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Habitat Conditions: Coastal Pelagic

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2.1.7 Coastal Pelagic

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Habitat Description

The oceanic water column between the surf zone and the continental shelf break represents the coastal pelagic habitat. Within Santa Monica Bay, the coastal pelagic habitat extends north to the Ventura-Los Angeles county line and south to Point Fermin. This is the most extensive habitat in the Bay and includes waters to depths of 1,600 feet.

The coastal contour and bathymetry of Santa Monica Bay influence ocean currents, upwelling, and other oceanographic processes that in turn dictate the physical and chemical properties of this habitat. The Bay generally features a clockwise circulating current. In addition, two eddies—one near Malibu Point, the other near the southern end of the Palos Verdes Peninsula—create upwelling that bring nutrients and less oxygenated and lower-pH water from depth, where they become available to upper water column (or pelagic) marine organisms. Upwelling also occurs when the Santa Ana winds blow offshore. The Bay is also located at a minor transition between warmer and colder biogeographies within the Southern California Bight. This means that a wider variety of species can be found here than elsewhere. The abundance of these species fluctuates as ocean current and temperature regimes undergo change. During El Niño periods, warmer water species (including popular migratory sport fish) increase in abundance, while colder water species likely move north and deeper. Marine organisms found in this habitat include microbes, phytoplankton, zooplankton, small schooling fish, larger predatory fish (e.g., California Barracuda, *Sphyrna argentea*), sea birds, sharks, sea lions, seals, dolphins, and whales.

This habitat is exposed to natural shifts in oceanographic and climatic conditions that occur at scales ranging from local to global. Bight-wide and local impacts related to human activities include point and nonpoint source discharges, ocean intakes, and shipping. The City of Los Angeles and the Sanitation Districts of Los Angeles County discharge treated wastewater into the Bay off of El Segundo and Whites Point, Palos Verdes, respectively, and an oil terminal is located in the southern portion of the Bay, offshore from Los Angeles International Airport (LAX). Shipping lanes for the nation's busiest port complex, the Ports

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of Los Angeles and Long Beach, pass the mouth of the Bay just off the continental shelf, and two ocean water intakes currently operate to support power generation off LAX and Redondo Beach. While a third intake at El Segundo was recently shut down, water suppliers are considering the possibility of desalination, which would likely reopen or create new intakes and discharges (for more on desalination, see Section 1.1). However, many of these activities are heavily regulated to reduce or mitigate their impact on the environment. For example, point and nonpoint source discharges are subject to strict water quality standards, and ocean intakes for once-through cooling power generation facilities are scheduled to be phased out by 2020. In addition, the coastal pelagic habitat and the species found here support a variety of other human activities, ranging from whale watching to sport and commercial fishing.

The conditions in Santa Monica Bay reflect what is occurring in the rest of the Bight on the grand scale (e.g., El Niño). This can provide context for interpreting the indicators below. However, the Bay has unique characteristics that may result in differences in conditions from the rest of the Bight.

Status and Trends

Extent: GOOD and IMPROVING (MODERATE confidence)

This category assesses the extent of the water column that is capable of supporting the organisms commonly found there. One indicator comprises this category. It is Extent of Hypoxic Conditions in the Bay. Based on this indicator, the extent of life-supporting coastal pelagic habitat in the Bay is in GOOD and IMPROVING condition. There is MODERATE confidence in this assessment due to the lack of reference conditions by which to judge an upper threshold ([Table 2.1.7](#)) and only quarterly monitoring within the Bay.

Extent of Hypoxic Conditions

Hypoxia is a condition in which levels of dissolved oxygen (DO) are lower than what can support most marine life, such as fish, which utilize oxygen to respire. Hypoxia is typically caused when phytoplankton assemblages grow, sink, and decay, consuming much of the available oxygen in the water. Hypoxic conditions are more common deeper in the water column, where sinking organic matter accumulates and oxygen levels are not quickly replenished by mixing with air at the surface (see Section 4.5 for more). This indicator is measured by the area exhibiting excursions into low DO levels near the seafloor (or at 100m in areas where the bottom is deeper than 100m) and the frequency of those low levels. Low DO is defined as less than 30% oxygen saturation (also 0.5ml/L or 62.5 μ M depending on the units of measurement). However, an upper threshold (to distinguish fair from good conditions) has not been established, in part because that level varies among different taxa.

Data come from quarterly monitoring conducted by the Sanitation District of Los Angeles County (LACSD) and the City of Los Angeles Environmental Monitoring Division (CLA-EMD). Temperature, salinity, and density from these samples are used to help interpret

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the data for this assessment. In the future, the upwelling index produced by the National Oceanic and Atmospheric Administration (NOAA) will be used instead.

In 2010–2014, 1.1% of the deep water in the Bay experienced water levels with less than 30% oxygen. This is down from the 2005–2009 time period, in which 8.6% of the deep water in the Bay experienced the same conditions. However, strong upwelling indicated by water temperatures below 10°C, salinities above 34psu (practical salinity units), and densities greater than $26.2\sigma_t$ (kg/m^3 at a given temperature) during this same period are the likely cause of the low DO. The areas that exhibit low DO tend to be in places where upwelling occurs, such as along the Palos Verdes Shelf and near the Point Dume, Santa Monica, and Redondo submarine canyons ([Figure 2.1.7](#)).

