southern California Bight, and it is this reservoir of historical residues that is thought to continually impact biota.

Priorities for Further Assessment

Fishing locations with samples greater than OEHHA's no consumption threshold should be prioritized for further assessment. These investigations should focus on sediment-associated species, since these species tended to accumulate the greatest concentrations within a habitat. While further work in the Los Angeles region is justified, the largest data gap would be for fishes in embayments of the San Diego region. Los Angeles already has a fish advisory in place; hence some protection of anglers currently exists. No such advisory has been developed for San Diego embayments and potentially harmful exposures may be occurring.

DDTs

Comparison to Thresholds

None of the samples from the Southern California Bight exceeded any of OEHHA's ATLs for DDTs in this study (Figure 4-6). Average DDT concentrations in fish caught from embayments, open coastal, and channel island habitats were at least five-fold below OEHHA's lowest, 2 serving ATL (520 ppb).

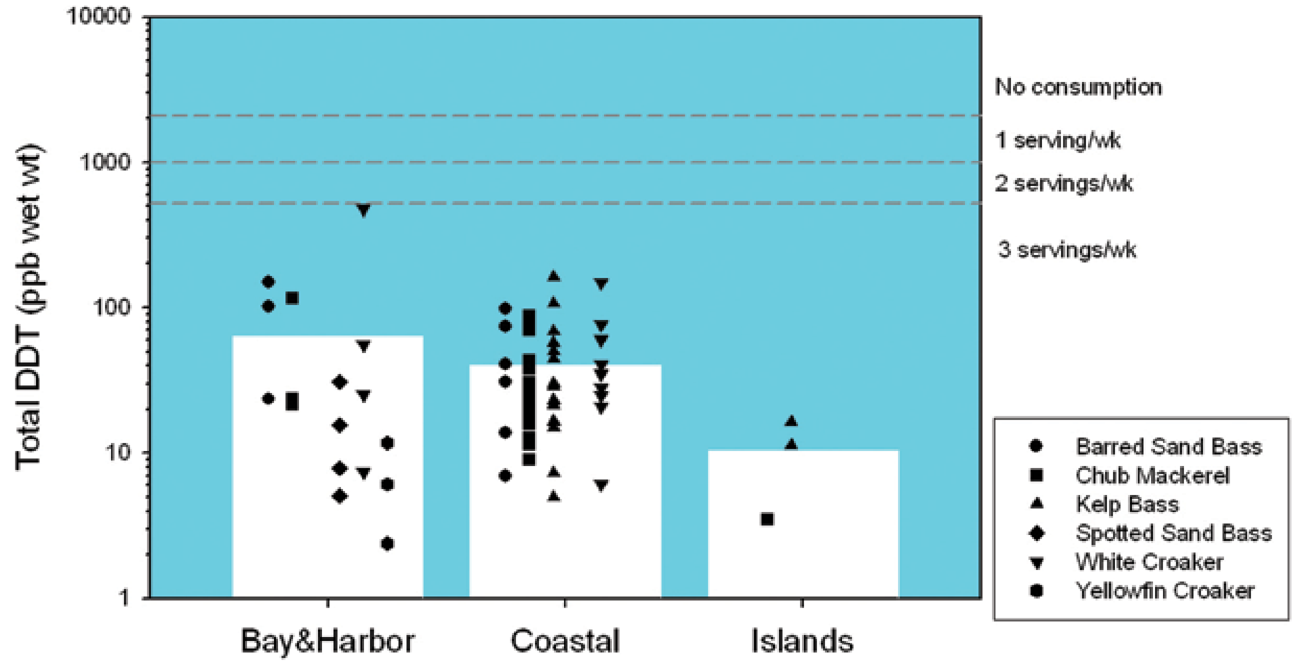


Figure 4-6. Concentrations of DDTs (ppb) in fish composites from three different habitats in the Southern California Bight. Bars represent the average of all species for each habitat. Symbols represent the concentration of each composite sample arranged by species.

Variation Among Species

Average DDT concentrations varied by a factor of four among species sampled. The greatest average DDT concentration was measured in white croaker (42 ± 42 ppb). The lowest average DDT concentration was measured in yellowfin croaker (10 ± 14 ppb) and spotted sand bass (10 ± 14 ppb). It is likely that the differences among species were driven, at least in part, by sampling location. Some samples of white croaker, Pacific chub mackerel, and kelp bass were collected from the Los Angeles margin. In contrast, no yellowfin croaker or spotted sand bass were collected near the Los Angeles margin. The yellowfin croaker and spotted sand bass were collected mostly south of Los Angeles.

Spatial Patterns

There was a clear spatial trend in DDT concentrations along the open coast of the Southern California Bight (Figure 4-7). Regardless of species, the greatest DDT concentrations occurred in fishing locations near the Los Angeles margin, peaking at Palos Verdes. Despite the tissue concentration maxima located near Los Angeles, none of the 19 fishing locations exceeded the 2 serving ATL. Like PCBs, minimum tissue concentrations of DDTs occurred in fishing locations furthest from Los Angeles such as Santa Barbara/ Gaviota or south Orange/north San Diego counties.

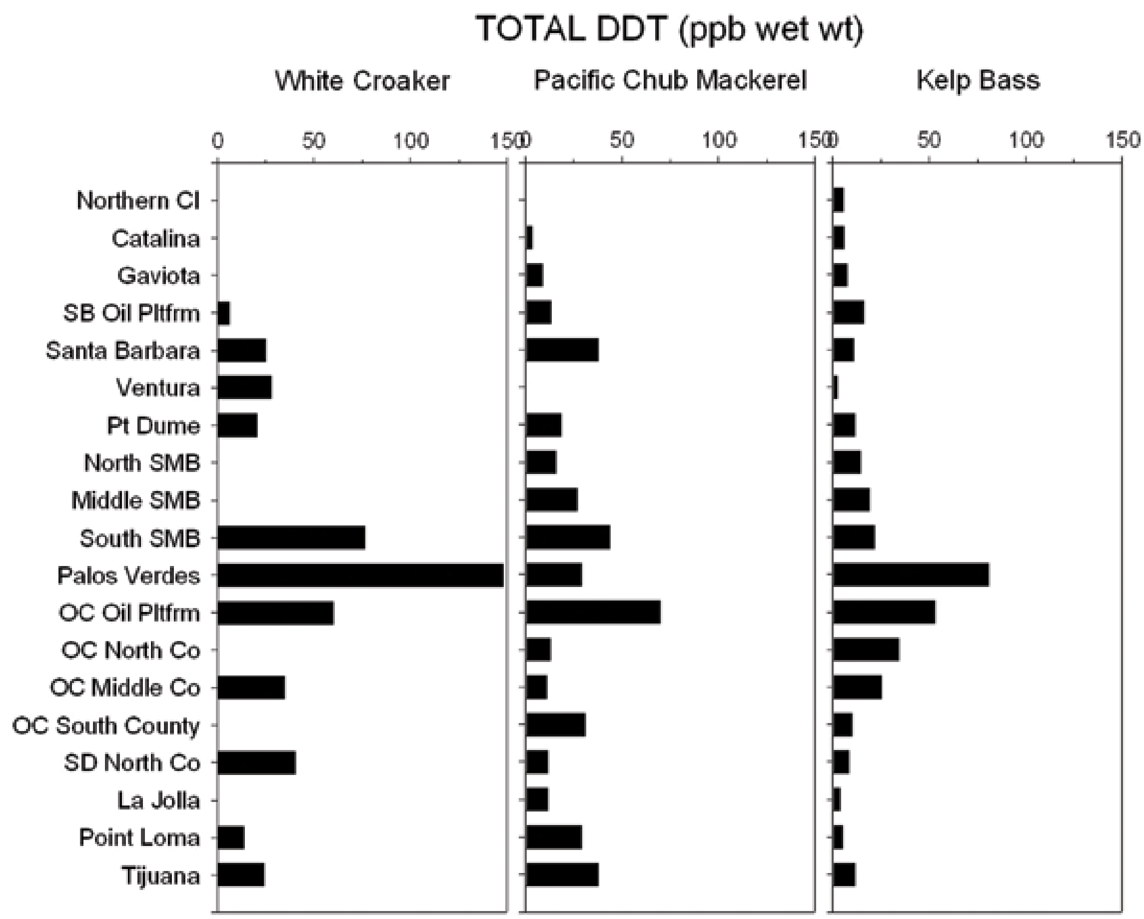


Figure 4-7. Average DDT concentrations (ppb) by fishing zone for three commonly occurring species in the Southern California Bight. The lowest ATL is 520 ppb, well above the highest average concentration measured in any zone for these three species during this study.

The sediments near Los Angeles have the greatest concentrations of DDTs found in the Southern California Bight (Maruya and Schiff 2009, Schiff 2000). In fact, Palos Verdes in the Los Angeles area is the location of a Superfund site, where up to 100 metric tons of DDTs are still found in offshore sediments (Lee et al. 2002). DDTs are a known persistent bioaccumulative organic contaminant. Food web transfer of DDTs has been well-documented in the Southern California Bight (Young et al. 1976, 1977) and elsewhere (Suedel et al. 1994). In fact, sediment concentrations have been well correlated with tissue levels in sediment-associated fishes (Schiff and Allen 2001). Even pelagic (water column) forage fishes have been shown to contain higher concentrations of DDTs near urban centers in the Southern California Bight (Jarvis et al. 2007).

Temporal Trends

Ongoing monitoring of DDTs in edible fish tissues is conducted by the Los Angeles County Sanitation Districts (LACSD). The LACSD has sampled white croaker and kelp bass fillets at several locations along Palos Verdes (Figure 4-8). Concentrations have declined in tissue composites from both species since

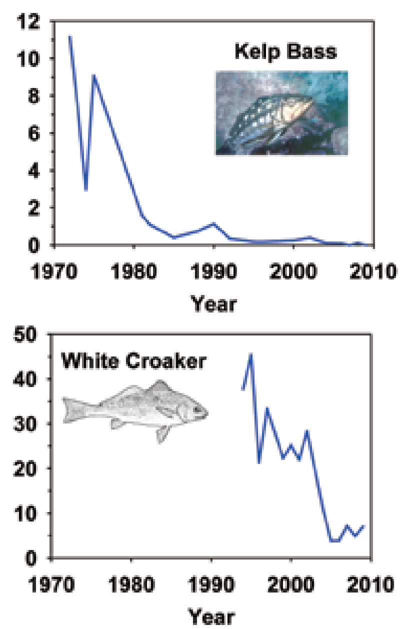


Figure 4-8. Median concentrations of DDTs (ppm) over time in muscle tissue from kelp bass and white croaker from Palos Verdes, California.

monitoring began in the 1970s. For kelp bass, DDT concentrations nearest the Superfund site have declined from 10 ppm in 1972 to below detection limits in 2009. For white croaker, DDT concentrations declined from 45 to 5 ppm between 1995 and 2009. This order-of-magnitude reduction now appears to have leveled off, with concentrations holding steady for the last four years. The NPDES monitoring data for kelp bass are consistent with the findings observed in the current study. The white croaker results from the NPDES monitoring, however, were much greater than the concentrations observed during the current study. Several explanations are available for this discontinuity, but the primary difference is presumed to be fishing location. The NPDES monitoring program collects white croaker at the Superfund site. The white croaker from the current study, while still collected from Palos Verdes, was collected kilometers away from the Superfund site.

Concentrations of DDTs, except for those fish on the Los Angeles margin, appear to be below OEHHA's ATLs. A fish advisory already exists along the Los Angeles margin. As a result, the primary management concerns are already being addressed. This includes ensuring public notification and education (http://www.pvsfish.org/; http://www.oehha.ca.gov/fish/so_cal/pdf_zip/SoCalFactsheet61809.pdf) as well as remediation activities to clean up the sediments responsible for the increased tissue levels (http://www.epa.gov/region9/superfund/pvshelf/index.html).

Priorities for Further Assessment

Since the Superfund site was subject to Natural Resource Damage Assessment (NRDA) actions, priorities and further assessments have been planned and are underway. Please visit the NRDA website for up to date information on these activities http://www.darrp.noaa.gov/southwest/montrose/msrphome.html

SECTION 5
SAN FRANCISCO BAY AND THE REGION 2 COAST

INTRODUCTION

Fish from San Francisco Bay contain concentrations of mercury, PCBs, and other chemical contaminants that are above thresholds of concern for human health. This problem was first documented in 1994 when the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) performed a pilot study to measure contaminant concentrations in Bay sport fish (Fairey et al. 1997). As a result of this pilot study the California Office of Environmental Health Hazard Assessment (OEHHA) issued an interim health advisory for consumption of fish from San Francisco Bay.

OEHHA issued an updated health advisory and safe eating guidelines for fish and shellfish caught from San Francisco Bay in 2011 (Gassel et al. 2011). The guidelines recommend avoiding shiner perch and other surfperch species from San Francisco Bay. Women ages 18-45 and children 1-17, who are most sensitive to mercury, should also avoid eating San Francisco Bay sharks, striped bass, or white sturgeon.

All segments of San Francisco Bay appear on the 303(d) List because the fish consumption advisory represents an impairment of the beneficial use of the Bay for sport fishing. The Clean Water Act also requires that Total Maximum Daily Load (TMDL), cleanup plans based on evaluation and reduction of contaminant loads, be developed in response to inclusion of a water body on the 303(d) List. Bay TMDLs for mercury and PCBs have been completed and Basin Plan Amendments adopted. In these TMDLs the emphasis has shifted away from enforcement of water quality objectives and toward enforcement of targets that are more directly linked with impairment, particularly methylmercury and PCB concentrations in sport fish and wildlife prey. Concentrations of mercury, PCBs, and other contaminants in sport fish are, therefore, fundamentally important indices of Bay water quality.

Sport fish monitoring in the Bay has been conducted on a three-year cycle since 1994 (Fairey et al. 1997). This section presents findings from the sixth round of sport fish sampling conducted in 2009 under the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) (Davis et al. 1999, Davis et al. 2002, Greenfield et al. 2003, Greenfield et al. 2005, Davis et al. 2006, Hunt et al. 2008). The monitoring program targets species that are frequently caught and consumed by Bay anglers at five popular fishing areas. This monitoring provides updates on the status of and long-term trends in contaminants of concern in Bay sport fish.

The objectives of the RMP fish contamination monitoring element are:

1. to produce the information needed for updating human health advisories and conducting human health risk assessments;
2. to measure contaminant levels in fish species over time to track temporal trends and to evaluate the effectiveness of management efforts;
3. to evaluate spatial patterns in contamination of sport fish and the Bay food web; and
4. to understand factors that influence contaminant accumulation in sport fish in order to better resolve signals of temporal and spatial trends.

The 2009 RMP sampling effort was supplemented substantially by coordination with SWAMP's statewide survey of contaminants in sport fish on the California coast. Coordination with SWAMP made it possible to sample a broader array of species and to generally invest more in sampling and analysis through savings achieved through joint reporting of the results. Coordination with SWAMP also made it possible to obtain data from coastal waters adjacent to the Bay, providing a much-needed update on the status of sport fish contamination in these areas, many of which had not been sampled since the Coastal Fish Contamination Program (CFCP) ended in 2003. The systematic and consistent statewide dataset being generated by SWAMP is also providing extremely valuable context for interpretation of coastal sport fish contamination.

This section also summarizes results for the Region 2 coast, including two sites of particular interest: Tomales Bay and Pillar Point Harbor. The CFCP and followup monitoring led to a consumption advisory and consideration of a TMDL for Tomales Bay due to methylmercury contamination, and to inclusion of Pillar Point Harbor on the 303(d) List due to methylmercury contamination.

SAN FRANCISCO BAY

Methylmercury

Methylmercury exposure is one of the primary concerns behind the sport fish consumption advisory for the Bay. The San Francisco Bay TMDL for mercury was approved by the U.S. EPA in February 2008. Continuing to monitor methylmercury in Bay sport fish will be crucial in assessing the effectiveness of the TMDL and tracking the additional reductions required to meet the target of 0.2 ppm that was established in the TMDL as the cleanup goal for protection of human health (SFBRWQCB 2006). The TMDL also established a 0.03 ppm target for small prey fish to protect piscivorous wildlife.

Comparison to Thresholds and Variation Among Species

Consistent with previous rounds of RMP sampling, methylmercury concentrations in Bay sport fish continue to exceed thresholds of concern (Figure 5-1, Tables 5-1 and 5-2). Two species, leopard shark and striped bass, had average concentrations (1.29 and 0.46 ppm, respectively) exceeding the no consumption ATL of

0.44 ppm. All leopard shark samples, ranging in concentration from a minimum of 0.78 ppm to a maximum of 1.84 ppm, exceeded 0.44 ppm. Concentrations in striped bass ranged from 0.25 ppm to 0.91 ppm. No samples of the other species approached 0.44 ppm.

The Mercury TMDL specifies that attainment of the target of 0.2 ppm is to be assessed using a grand mean of five popular species: striped bass, California halibut, white sturgeon, jacksmelt, and white croaker. Methylmercury was only analyzed in three of these species in 2009, precluding a precise assessment of status relative to the target. Average concentrations for the three species that were analyzed were 0.46 ppm for striped bass, 0.22 ppm for California halibut, and 0.08 ppm for jacksmelt.

None of the species sampled in the Bay had an average concentration, or even a single sample, below the lowest methylmercury threshold (the 2 serving ATL of 0.07 ppm). Jacksmelt had the lowest average (0.08 ppm). Shiner surfperch had the second lowest average concentration (0.12 ppm).

Spatial Patterns

Significant variation among the five Bay sampling locations for most of the species collected was not expected, due primarily to their wide movements, especially striped bass which are known to move throughout the entire Bay-Delta Estuary (Davis et al. 2003). Shiner surfperch, however, have proven to be a useful indicator of spatial variation in past sampling, and the collection of replicate samples in this sampling round allowed for examination of spatial patterns. This information is valuable in guiding efforts to identify and reduce the sources and pathways of methylmercury contamination. The high site fidelity of this species, coupled with the large numbers of fish going into each composite sample (typically 15-20 fish), yields a surprising degree of statistical power to detect spatial patterns even with only three composites per location.

Three replicate composite shiner surfperch samples were collected at each of the five Bay sampling locations. The observed variance within each location was very low (coefficients of variation for each site ranged between 2% and 10%), allowing detection of statistically significant differences among multiple locations (Figure 5-2). Oakland had the highest average concentration (0.19 ppm), significantly higher than all of the other locations. South Bay was second highest (0.13 ppm), and also significantly higher than Berkeley (0.10 ppm), San Francisco (0.09 ppm), and San Pablo Bay (0.08 ppm). The highest average at Oakland was 2.4 times higher than the lowest average at San Pablo Bay.

Temporal Trends

Methylmercury in striped bass is perhaps the most important indicator of mercury contamination in the Bay and Delta from a human health perspective. This is due to a combination of the high mercury concentrations that sometimes occur in their tissue, their abundance, and their popularity among anglers. Striped bass are high trophic level predators and therefore highly susceptible to accumulating high concentrations of methylmercury. Striped bass are also good integrative indicators of mercury contamination in the Bay-Delta

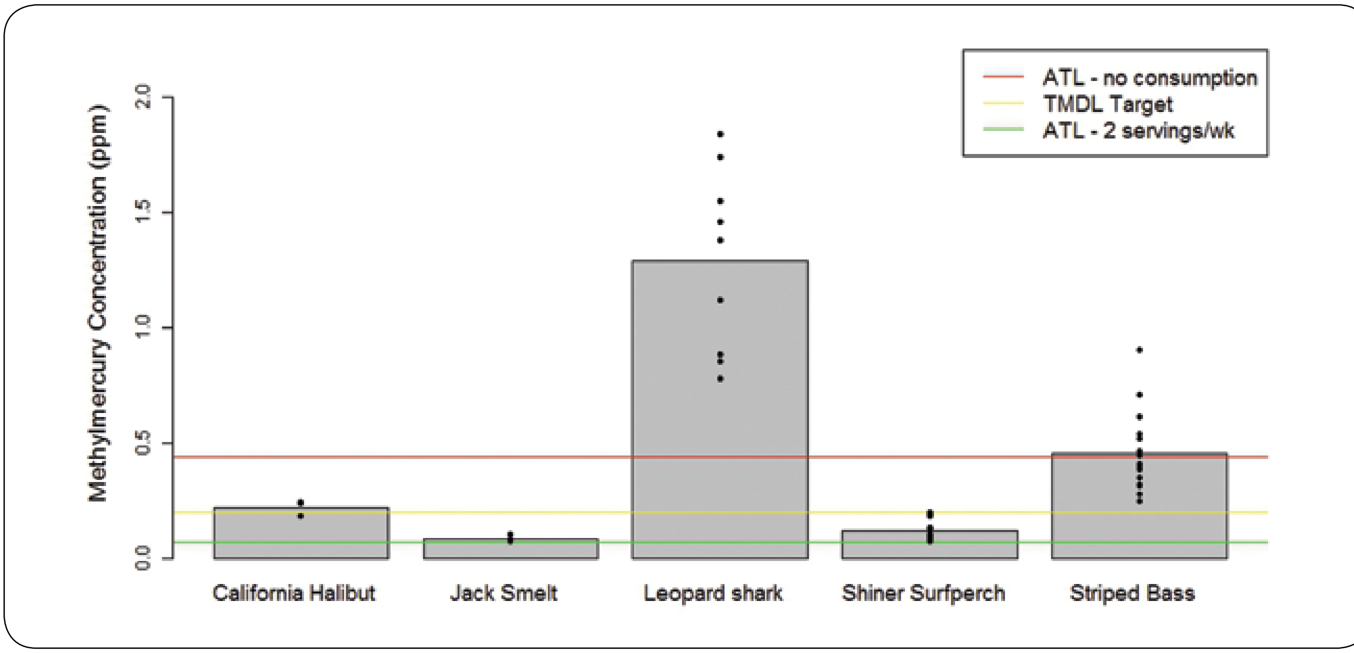


Figure 5-1. Methylmercury concentrations (ppm) in sport fish species in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent individual samples (either composites or individual fish).

Estuary because of their use of the entire ecosystem, including both fresh and saline waters. Striped bass spend most of their lives in San Francisco Bay, but also move into freshwater and the coastal ocean. Recent data have shown that individual striped bass are quite variable in their use of Bay, freshwater, and ocean habitats (Ostrach, D. unpublished data). While this extensive movement makes striped bass good integrative indicators of the estuarine ecosystem, it makes them poor indicators of small-scale spatial variation within the Bay-Delta and also may confound attempts to discern long-term trends.

A relatively extensive historical dataset exists for striped bass in the Bay, allowing evaluation of trends over 39 years from 1971-2009 (Figure 5-3). The data are presented as estimated concentrations of each striped bass at a standard length of 60 cm in order to remove any bias that might occur from sampling different-sized fish in different years. Greenfield et al. (2005) used this technique previously for Bay-Delta striped bass. Striped bass generally show a correlation with size, as seen for the 2009 data ($p = .07$) in Figure 5-4. The 0.44 ppm no consumption ATL provides a useful point of reference for examining fluctuations in annual average concentrations (Figure 5-3). Overall, intra-annual variance has been high and average concentrations in recent years are not significantly different from those measured in the early 1970s. A more rigorous analysis of this dataset is in preparation as a manuscript by Melwani and coauthors. Note that due to length-correction the average shown in Figure 5-3 is slightly different from that discussed previously.

Table 5-1
Summary statistics by species.

Common Name (Sample Type)		Average Number of Fish in Composites	Average Total Length (mm)	Average Percent Lipid	Average Mercury (ppm)	Average Selenium (ppm)	Average Sum of PCBs (ppb)	Average Sum of Dioxin TEQs (pptr)	Average Dieldrin (ppb)	Average Sum of DDTs (ppb)	Average Sum of Chlordanes (ppb)	Average Sum of PBDEs (ppb)	Average PFOS (ppb)
California Halibut (Composite)	average	3	663	0.23	0.22	0.40	18		0.0	3.1	0.3	1.8	0.0
	count		3	3	3	3	3		1	3	3	3	3
Jack Smelt (Composite)	average	5	263	0.69	0.08	0.32	22		0.5	12.5	1.8	1.5	
	count		4	4	4	4	4		2	4	4	4	
Leopard shark (Composite)	average	3	1095	0.38		0.30	21		0.2	7.3	1.1	4.9	6.0
	count		3	3		3	3		2	3	3	3	3
Leopard shark (Individual)	average	1	1095		1.29								
	count		9		9								
Northern Anchovy (Composite)	average	38	88	1.49		0.47	118		0.9	18.9	5.5	7.9	4.4
	count		9	9		9	9		9	9	9	9	3
Shiner Surfperch (Composite)	average	18	115	1.52	0.12	0.42	121	0.89	1.1	21.8	7.1	8.3	0.0
	count		15	15	15	15	15	10	7	15	15	15	3
Striped Bass (Composite)	average	3	609	0.60		0.46	30		0.3	11.1	1.5	5.0	0.0
	count		6	6		6	6		4	6	6	6	3
Striped Bass (Individual)	average	1	609		0.46								
	count		18		18								
White Croaker - skin off (Composite)	average	5	256	1.22		0.39	52	0.44	0.5	8.7	2.2	4.3	0.0
	count		12	12		12	12	12	11	12	12	12	3
White Croaker - skin on (Composite)	average	5	256	3.01			144		1.0	23.3	5.6	11.4	
	count		12	12			12		9	12	12	12	
White Sturgeon (Composite)	average	3	1322	0.50			11		0.2	5.5	1.2	2.8	3.2
	count		4	4			4		4	4	4	4	3
White Sturgeon (Individual)	average	1	1322			1.47							
	count		12			12							

Lipid percentages (and counts) for dioxin batches were 1.8 (10) and 1.19 (12) for shiner surfperch and white croaker (skin off), respectively.

Table 5-2
Counts of samples exceeding Regional Water Board TMDL targets (number of samples above target/total number of samples analyzed) for mercury and PCBs and calculated targets for other contaminants. Calculated targets were derived using the same assumptions that were used in deriving the TMDL targets: one extra cancer case for an exposed population of 100,000 over a 70-year lifetime, a mean body weight of 70 kg, and a mean daily consumption rate of 0.032 kg/day (the 95th percentile upper bound estimate of fish intake reported by all Bay fish-consuming anglers).

Common Name	Sample Type	Mercury (0.2 ppm)	Sum of PCBs (10 ppb)	Sum of Dioxin TEQs (0.14 pptr)	Dieldrin (1.4 ppb)	Sum of DDTs (64 ppb)	Sum of Chlordanes (17 ppb)
California Halibut	Composite	2/3	2/3		0/1	0/3	0/3
Jacksmelt	Composite	0/4	3/4		0/2	0/4	0/4
Leopard shark	Composite		3/3		0/2	0/3	0/3
Leopard shark	Individual	9/9					
Shiner Surfperch	Composite	0/15	15/15	10/10	0/7	0/15	0/15
Striped Bass	Composite		5/6		0/4	0/6	0/6
Striped Bass	Individual	18/18					
White Croaker - skin off	Composite		11/12	12/12	0/11	0/12	0/12
White Croaker - skin on	Composite		12/12		0/9	0/12	0/12
White Sturgeon	Composite		3/4		0/4	0/4	0/4

Management Implications and Priorities for Further Assessment

The 2009 data indicate that high methylmercury concentrations in the Bay persist and do not show obvious signs of decline. Striped bass and California halibut had average concentrations above the TMDL target of 0.2 ppm, while jacksmelt had an average lower than the target. The shiner surfperch data suggest that some locations, such as Oakland Harbor and South Bay, contribute more to methylmercury accumulation in the food web and may be a higher priority for efforts to reduce sources and pathways.

Future rounds of sampling should include all five species that are specified as targets in the Mercury TMDL. Measuring methylmercury in northern anchovy would also provide valuable information on wildlife exposure from this important prey species.

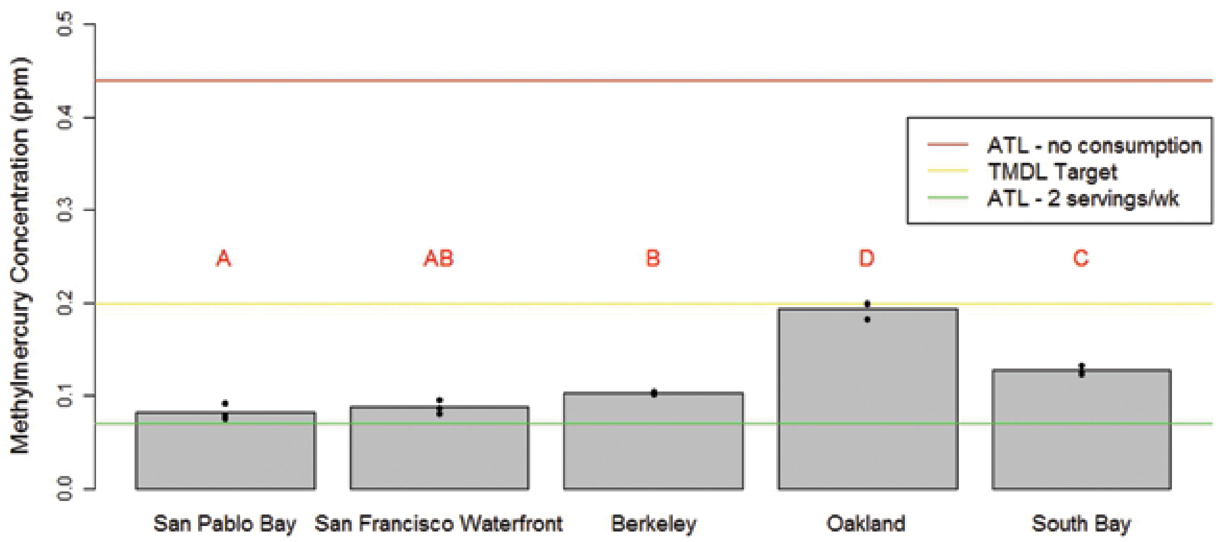


Figure 5-2. Methylmercury concentrations (ppm) in shiner surfperch in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent composite samples with 13-20 fish in each composite. Locations with the same letter were not significantly different from each other (p = .05).

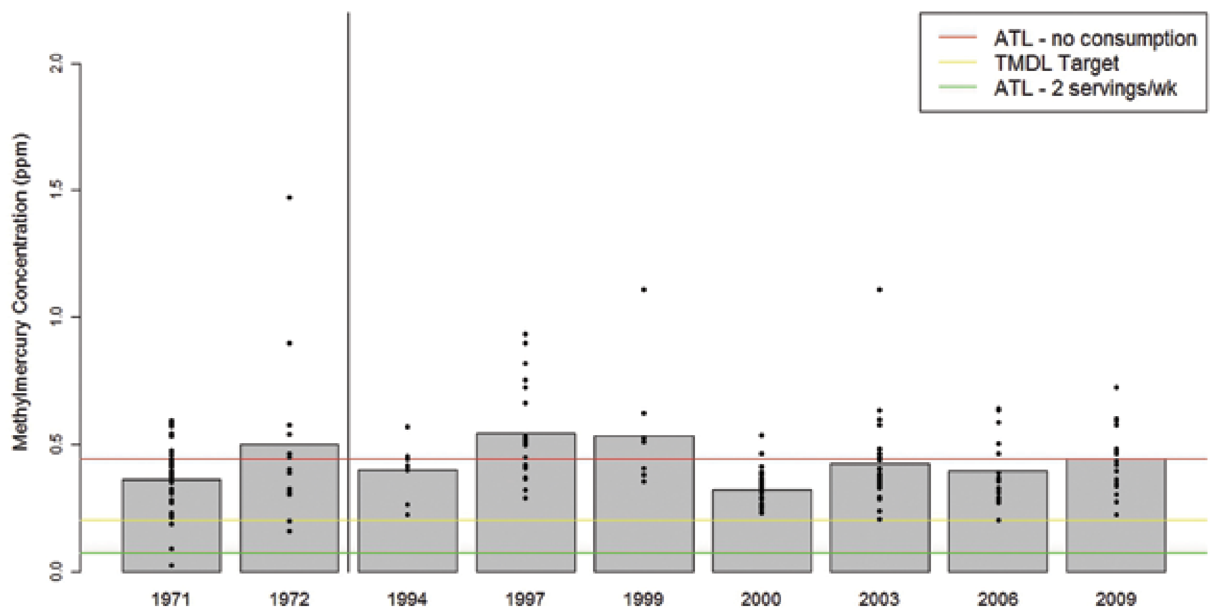


Figure 5-3. Methylmercury concentrations (ppm) in striped bass from San Francisco Bay, 1971-2009. Bars indicate average concentrations. Points represent individual fish. To correct for variation in fish length, all plotted data have been calculated for a 60-cm fish using the residuals of a length vs. log(Hg) relationship. Data were obtained from CDFG historical records (1971 – 1972), the Bay Protection and Toxic Cleanup Program (1994), a CalFed-funded collaborative study (1999 and 2000), and the Regional Monitoring Program (1997, 2000, 2003, 2006, and 2009).

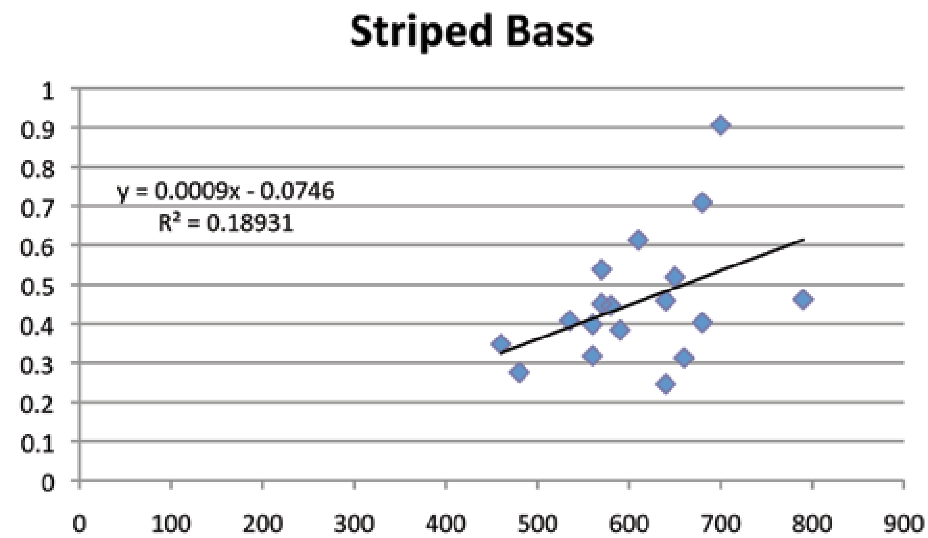


Figure 5-4. Methylmercury (ppm - vertical axis) versus length (mm - horizontal axis) in striped bass samples collected by the RMP in 2009. Each point represents an individual fish.

PCBs

PCB exposure is another primary concern behind the sport fish consumption advisory for the Bay. The San Francisco Bay TMDL for PCBs was approved by the U.S. EPA in February 2010. Continuing to monitor PCBs in Bay sport fish will be crucial in assessing the effectiveness of the TMDL and tracking the additional reductions required to meet the target of 10 ppb that was established as a cleanup goal for protection of human health in the TMDL (SFBRWQCB 2008). Attaining this target will require a substantial reduction in PCBs in the Bay food web that is anticipated to also result in protection of wildlife from risks due to PCB exposure.

White croaker and shiner surfperch are the two species identified in the PCBs TMDL as indicators for comparison to the 10 ppb TMDL target. White croaker traditionally have been analyzed as fillets with skin in the RMP, as some anglers consume these fish with skin and this represents a conservative approach for estimating exposure. On the other hand, drawbacks in using this approach are that it is inconsistent with the advice provided by OEHHA for preparation of fish fillets; it is inconsistent with how white croaker samples are processed in other parts of the state; and skin is difficult to homogenize, leading to higher variance in the results. In 2009 the RMP began a switch to using fillets without skin. To provide more information in support of this transition, white croaker fillets were analyzed for organics in both fillets with and without skin. Removing the skin was found to result in substantially lower concentrations (Figure 5-5). For PCBs, the average reduction was 65%. The reduction in PCBs and other organic contaminants was driven by a 60% average reduction in lipid in the fillets without skin (Table 5-1). Preparing white croaker fillets without skin is a very effective way to reduce exposure to organic contaminants. The graphs presented for PCBs and the other organics display the results for white croaker without skin.

Comparison to Thresholds and Variation Among Species

Consistent with past RMP sampling, PCB concentrations in Bay sport fish continue to exceed thresholds of concern (Figure 5-6, Tables 5-1 and 5-2). The degree of PCB contamination in the Bay was similar to that observed for methylmercury, with one key indicator species (shiner surfperch) having a Baywide average (121 ppb) just above the no consumption ATL (120 ppb), and other species exhibiting moderate levels of contamination.

Shiner surfperch are a species that are also not processed as fillets (they are processed whole with head, viscera, and tail removed due to their small size - typically 11 cm, or 4.3 in), but these fish are caught and consumed by anglers. Two locations in the Bay had average concentrations that were above 120 ppb (discussed further below).

Northern anchovy also had an average concentration (118 ppb) approaching 120 ppb (Figure 5-6). Northern anchovy are not a target species for human consumption, but they are collected in the RMP sport fish trawls and analyzed as an indicator of wildlife exposure. They accumulate high concentrations of PCBs and other organic contaminants in spite of their small size (9 cm, or 3.5 in) and low trophic position. Their analysis as whole body samples and consequent relatively high lipid content (averaging 1.5%) are factors contributing to the high accumulation.

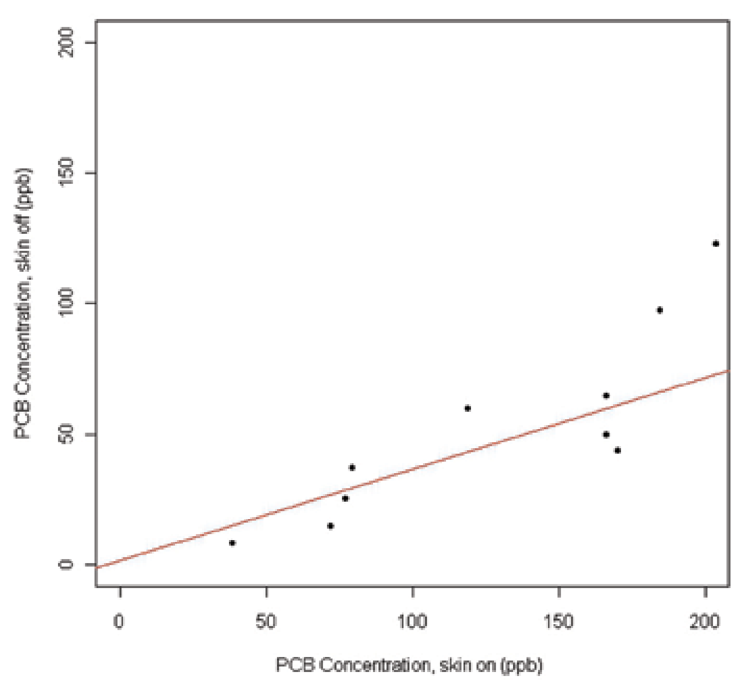


Figure 5-5. PCB concentrations (ppb) in paired samples of white croaker fillets with and without skin. The slope of the line is 0.35 ($p = 0.02$), indicating a 65% average reduction in concentration in the samples without skin.

White croaker had the third highest average PCB concentration (52 ppb – well below the no consumption ATL, but well above the 10 ppb TMDL target) (Figure 5-6). One white croaker sample (from Oakland) exceeded 120 ppb. PCB concentrations in the white croaker fillets with skin were much higher, averaging 144 ppb (Table 5-1).

Average PCB concentrations in other species were lower, ranging from 30 ppb in striped bass to the lowest average of 11 ppb in white sturgeon. All of the species sampled had an average above the 10 ppb TMDL target. Every Bay sample analyzed was higher than the FCG of 3.6 ppb.

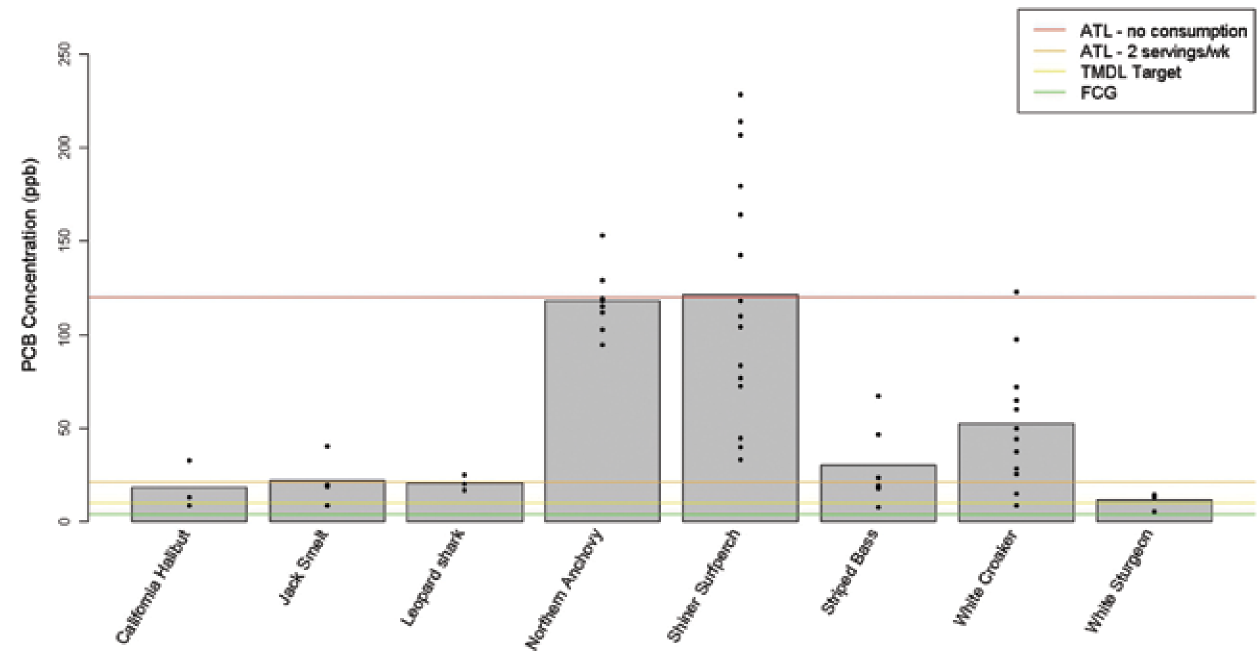


Figure 5-6. PCB concentrations (ppb) in sport fish species in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent composite samples. White croaker data are for the samples without skin. Note that northern anchovy are not a sport fish species – they are an important wildlife prey species that is collected in the surveys in San Francisco Bay and analyzed as whole fish.

Spatial Patterns

As described above, shiner surfperch have high site fidelity and are an excellent indicator of spatial patterns. Their sensitivity as a spatial indicator was particularly evident in the 2009 PCB results (Figure 5-7). As seen for methylmercury, the observed variance within each location was very low: coefficients of variation for each site ranged between 5% and 15%. For PCBs, this allowed for the unusual result that every sampling location was significantly different from every other sampling location. Two locations had average concentrations exceeding the no consumption ATL of 120 ppb: Oakland (216 ppb) and San Francisco (162 ppb). Average concentrations for the other locations were 111 ppb in South Bay, 77 ppb at Berkeley, and 39 ppb in San Pablo Bay. These data indicate the presence of strong spatial gradients in PCB concentrations in the Bay, which spanned over a five-fold difference between Oakland and San Pablo Bay. The availability of shiner surfperch data from other parts of the state (Section 3, Figure 3-10) provide additional context for interpreting these Bay data. The average concentration observed in San Pablo Bay was actually higher than many other coastal locations. The shiner surfperch data clearly illustrate that PCB concentrations in San Francisco Bay are generally elevated throughout the ecosystem, with distinct spatial gradients.

Temporal Trends

Shiner surfperch and white croaker are the key indicator species identified in the PCBs TMDL, and have been the focus of efforts to establish long-term time series in the RMP.

Examining time series of wet weight PCB concentrations provides information on trends in human exposure and in progress toward achieving the 10 ppb TMDL target (Figures 5-8 and 5-9). The Baywide average shiner surfperch concentration was lower in 2009 than in 1997, but not significantly different from 2000, 2003, or 2006. The spatial coherence observed in 2009 has also been evident in past sampling, with Oakland, San Francisco, and South Bay consistently higher than the other two locations. The high average concentration in 1997 was driven by exceptionally high concentrations measured at Oakland (over 500 ppb). Concentrations at Oakland appear to have declined markedly since 1997, although this pattern is largely due to variation in lipid and may also be partially due to small-scale spatial variation and fine-scale changes in sampling location within the Port of Oakland and San Leandro Bay. Overall, the wet weight shiner data indicate no decline over the last four rounds of sampling from 2000 to 2009.

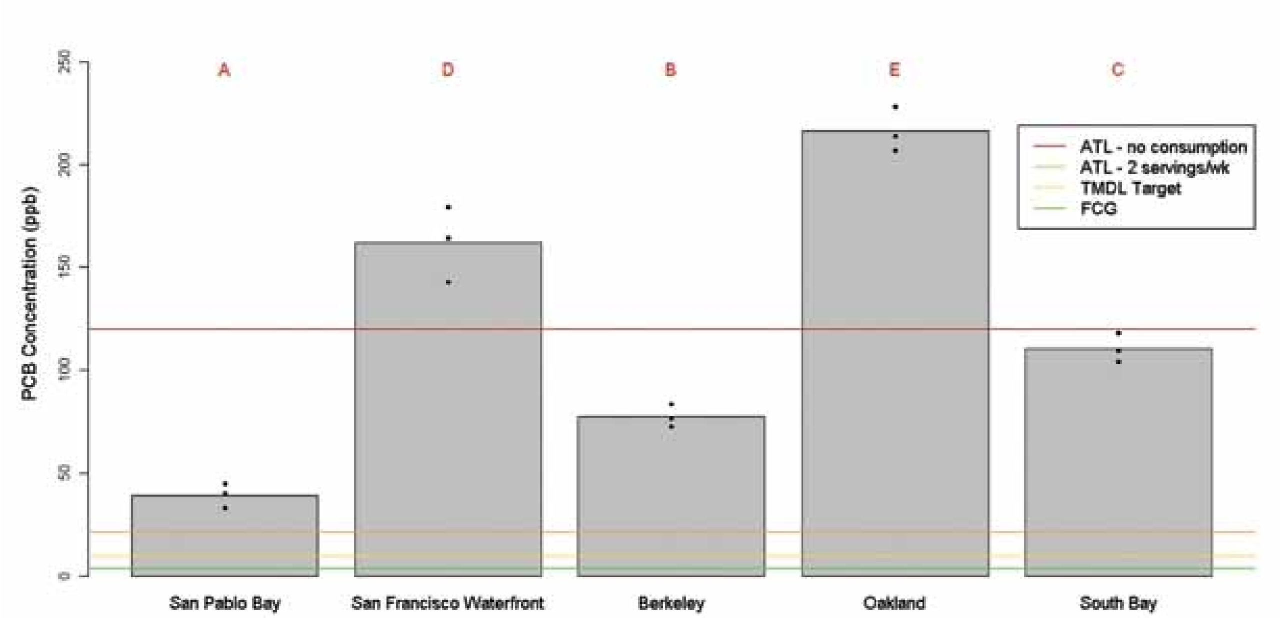


Figure 5-7. PCB concentrations (ppb wet weight) in shiner surfperch in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent composite samples with 13-20 fish in each composite. Locations with the same letter were not significantly different from each other ($p = .05$).

Wet weight PCB concentrations in white croaker were considerably lower in 2009 due primarily to the switch to fillets without skin (Figure 5-9). The switch to fillets without skin presents a significantly different picture of concerns due to consumption of white croaker. The average concentration in 2009 for fillets with skin (144 ppb) was also low relative to past years, though this difference was driven largely by lower lipid in the 2009 samples.

The long-term time series for shiner surfperch and white croaker can also be examined on a lipid weight basis to provide a better index of trends in ambient concentrations of PCBs in the Bay (Figures 5-10 and 5-11). The lipid-normalized trends are quite different from the wet weight trends. For shiner surfperch, no significant differences among years were detected, and the average concentration in 2009 was quite similar to averages observed in 1997 and 2000. The time series for Oakland is also quite different on a lipid weight basis, with the highest average concentration occurring in 2006, in contrast to the elevated wet weight concentrations occurring there in 1997 (Figure 5-8). The lipid weight data for white croaker (Figure 5-11) also do not suggest any long-term trend. It is noteworthy that when the PCB concentrations are expressed on a lipid weight basis, the skin off fillets are directly comparable to the skin on fillets from previous rounds, and the 2009 concentrations are very consistent with the earlier results (Figure 5-11). Overall, the lipid weight PCB data for shiner surfperch and white croaker suggest that ambient PCB concentrations in the Bay did not decline appreciably from 1997-2009.

Management Implications and Priorities for Further Assessment

The 2009 results indicate that high PCB concentrations in the Bay persist and do not show obvious signs of decline. The shiner surfperch data indicate that some locations, such as Oakland Harbor and San Francisco, contribute more to PCB accumulation in the food web and may be a higher priority for efforts to reduce sources and pathways. The spatial variation in shiner surfperch also has implications for human exposure, with two locations clearly exceeding the 120 ppb no consumption ATL. Removal of skin from white croaker fillets is a very effective way of reducing PCB exposure. Consistently high PCB concentrations in northern anchovy, an important prey species, pose a concern for piscivorous Bay wildlife.

DIOXINS

Polychlorinated dibenzodioxins and dibenzofurans (in this report the term “dioxins” will be used to refer collectively to all dioxins and furans) are classes of contaminants that are ubiquitous in the environment and are classified as human carcinogens. As part of the PCB TMDL, the SFBRWQCB has calculated a fish tissue target of 0.14 pptr (parts per trillion) for the assessment of risk to human health due to dioxins (SFBRWQCB 2008). This dioxin tissue target is not regulatory. The SFBRWQCB is in the early stages of developing a TMDL for dioxins. OEHHA has not developed ATLs or a FCG for dioxins.

Dioxin data are presented as toxic equivalents (TEQs). In calculating dioxin TEQs, the relative toxicity of a dioxin-like compound compared to dioxin (toxic equivalency factors, or TEF) is multiplied by the measured concentration of the chemical to derive a dioxin TEQ. For example, 2,3,7,8-tetrachorodibenzofuran (2,3,7,8-TCDF) is one-tenth as potent as dioxin and has a TEF of 0.1. If a sample contains 50 pptr of 2,3,7,8-TCDF, the dioxin TEQ attributable to 2,3,7,8-TCDF in that sample is 5 pptr. Dioxin TEQs for measured dioxin-like compounds with established TEFs can be added to calculate the total dioxin TEQs in a sample. The TEFs used in this report were from WHO (2005) (Appendix 6). The dioxin TEQs presented in this report are based

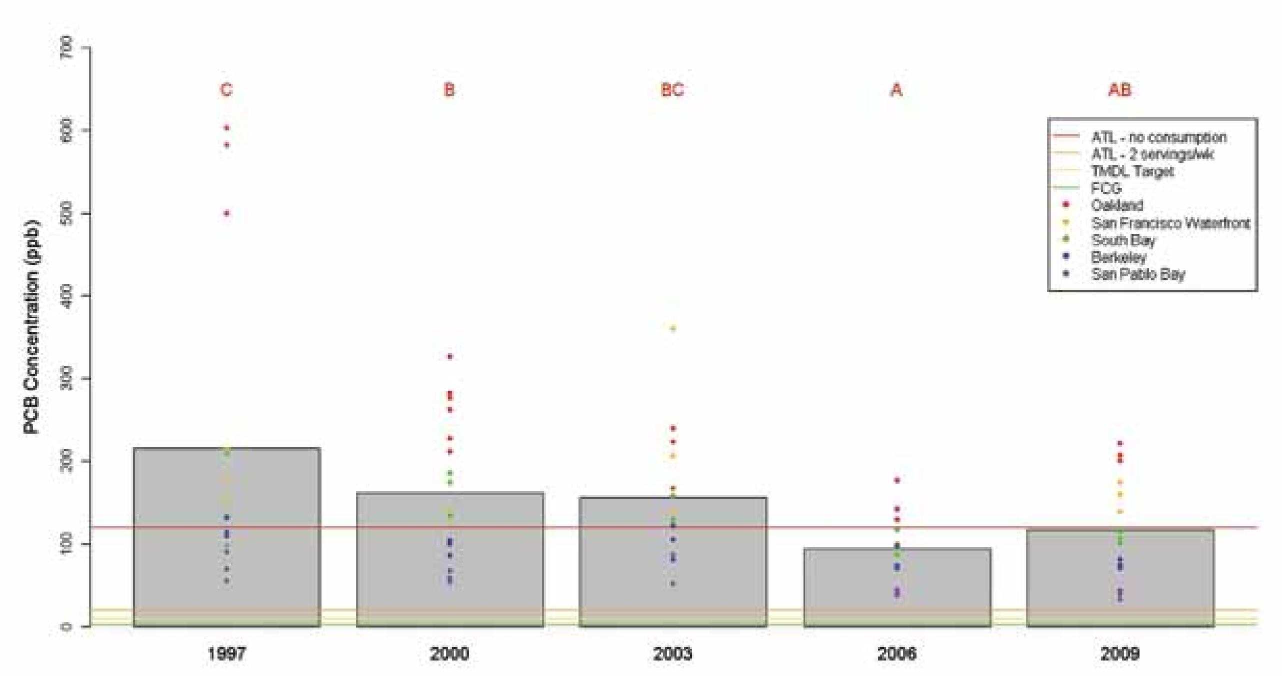


Figure 5-8. PCB concentrations (ppb wet weight) in shiner surfperch in San Francisco Bay, 1997-2009. Bars indicate average concentrations. Points represent composite samples. Years with the same letter were not significantly different from each other (p = .05).

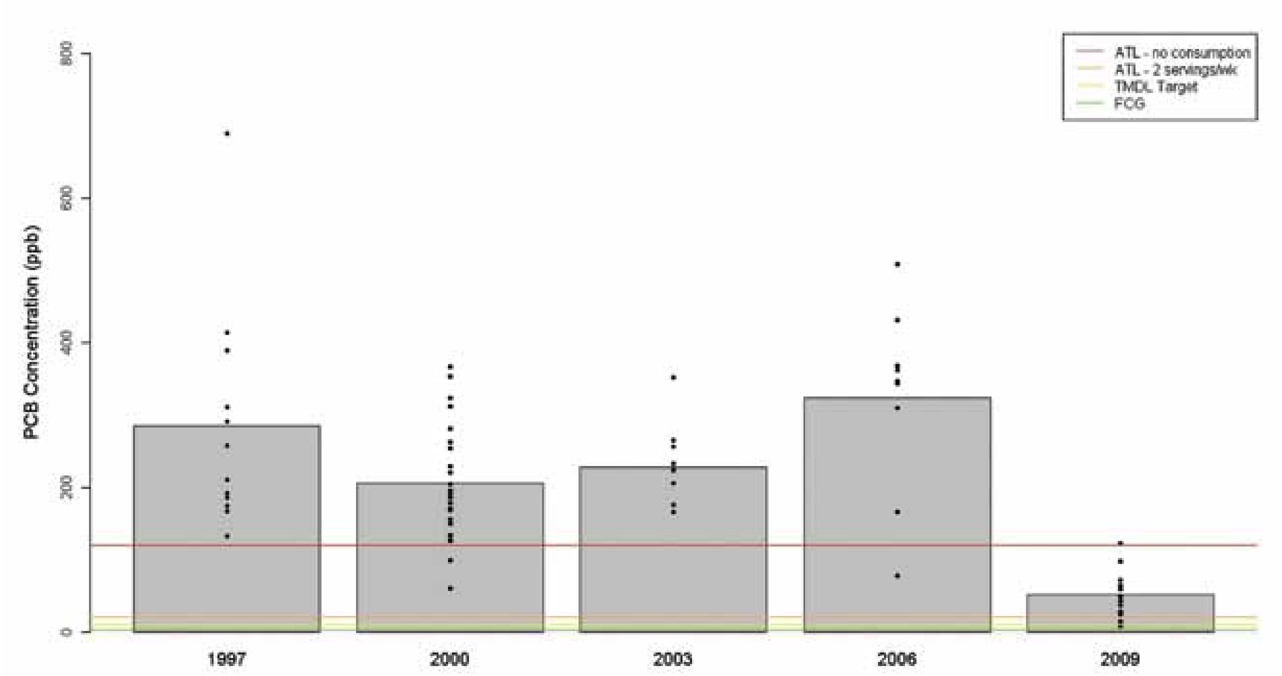


Figure 5-9. PCB concentrations (ppb wet weight) in white croaker in San Francisco Bay, 1997-2009. Bars indicate average concentrations. Points represent composite samples. Data from 2000-2006 are for fillets with skin, data from 2009 are for fillets without skin.

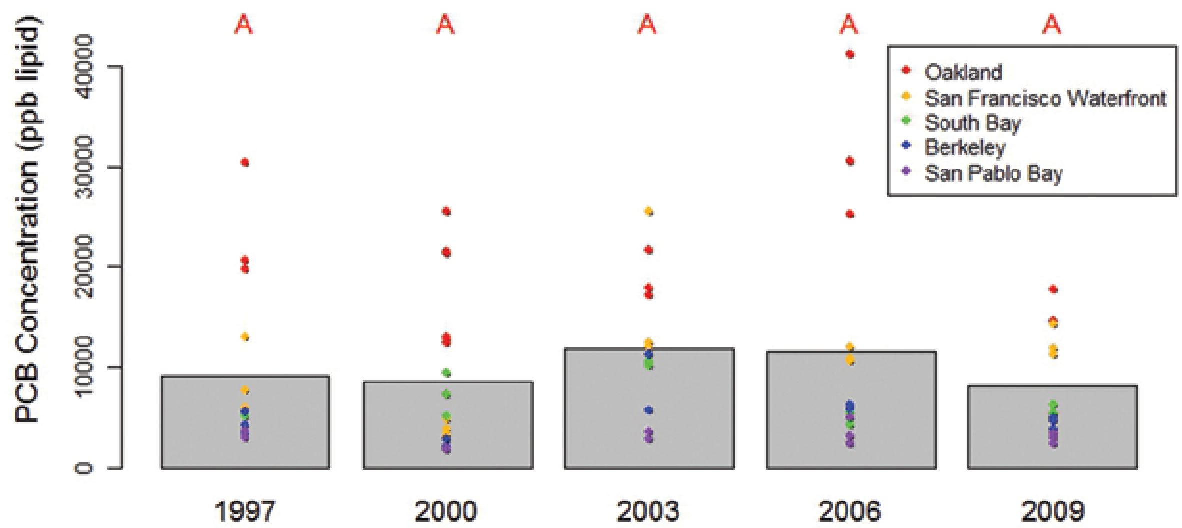


Figure 5-10.PCB concentrations (ppb lipid weight) in shiner surfperch in San Francisco Bay, 1997-2009. Bars indicate average concentrations. Points represent composite samples. Years with the same letter were not significantly different from each other (p = .05). Data for 2009 are expressed as the sum of 40 congeners that were also analyzed in earlier rounds of sampling (rather than a sum of the 55 congeners analyzed in the 2009 samples).

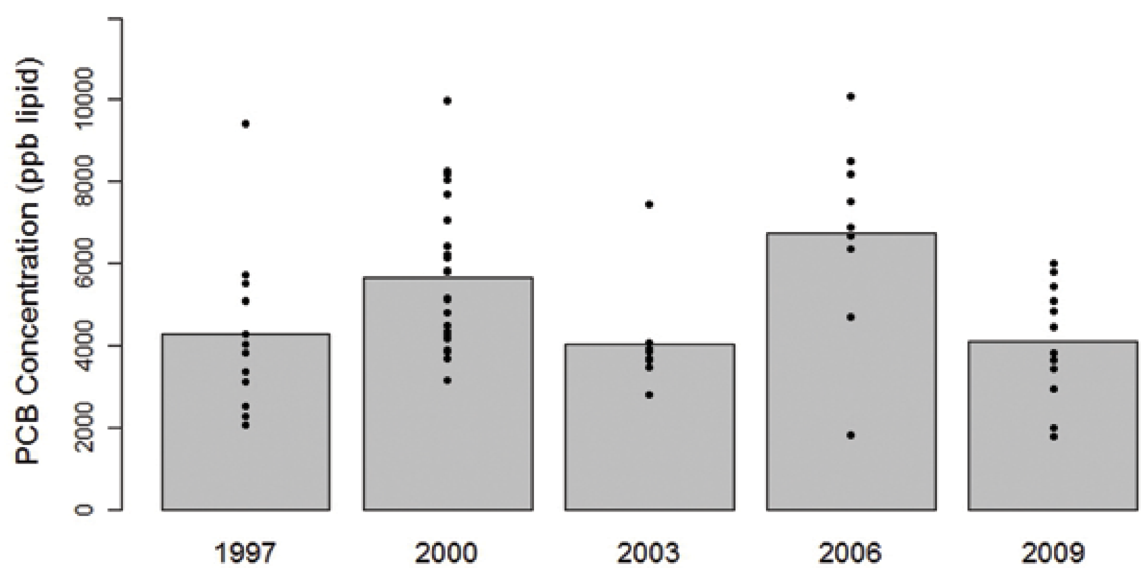


Figure 5-11. PCB concentrations (ppb lipid weight) in white croaker in San Francisco Bay, 1997-2009. Bars indicate average concentrations. Points represent composite samples. Data from 2000-2006 are for fillets with skin, data from 2009 are for fillets without skin. Data for 2009 are expressed as the sum of 40 congeners that were also analyzed in earlier rounds of sampling (rather than a sum of the 55 congeners analyzed in the 2009 samples).

on measurements of six dioxins and 10 dibenzofurans (Appendix 7); the notation TEQPCDD/PCDF is used to clearly indicate this distinction.

It should be noted that many other contaminants also have dioxin-like potency, most prominently the PCBs. Specifically, several coplanar PCBs (especially PCB 126) have significant dioxin-like potency that results in PCB TEQs that actually often exceed TEQPCDD/PCDF. The most potent coplanar PCBs are usually not quantified using analytical methods for PCBs (as was the case in this study) because they are present at concentrations that are much lower than the abundant congeners and require a more sensitive method. Past work that did measure the coplanar PCBs in Bay fish found that PCB TEQs were actually about five times greater than TEQPCDD/PCDF (Davis et al. 1999). The San Francisco Bay Water Board has chosen to regulate PCBs in the Bay on the basis of the sum of all PCBs, rather than on the basis of their dioxin-like potency. Achieving the 10 ppb target for sum of PCBs is anticipated to also reduce to dioxin-like PCBs to an acceptable level (SFBRWQCB 2008). It is important to recognize that, even though there are other significant sources of dioxin TEQs that contribute to the overall dioxin-like potency of residues in fish tissue, the TEQs attributable to dioxins and furans on their own exceed the existing threshold for concern by a considerable margin.

Dioxin analyses are relatively expensive, and therefore dioxin monitoring was limited in 2009, as in previous monitoring, to the high lipid species that accumulate the greatest concentrations of organic contaminants: shiner surfperch and white croaker.

Comparison to Thresholds and Variation Among Species

Consistent with past RMP sampling, TEQPCDD/PCDF concentrations in shiner surfperch and white croaker from the Bay continue to exceed the 0.14 pptr threshold of concern (Figure 5-12, Tables 5-1 and 5-2). The average TEQPCDD/PCDF concentration in shiner surfperch was 0.89 pptr, six times higher than the Water Board target. The average in white croaker was 0.44 pptr, three times higher than the target. All of the samples analyzed had concentrations greater than 0.14 pptr. The overall range of TEQPCDD/PCDF concentrations was from 0.20 to 1.59 pptr.

Spatial Patterns

Due to budget limitations, only two replicates of shiner surfperch were analyzed at each location. This limited the statistical power to detect spatial patterns. Nevertheless, the shiner surfperch data do suggest spatial variation that resembles the pattern seen for methylmercury and PCBs. Oakland had the highest average TEQPCDD/PCDF concentration (1.42 pptr) and San Pablo Bay had the lowest (0.53 pptr), a 2.7-fold difference. Other locations had similar concentrations of approximately 0.80 pptr.

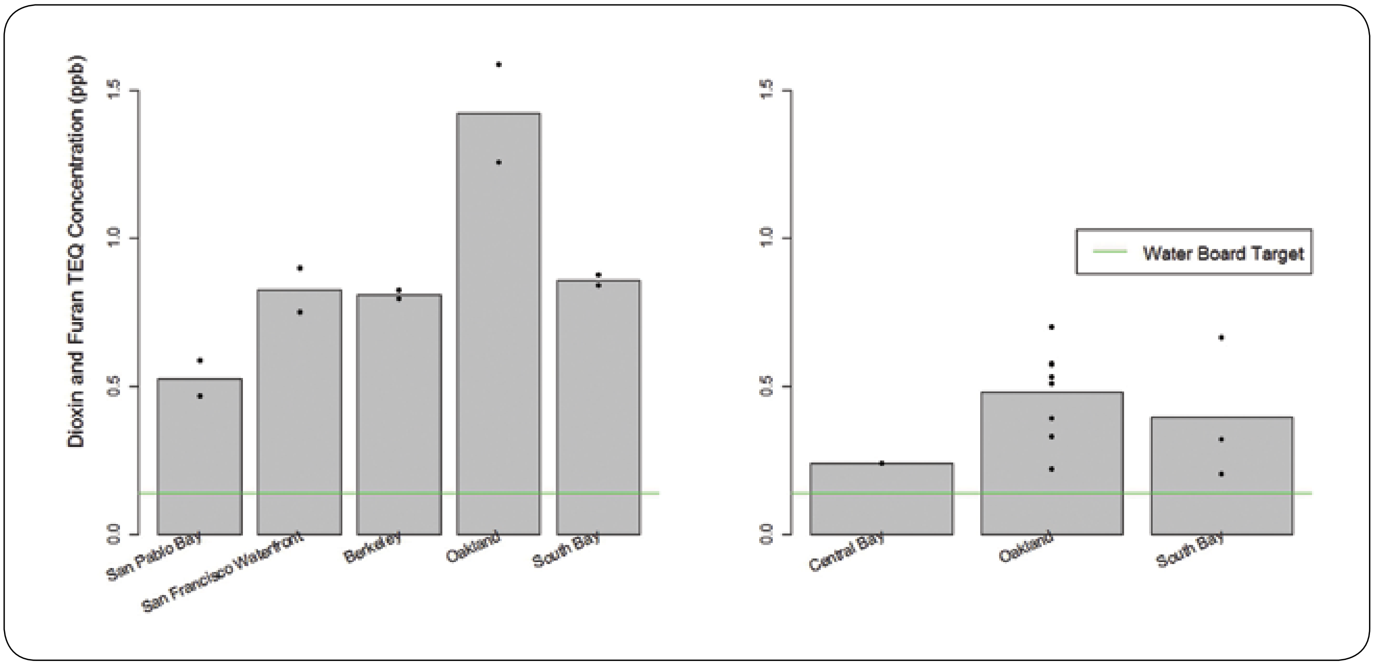


Figure 5-12. Dioxin TEQ concentrations (ppb) in shiner surfperch (left) and white croaker (right, without skin) in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent composite samples.

Temporal Trends

RMP assessment of long-term trends in dioxins has focused on white croaker. Examining time series of wet weight TEQPCDD/PCDF concentrations provides information on temporal variation in human exposure and in progress toward achieving the 0.14 pptr target (Figure 5-13). Wet weight TEQPCDD/PCDF concentrations in white croaker were considerably lower in 2009 due primarily to the switch to fillets without skin. The switch to fillets without skin presents a significantly different estimate of concern due to consumption of white croaker. TEQPCDD/PCDF were not measured in fillets with skin, but the lipid reduction observed in the fillets without skin certainly had a large influence on the lower concentrations observed in 2009.

The long-term time series for white croaker can also be examined on a lipid weight basis to provide a better index of trends in ambient concentrations of TEQPCDD/PCDF in the Bay (Figure 5-14). The lipid-normalized time series suggests that ambient concentrations were higher in 2000 than in 2003-2009. The average concentration in white croaker in 2009 was similar to those observed in 2003 and 2006. The cause of the higher concentrations observed in 2000 is unknown. Since 2003, concentrations appear to be holding relatively constant.

Management Implications and Priorities for Further Assessment

TEQPCDD/PCDF concentrations in the Bay are higher than the Water Board target and do not show obvious signs of decline. The shiner surfperch data indicate that Oakland Harbor has particularly high

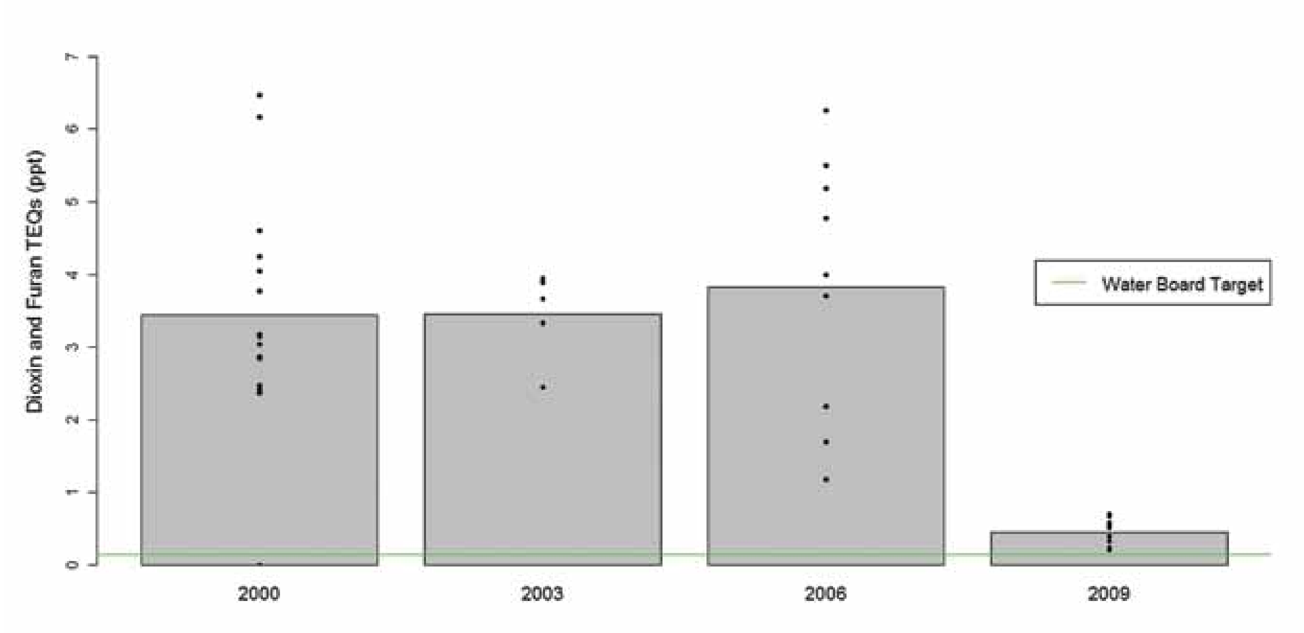


Figure 5-13. Dioxin TEQ concentrations (pptr wet weight) in white croaker in San Francisco Bay, 2000-2009. Bars indicate average concentrations. Points represent composite samples. Data from 2000-2006 are for fillets with skin, data from 2009 are for fillets without skin.

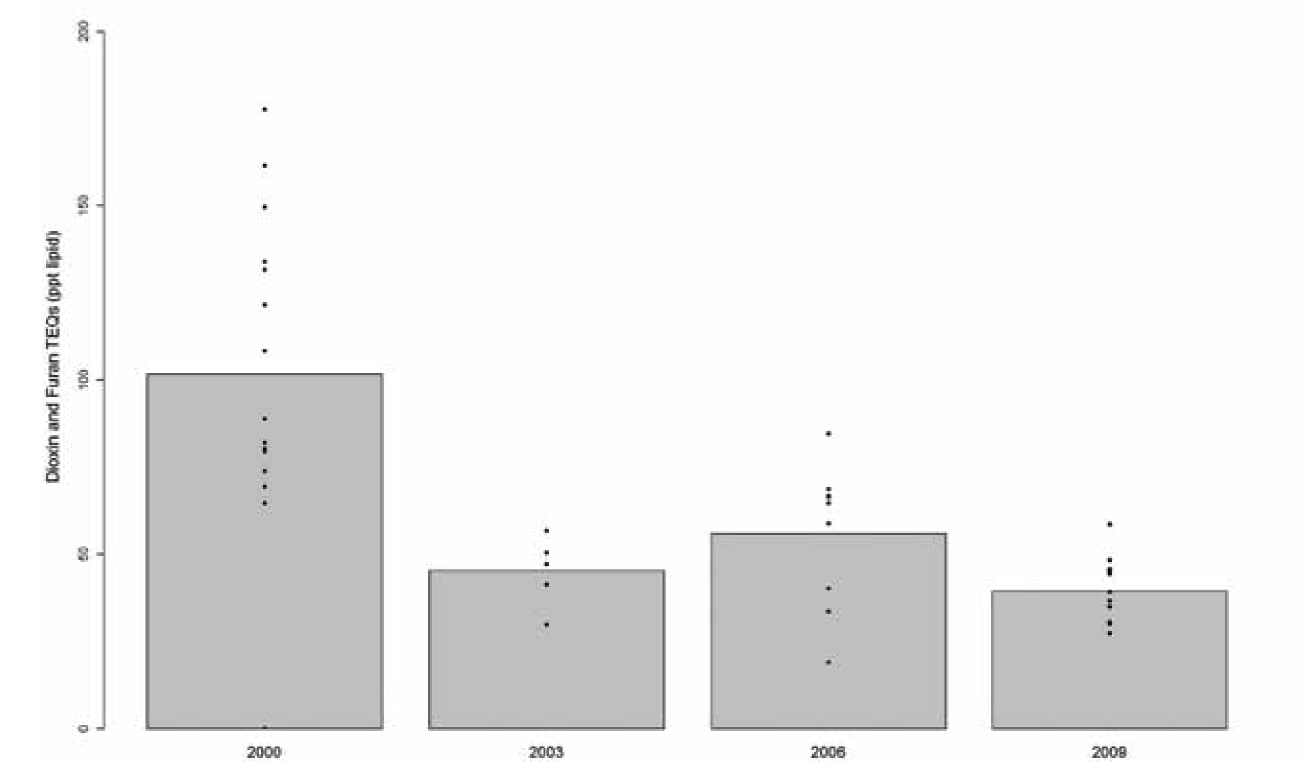


Figure 5-14. Dioxin TEQ concentrations (pptr lipid weight) in white croaker in San Francisco Bay, 2000-2009. Bars indicate average concentrations. Points represent composite samples. Data from 2000-2006 are for fillets with skin, data from 2009 are for fillets without skin.

concentrations. Removal of skin from white croaker fillets greatly reduced wet weight concentrations compared to past measurements of fillets with skin. Measuring TEQPCDD/PCDF in northern anchovy would also provide valuable information on wildlife exposure from this important prey species.

LEGACY PESTICIDES

San Francisco Bay is included on the 303(d) List due to impairment from the legacy pesticides DDTs, dieldrin, and chlordanes. A TMDL for these chemicals is in the early stage of development. These chemicals have occasionally exceeded applicable thresholds over the past several rounds of RMP fish sampling, but generally concentrations and concern for human health have been consistently low.

DDTs

All of the samples analyzed had DDT concentrations below the Water Board target of 64 ppb. The maximum concentration observed was 34 ppb in a shiner surfperch composite from Oakland. Shiner surfperch had the highest average concentration (22 ppb), just above the FCG of 21 ppb. Jacksmelt had the second highest average concentration (13 ppb), striped bass was third (11 ppb), and white croaker was fourth (9 ppb). Skin removal yielded a 61% reduction in DDT concentrations in white croaker fillets. DDT concentrations in white croaker in 2009 were lower than in past years (Figure 5-15) due to the switch to fillets without skin. Concentrations in shiner surfperch in 2009 were similar to past years, though concentrations were significantly higher in 1997 and 2000 than in other years (Figure 5-16).

Dieldrin

All of the samples analyzed had dieldrin concentrations below the Water Board target of 1.4 ppb. The maximum concentration observed was 1.3 ppb in a shiner surfperch composite from Oakland. Shiner surfperch had the highest average concentration (1.1 ppb), higher than the FCG of 0.46 ppb. Jacksmelt and white croaker also had average concentrations (both at 0.5 ppb) higher than the FCG. Skin removal yielded a 50% reduction in dieldrin concentrations in white croaker fillets. Dieldrin concentrations in white croaker in 2009 were lower than in past years (Figure 5-17) due to the switch to fillets without skin. Concentrations in shiner surfperch in 2009 were similar to past years (Figure 5-18).

Chlordanes

All samples analyzed had chlordane concentrations below the Water Board target of 17 ppb. The maximum concentration observed was 16 ppb in a shiner surfperch composite from Oakland. Shiner surfperch had the highest average concentration (7.1 ppb), higher than the FCG of 5.6 ppb. No other species had an average concentration higher than the FCG. Skin removal yielded a 61% reduction in chlordane concentrations in white croaker fillets.

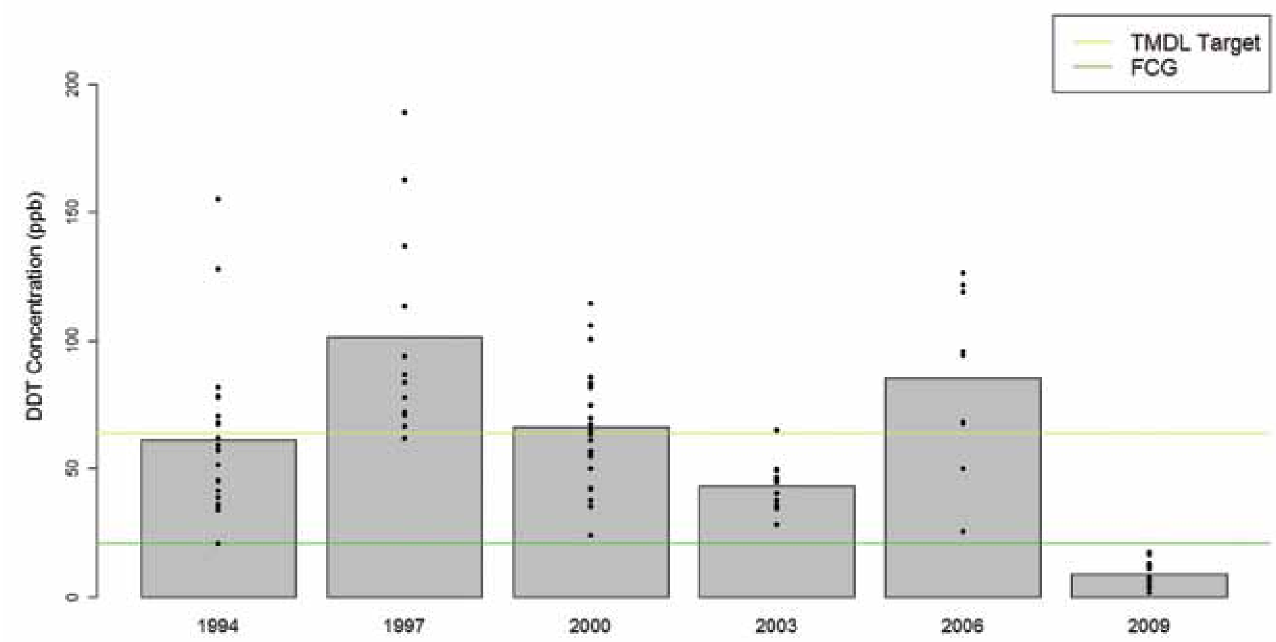


Figure 5-15. DDT concentrations (ppb wet weight) in white croaker in San Francisco Bay, 1994-2009. Bars indicate average concentrations. Points represent composite samples. Data from 2000-2006 are for fillets with skin, data from 2009 are for fillets without skin.

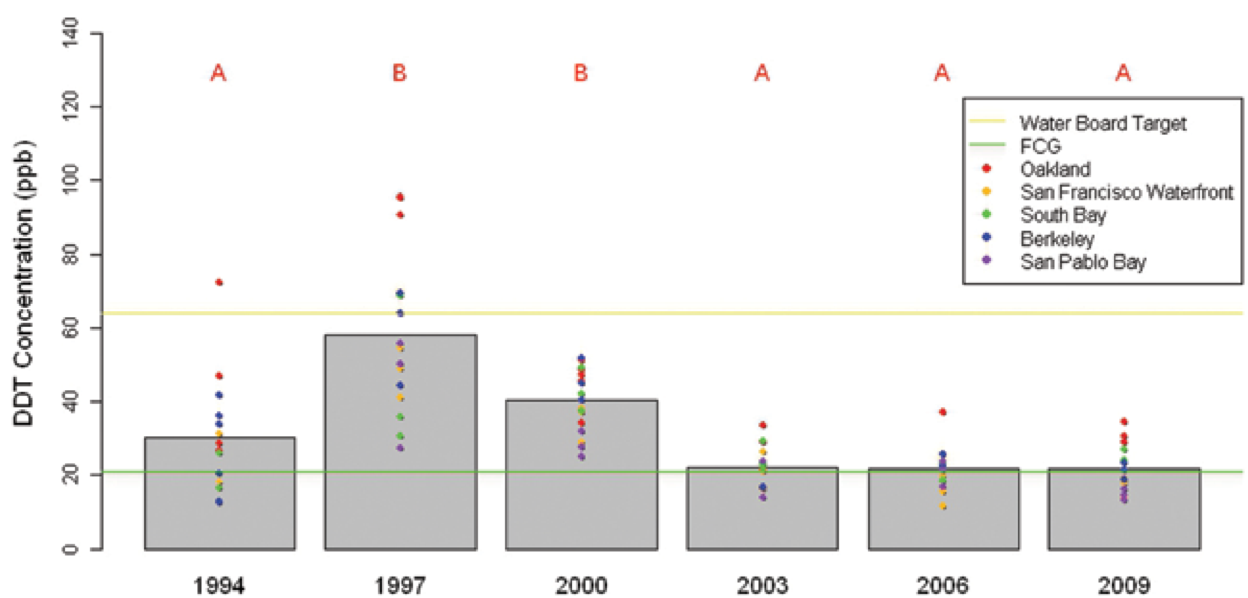


Figure 5-16. DDT concentrations (ppb wet weight) in shiner surfperch in San Francisco Bay, 1994-2009. Bars indicate average concentrations. Points represent composite samples. Years with the same letter were not significantly different from each other (p = .05).

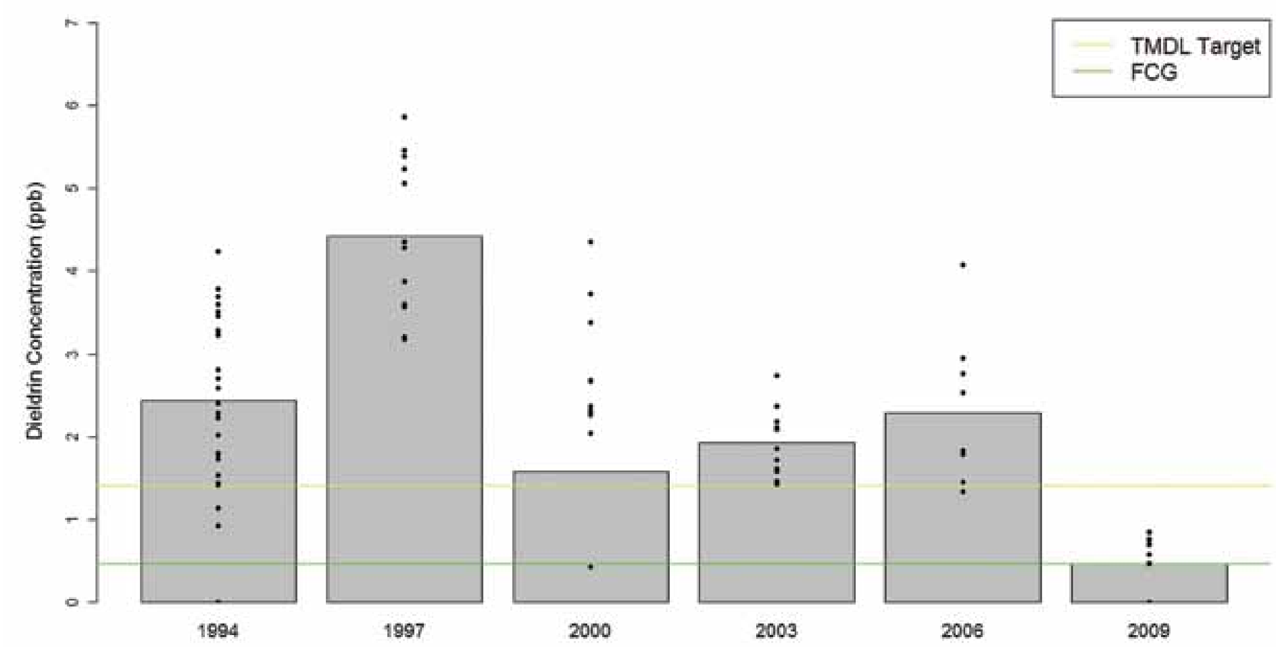


Figure 5-17. Dieldrin concentrations (ppb wet weight) in white croaker in San Francisco Bay, 1994-2009. Bars indicate average concentrations. Points represent composite samples. Data from 2000-2006 are for fillets with skin, data from 2009 are for fillets without skin.

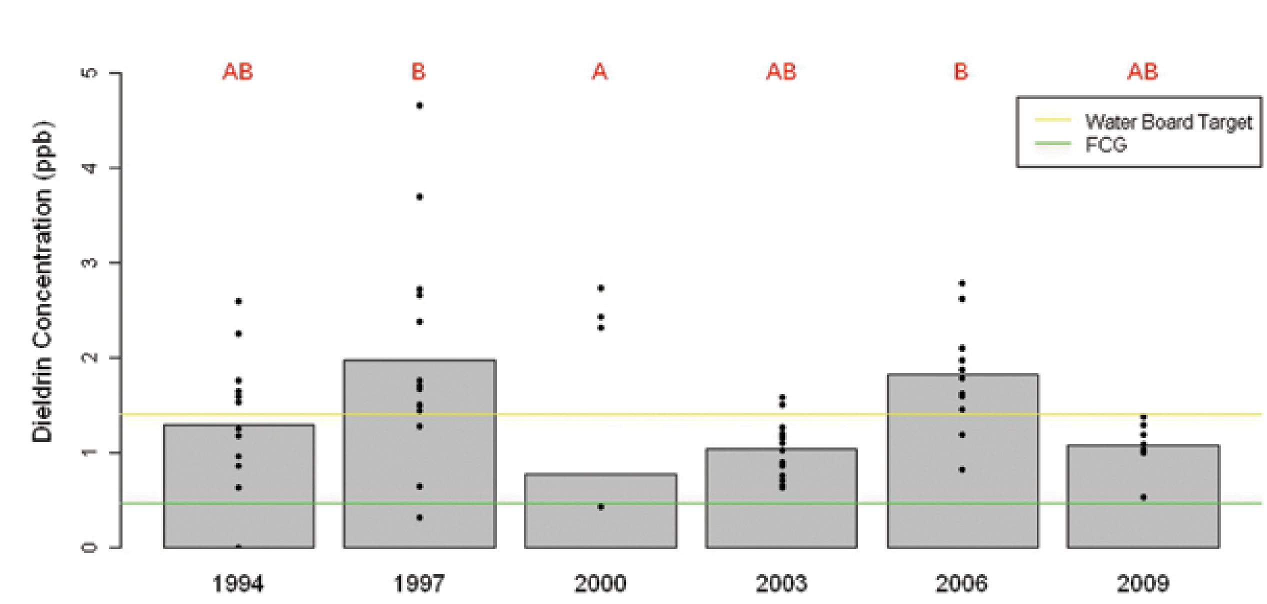


Figure 5-18. Dieldrin concentrations (ppb wet weight) in shiner surfperch in San Francisco Bay, 1994-2009. Bars indicate average concentrations. Points represent composite samples. Years with the same letter were not significantly different from each other (p = .05).

SELENIUM

San Francisco Bay has been on the 303(d) List since 1998 for selenium because bioaccumulation of this element has led to recurring health advisories for local hunters against consumption of diving ducks. Moreover, elevated selenium concentrations found in biota often exceed levels that can cause potential reproductive impacts in white sturgeon and are often higher than levels considered safe for fish and other wildlife species in the Estuary. Sources and pathways leading to the possible impairment in northern and southern segments of the Bay differ significantly and therefore a separate approach to addressing the problem in these segments is being followed. Thus, a TMDL is being developed for the North San Francisco Bay segments only, which include a portion of the Sacramento/San Joaquin Delta, Suisun Bay, Carquinez Strait, San Pablo Bay, and Central Bay. This TMDL project was initiated in 2007 to assess the current state of impairment in the North Bay, identify pathways for bioaccumulation, enhance understanding of the relationship between sources of selenium and fish and wildlife exposure, and establish site-specific water quality targets protective of aquatic biota. In developing the TMDL, the Water Board, with support from stakeholders, is conducting a series of analysis to refine understanding of the behavior of selenium in the Estuary that will help formulate a strategy for attaining water quality standards. A Preliminary TMDL Project Report was published in January 2011 (SFBRWQCB 2011). As part of this information gathering effort, the RMP measured selenium concentrations in all eight species sampled in 2009.

The Preliminary TMDL Project Report compared selenium concentrations in Bay sport fish to the FCG of 7.4 ppm developed by OEHHA (Klasing and Brodberg 2008). OEHHA also developed a series of ATLs for selenium, the lowest being the 2 serving ATL of 2.5 ppm.

White sturgeon, the key sport fish selenium indicator species for the Bay, is the largest freshwater fish species in North America. It can live to be over 100 yr old and up to 6 m in length. The white sturgeon size range targeted for RMP is between 1170 mm (the legal minimum) and 1500 mm, which corresponds to an age of approximately 12-14 yr. Sacrificing these fish in the early phases of such a potentially long lifespan is clearly undesirable, especially since the population has been in decline in recent years. In 2009 a pilot study of a non-lethal sampling method using biopsies was performed to investigate whether lethal sampling can be discontinued.

Comparison to Thresholds and Variation Among Species

The latest round of RMP sampling indicated that average selenium concentrations in Bay sport fish remain well below thresholds for human health concern (Figure 5-19). White sturgeon had the highest average concentration by far (1.47 ppm), well below the 2 serving ATL of 2.5 ppm, and even further below the FCG of 7.4 ppm. Average concentrations for other species were all between 0.30 and 0.47 ppm). Only one white sturgeon sample was above the 2 serving ATL.

Plug Study

Selenium concentrations in 12 paired samples of muscle plugs and traditional fillets in white sturgeon showed reasonable agreement (Figure 5-20). A linear regression was highly significant ($p < .001$). The slope of the regression line indicated that the plugs were an average of 25% higher than the fillets. If these results are an accurate reflection of a true bias, this would imply that selenium is not homogeneously distributed in sturgeon muscle tissue. The regression was also highly influenced by two points with higher plug and fillet concentrations than the other samples. This dataset is not entirely definitive, with a small sample size, an apparent bias toward higher concentrations in the plugs, and a sparse distribution in the higher end of the concentration range. However, the results do indicate that plug concentrations provide reasonably accurate estimates of fillet concentrations. Furthermore, since selenium concentrations in white sturgeon are generally well below thresholds of concern for human health and given the unusual impact of sampling on the white sturgeon population, a switch to exclusive sampling of plugs is recommended for future sampling.

Temporal Trends

Long-term trend monitoring has focused on white sturgeon. The average concentration of 1.47 ppm in 2009 was very similar to average concentrations observed from 1997-2006 (Figure 5-21). There is no indication of an increase or decrease in these concentrations.

Management Implications and Priorities for Further Assessment

The 2009 selenium analyses documented the concentrations were similar to previous years and below human health thresholds, and that concentrations in other species were much lower still. Given these data, the focus of the North Bay Selenium TMDL on impacts on aquatic life is appropriate. A valuable time series of concentrations in white sturgeon has been established, indicating that concentrations in the North Bay food web have not declined since 1997. If extending this time series is a priority, consideration should be given to switching to non-lethal sampling using muscle plugs.

PBDEs

Polybrominated diphenyl ethers (PBDEs), a class of bromine-containing flame retardants that was practically unheard of in the early 1990s, increased rapidly in the Bay food web through the 1990s and are now pollutants of concern. They have not been placed on the 303(d) List, but information on them is lacking and they are being studied through the RMP to better understand their spatial distribution, temporal trends, and the concerns they pose to wildlife and humans. The California Legislature has banned the use of two types of PBDE mixtures (“penta” and “octa”) in 2006, but one mixture remains in use (“deca”). Tracking the trends in these chemicals is critical to determining the effect of the ban and if further management actions are necessary. In 2011, OEHHA published a FCG and ATLs for PBDEs (Klasing and Brodberg 2011).

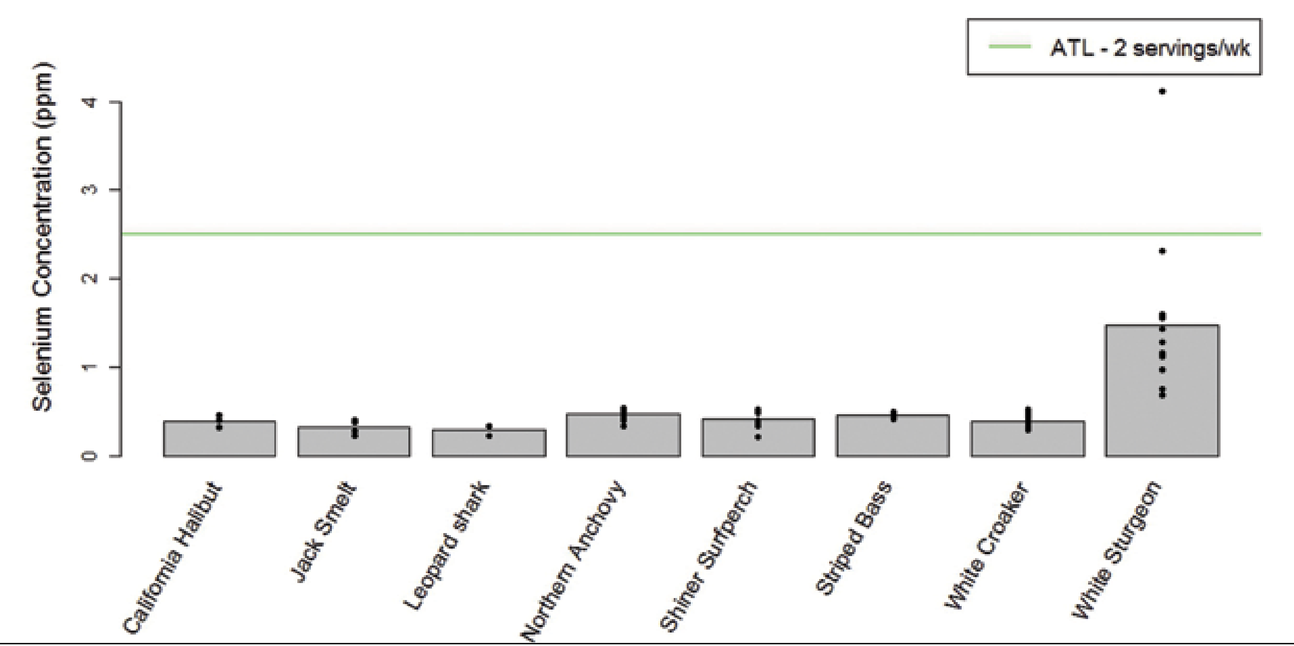


Figure 5-19. Selenium concentrations (ppm) in sport fish species in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent individual samples (either composites or individual fish). Note that northern anchovy are not a sport fish species – they are an important wildlife prey species that is collected in the surveys in San Francisco Bay and analyzed as whole fish.

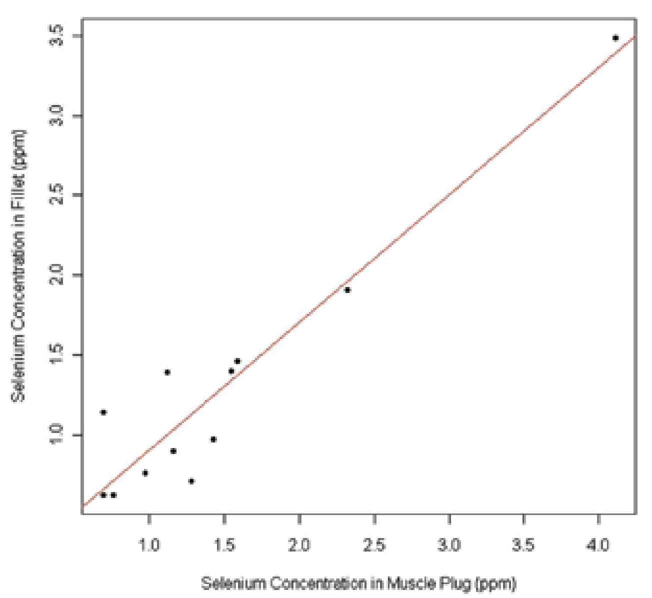


Figure 5-20. Selenium concentrations in paired samples of muscle plugs and fillets in white sturgeon from San Francisco Bay, 2009. Regression was significant ($p < .001$, Fillet = 0.80*plug + 0.10), but not when two highest points were excluded.

Variation Among Species

Like the other organic contaminants, average PBDE concentrations were highest in shiner surfperch and northern anchovy (both at 8 ppb) (Figure 5-22, Table 5-1). The highest concentration measured was 14 ppb in a shiner surfperch sample. Other species all averaged 5 ppb or less. Unlike PCBs, leopard shark and striped bass had slightly higher average concentrations than white croaker.

Spatial Patterns

Significant spatial variation was detected in shiner surfperch (Figure 5-23). As for all other contaminants, Oakland had the highest average concentration (13 ppb), significantly higher than Berkeley (8 ppb), San Francisco (6 ppb), and San Pablo Bay (5 ppb). South Bay had the second highest average (10 ppb), and

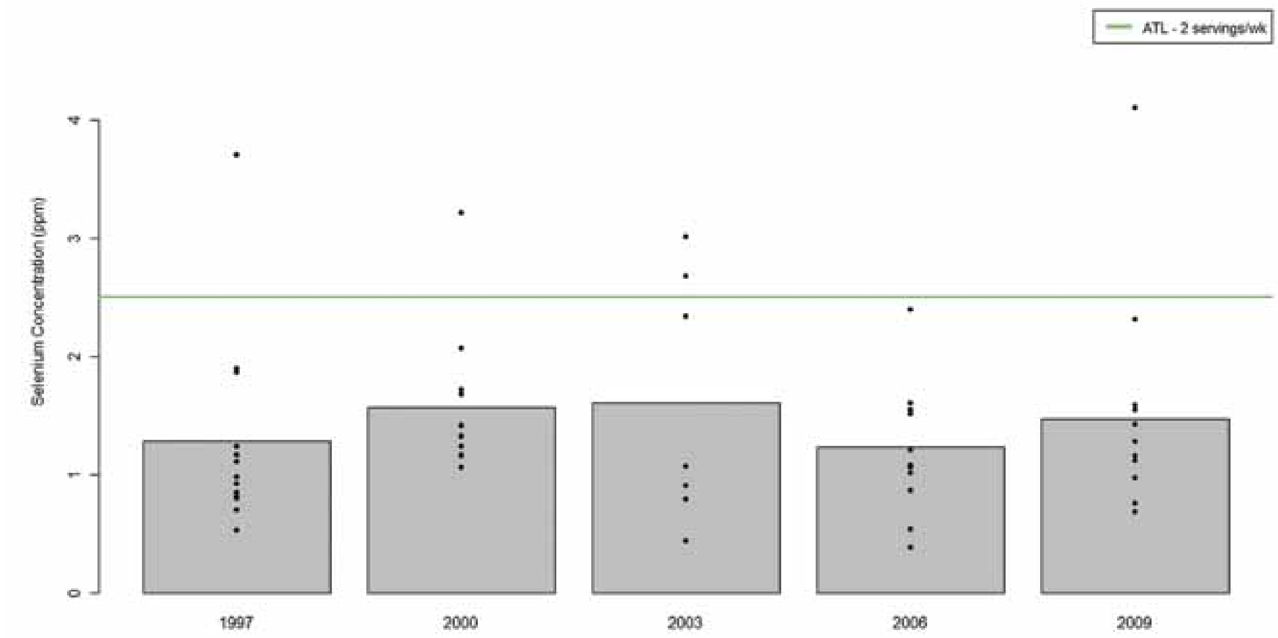


Figure 5-21. Selenium concentrations (ppm) in white sturgeon from San Francisco Bay, 1997-2009. Bars indicate average concentrations. Points represent individual fish. No significant differences among years were observed.

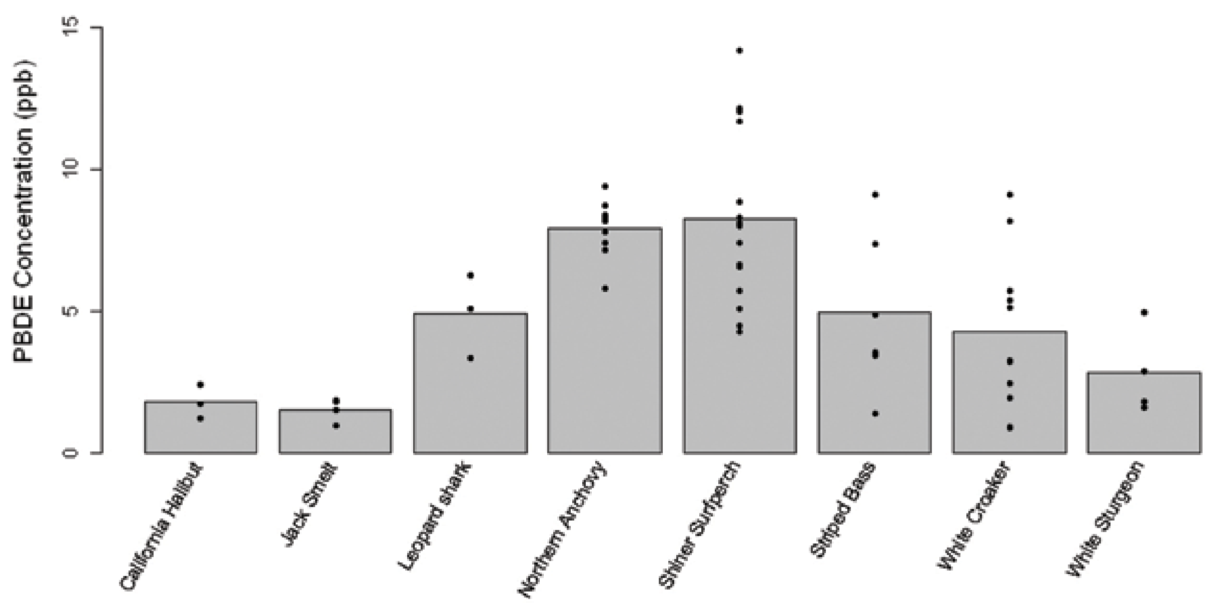


Figure 5-22. PBDE concentrations (ppb) in sport fish species in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent individual samples (either composites or individual fish). White croaker data are for fillets without skin. All samples were well below the lowest OEHHA threshold (the 100 ppb 2 serving ATL).

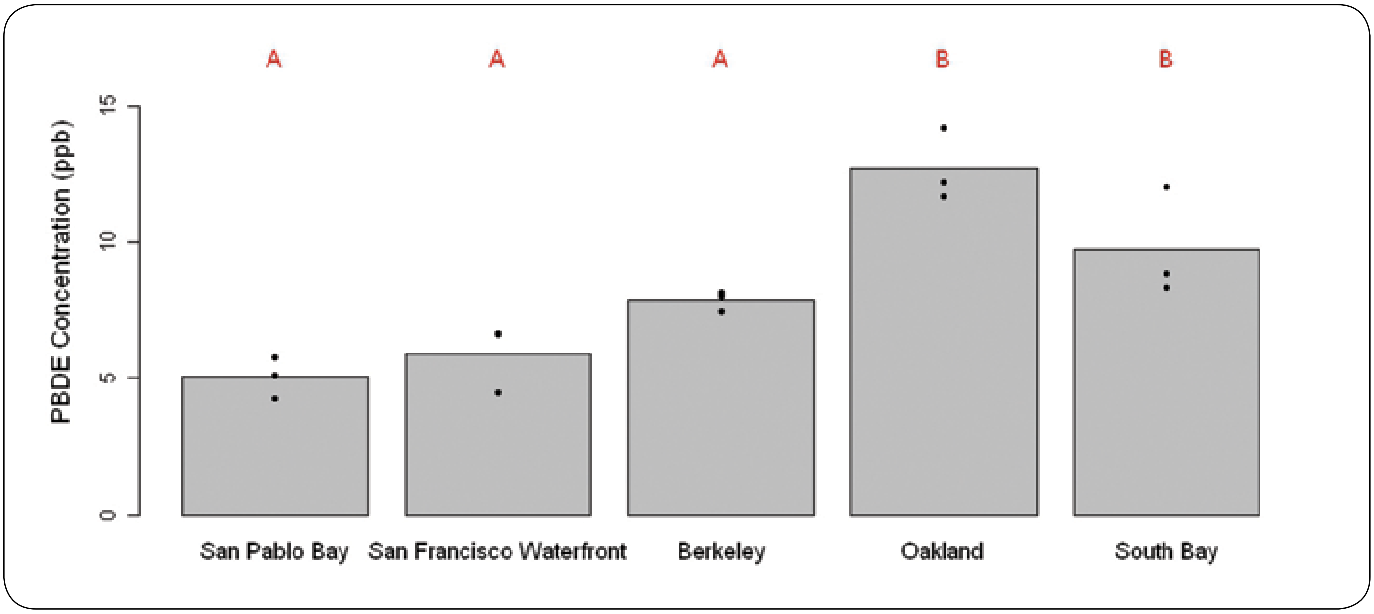


Figure 5-23. PBDE concentrations (ppb) in shiner surfperch in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent composite samples. Locations with the same letter were not significantly different from each other (p = .05).

was also significantly greater than Berkeley, San Francisco, and San Pablo Bay, but not significantly different from Oakland. Overall, these averages spanned a 2.6 fold range from Oakland to San Pablo Bay.

Temporal Trends

Measurement of PBDEs in Bay sport fish has been performed by the RMP and other groups for samples collected in 1997, 2000, 2002, 2003, and 2006. However, the early analyses of PBDEs (1997-2002) are not completely reliable or comparable to recent data due to issues with sample storage, quality assurance documentation, and the early analytical methods (Klosterhaus et al. 2010). Analysis of the 2003 and 2006 samples was performed with electron capture detection (GC-ECD), external standard calibration, and p,p-DDD as a surrogate recovery standard – these procedures are typically not recommended for the analysis of PBDEs in tissue. In spite of these issues, the 2003 and 2006 data are still considered reliable. The 2009 data were generated using a GC-MS method and isotopically-labelled PBDEs as internal standards – these data are considered highly reliable.

PBDE concentrations in white croaker were much lower in 2009 due to the analysis of fillets without skin. The combination of this switch in processing of the white croaker, and better spatial coherence and higher concentrations in shiner surfperch makes the latter a better indicator of trends through time. The Baywide average for shiner surfperch (8 ppb) was lower than the averages observed in 2003 and 2006 (Figure 5-24). A decline might be anticipated in response to the bans on the penta and octa mixes, but how quickly the decline would occur as the overall inventory in the watersheds is reduced is unknown. Given the short time series available and a potential lack of comparability due to the switch to a new method in 2009, it is unclear

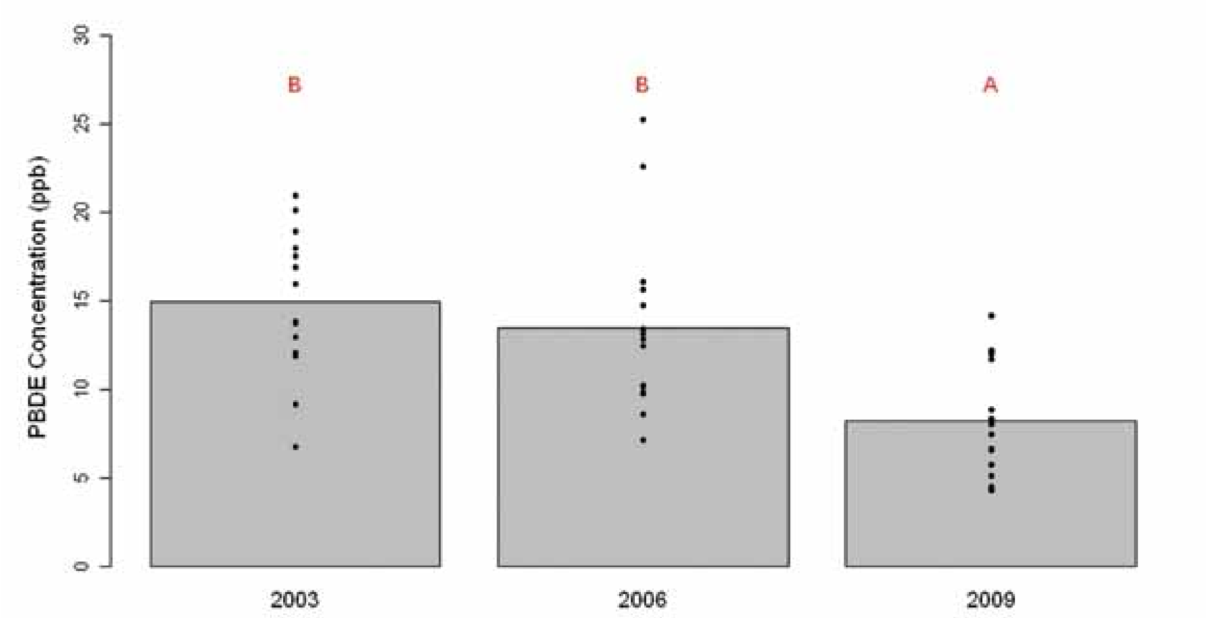


Figure 5-24. PBDE concentrations (ppb wet weight) in shiner surfperch in San Francisco Bay, 2003-2009. Bars indicate average concentrations. Points represent composite samples. Years with the same letter were not significantly different from each other (p = .05).

whether the lower concentrations in 2009 are a sign of a real decline or not. Continued monitoring of sport fish and other matrices in the Bay will be needed to determine whether the bans are indeed reducing PBDE concentrations in the Bay food web.

Management Implications and Priorities for Further Assessment

PBDE concentrations in all samples were far below the lowest OEHHA threshold (the 100 ppb 2 serving ATL), indicating that PBDE concentrations in Bay sport fish are not a concern with regard to human health. Continued monitoring of sport fish and other matrices in the Bay will be needed to determine whether the bans of the penta and octa mixtures are indeed reducing PBDE concentrations in the Bay food web.

PFCs

Perfluorinated chemicals (PFCs) have been used extensively over the last 50 years in a variety of products including textiles treated with stain-repellents, fire-fighting foams, refrigerants, and coatings for paper used in contact with food products. As a result of their chemical stability and widespread use, PFCs such as perfluorooctane sulfonate (PFOS) have been detected in the environment. PFOS and related PFCs have been associated with a variety of toxic effects including carcinogenity and abnormal development.

In 2006, the RMP began analyzing bird eggs for PFCs. PFOS concentrations in Double-crested Cormorant eggs were found to approach a published effect threshold. Consistent with studies elsewhere, PFOS was the dominant PFC detected in cormorant eggs. Concentrations of PFOS were highest in the South Bay, and higher than concentrations reported in other regions. PFCs have been detected in sport fish fillets in other studies. Sampling has been fairly extensive in Minnesota, where concentrations have been high enough that the state has established thresholds for issuing consumption guidelines (Delinsky et al. 2010). Neither OEHHA or the Water Board have developed thresholds for evaluating the risks to humans from consumption of contaminated sport fish from San Francisco Bay.

The 2009 results for PFCs were mostly below detection limits (Figure 5-25, Table 5-1). The only PFC detected was PFOS, and only four samples had detectable PFOS concentrations. The highest concentration was 18 ppb in a leopard shark composite. The other samples with reportable concentrations were from northern anchovy and white sturgeon. The available data are insufficient for assessing variation among species, over time, or among locations in the Bay. The state of Minnesota has established a threshold of 40 ppb associated with a consumption rate of 1 meal/wk. If higher rates of consumption are considered, as OEHHA has done for other chemicals, the highest concentration observed may be approaching a level where a low degree of concern is indicated.

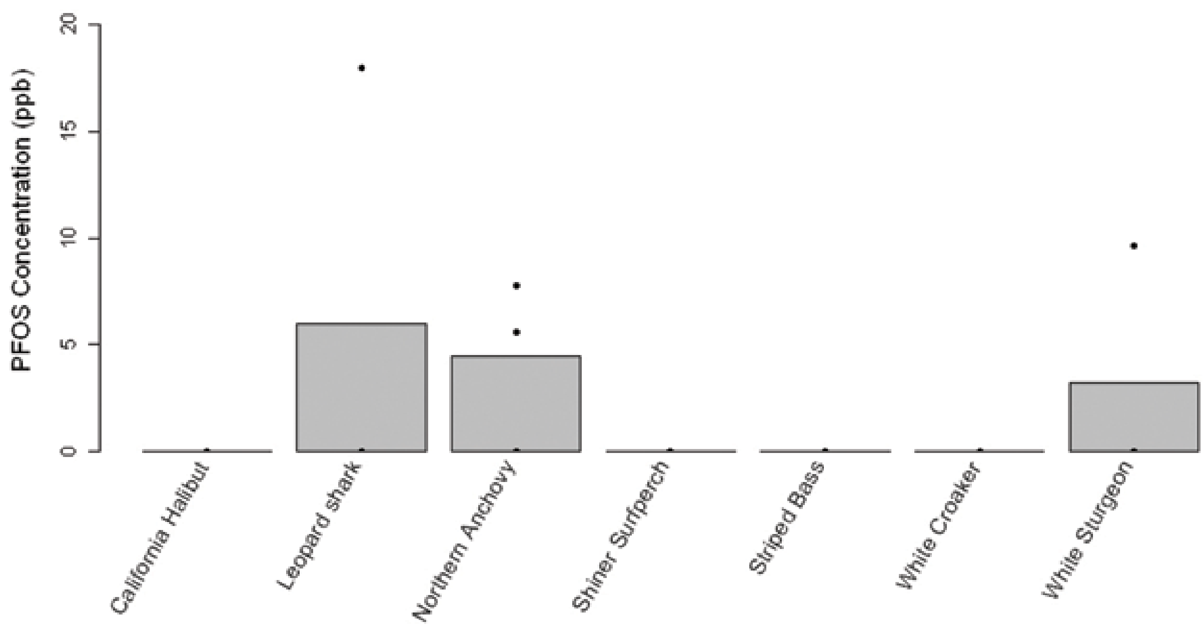


Figure 5-25. PFOS concentrations (ppb) in sport fish species in San Francisco Bay, 2009. Bars indicate average concentrations. Points represent individual samples (either composites or individual fish). White croaker data are for fillets without skin. Concentrations were below the detection limit in most samples.

THE REGION 2 COAST

General Assessment

Contaminant concentrations in sport fish from coastal locations in Region 2 were lower than in San Francisco Bay and were frequently below OEHHA thresholds (Figures 5-26 and 5-27).

Methylmercury concentrations in most species were at or below 0.07 ppm. Concentrations were above 0.44 ppm in the two shark samples (both from Tomales Bay). Other species with moderately elevated concentrations were lingcod (measuring 0.42 ppm at Pacifica and 0.27 ppm at Half Moon Bay) and gopher rockfish (ranging from 0.26 at Half Moon Bay to 0.43 off the San Mateo Coast). Gopher rockfish even accumulated 0.29 ppm at the Farallon Islands.

PCB concentrations were below the ATLs in all samples, and most were also below the FCG of 3.6 ppb. Even shiner surfperch were quite low. The highest concentration was 36 ppb in a barred surfperch sample offshore of San Francisco.

Concentrations of other contaminants in samples from the Region 2 coast were all low.

Specific Locations of Interest

Tomales Bay

The mouth of Walker Creek in Tomales Bay was subject to a considerable amount of mercury contamination from historic mining in the Walker Creek watershed. Past sport fish sampling under the CFCP and SWAMP regional monitoring found elevated concentrations, resulting in a consumption advisory (Gassel et al. 2004). The Water Board has established a TMDL for the Walker Creek watershed and a TMDL for Tomales Bay is underway. However, the Water Board considers that no further implementation actions are required for methylmercury – the actions needed are already completed or underway and the primary focus is now on monitoring the outcome. Results from this sampling support that conclusion. Methylmercury concentrations in the three non-shark species sampled (shiner surfperch, topsmelt, and white surfperch) were all below 0.07 ppm. Tomales Bay was actually one of the cleanest locations sampled in the state – it was one of only seven locations sampled in 2009 with fish samples that were below thresholds for all contaminants (shiner surfperch and white surfperch). While sport fish in Tomales Bay appear to be below thresholds for concern, recent sampling of small fish and crabs in Tomales Bay marshes indicates that concern for wildlife exposure in these habitats may be warranted.

Pillar Point Harbor

Pillar Point Harbor was placed on the 303(d) List as a result of methylmercury measurements in the CFCP. Pillar Point Harbor exhibited a low degree of contamination in this Survey. The highest methylmercury concentration was in the one white croaker sample analyzed (0.10 ppm). Four other species (shiner

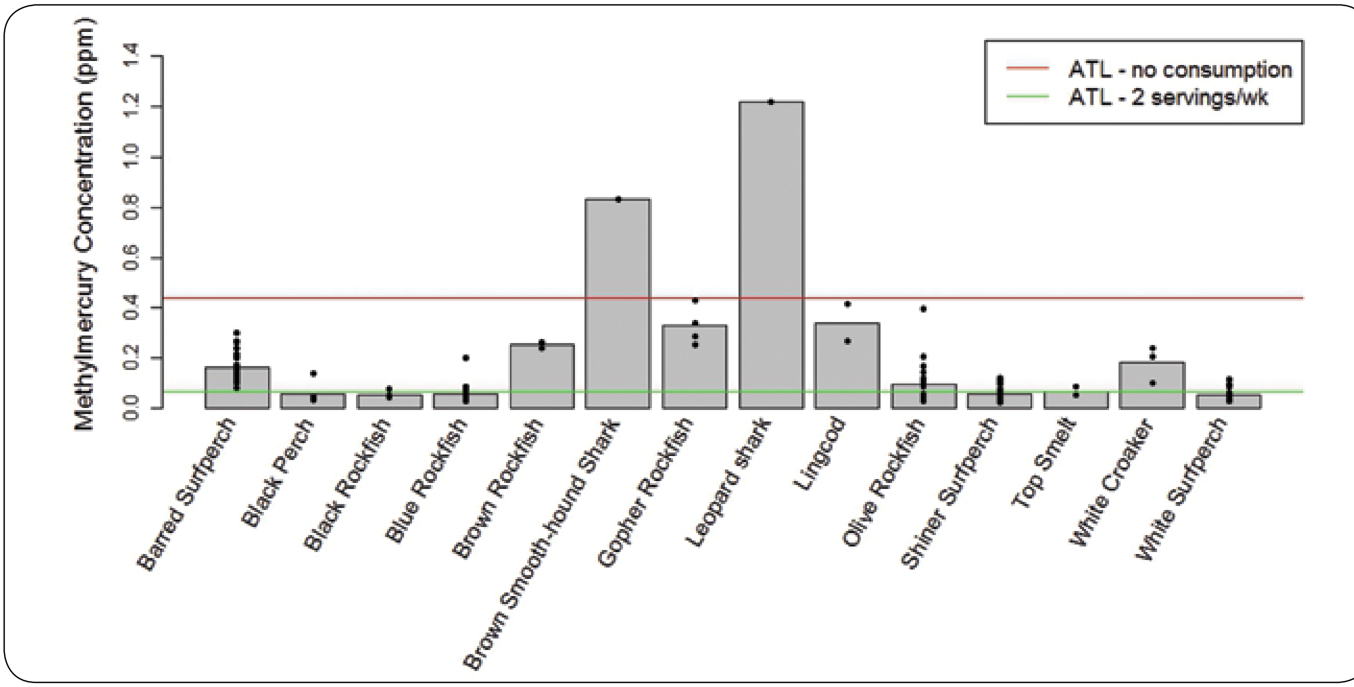


Figure 5-26. Methylmercury concentrations (ppm) in sport fish species on the Region 2 coast, 2009. Bars indicate average concentrations. Points represent individual samples (either composites or individual fish).

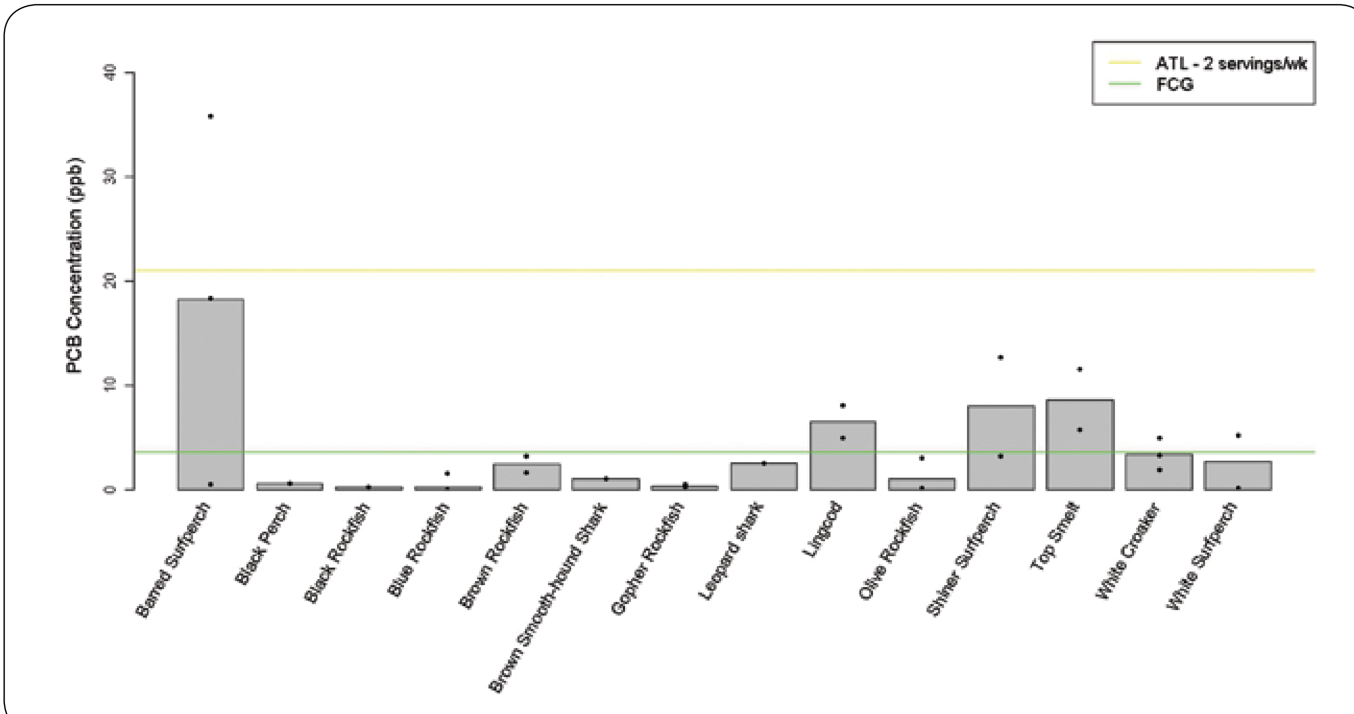


Figure 5-27. PCB concentrations (ppb) in sport fish species on the Region 2 coast, 2009. Bars indicate average concentrations. Points represent composite samples.

surfperch, white surfperch, black perch, and topsmelt) all had average concentrations below 0.07 ppm. PCBs reached a maximum of 13 ppb in shiner surfperch. Topsmelt was second at 12 ppb. White croaker, white surfperch, and black perch were at or below the FCG of 3.6 ppb.

Management Implications and Priorities for Further Assessment

Data from this Survey indicate that contaminant concentrations in sport fish on the Region 2 coast were generally low. A moderate degree of contamination observed for methylmercury in some species (lingcod and gopher rockfish) may warrant further investigation.

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