The extent of deep water in the Bay experiencing hypoxia is considered to be in GOOD condition (i.e., little hypoxia is observed); however, the experts emphasize that, without an upper threshold to distinguish fair from good, this score mostly reflects the fact that the Bay is not in poor condition with respect to hypoxia. The trend appears to be IMPROVING, although this is not necessarily meaningful, as the trend has only been present for one five-year time step and is likely more indicative of changes in upwelling patterns. Because of the lack of an upper threshold and only quarterly monitoring within the Bay, confidence in this assessment is MODERATE ([Table 2.1.7](#)).

Vulnerability: GOOD and CONSTANT (MODERATE Confidence)

This category assesses the extent to which indicators of changing ocean chemistry due to global climate change are present in the Bay. This category consists of one indicator: ocean acidification. Based on this indicator, the ocean chemistry in the Bay is in GOOD and CONSTANT condition. Confidence in this assessment is MODERATE due to uncertainty about how to interpret the thresholds ([Table 2.1.7](#)) and only quarterly monitoring within the Bay.

Ocean Acidification

Increasing levels of carbon dioxide (CO_2) in the atmosphere causes more CO_2 to diffuse into the ocean and leads to a decrease in ocean pH and carbonate ions through spontaneous chemical reactions. This process is termed *ocean acidification*. Many organisms in the ocean, from microscopic coccolithophorids to commercially harvested shellfish, need carbonate ions to form their calcium carbonate shells. Less-available carbonate and increased acidity (lower pH) can hamper the growth of these organisms (Orr et al. 2005). However, the extent of the impact, especially for species common in Santa Monica Bay, is not fully understood (for more, see Section 4.4). This indicator is measured by the area exhibiting excursions into lower pH levels and the frequency of excursions. The global average for ocean pH is 8.2. Levels measured in the Southern California Bight typically range from 7.6 to 8.2 (Alin et al. 2012). For this

Coccolithophorids are microscopic phytoplankton that create calcium carbonate plates on their exteriors. They are an important base of the marine food web.

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assessment, low pH was defined as 7.4. An additional value of 7.8 was used as an upper threshold (between fair and good). Data come from quarterly monitoring conducted by LACSD and CLA-EMD. Oxygen, temperature, and salinity from the same samples are used to help interpret the data for this assessment.

In the last 17 years, only the time period from 2000 to 2004 saw a drop in pH below 7.4, and the frequency of this occurrence in that time period was 0.1%. Excursions below 7.8 occurred in all four 5-year time steps in the last 20 years. The frequency of these occurrences range from 22.9% in the years 1989–1999 to 34.5% in the 2005–2009 time period. In the 2010–2014 time period, the frequency of excursions into pH levels between 7.4 and 7.8 was 24.7%. Interestingly, oxygen levels and pH levels do not correlate in time. However, the areas in which low DO and low pH are concerns are similar and coincide with areas of upwelling. The ocean acidification is considered to be in GOOD condition (i.e., little evidence of it). Due to the variation observed over the years, the trend is considered to be CONSTANT. Confidence in this assessment is MODERATE due to limited information on how to interpret the thresholds (i.e., what percentage below or between thresholds is significant) ([Table 2.1.7](#)) and only quarterly monitoring within the Bay.

Structure and Disturbance: FAIR and CONSTANT (MODERATE confidence)

The basis of the coastal pelagic food web consists of nutrients and phytoplankton. However, specific types of phytoplankton, at high concentrations and under certain circumstances, can significantly disrupt the top of the coastal pelagic food web. This category measures the status of these building blocks in the form of (1) dissolved inorganic nitrogen (DIN) and phosphorus (DIP), (2) chlorophyll *a* (Chl *a*), and (3) harmful algal blooms (HABs). Based on these indicators, the structure of the coastal pelagic ecosystem in Santa Monica Bay is in FAIR and CONSTANT condition. However, confidence in this assessment is LOW due to low confidence in the assessment of all of the three indicators in this category.

DIN and DIP

Nutrients enter the coastal pelagic zone through three primary pathways: coastal upwelling; effluent discharges, including treated wastewater and coastal runoff; and aerial deposition. Nitrogen is a principal ingredient for phytoplankton when building protein and nucleic acids, and phosphorus is critical for nucleic acids and other cellular constituents. In much of the world's ocean, marine algal growth is generally nitrogen-limited, meaning that phytoplankton populations run out of nitrogen before they run out of phosphorus or other elements. These and other nutrients tend to stratify by depth, where concentrations are near zero at the surface due to utilization by phytoplankton and increase with increasing depth. This indicator is measured by five-year averages of DIN and DIP concentrations at a depth of 30m. Data come from quarterly monitoring of the Southern California Bight by the California Cooperative Oceanic Fisheries Investigation (CalCOFI). Data from Santa Monica Bay are compared with data from a site 100km south of the Santa Monica Bay, off Del Mar, San Diego. However, an objective assessment is difficult because thresholds have not been established.

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Nutrient levels at both sites (Santa Monica Bay and Del Mar) have steadily increased from approximately 2 μ M/L DIN and 0.4 μ M/L DIP in 1980–1984 to approximately 8 μ M/L DIN and 0.8 μ M/L DIP in 2010–2014. These substantial and significant increases are also consistent with observations along the coast of California and appear to be caused by a change in source water that is being brought into the region by large-scale ocean currents (Bograd et al., 2015). Nutrient levels in Santa Monica Bay are in FAIR condition. There is a clear increasing trend, but experts were not comfortable interpreting this trend. Confidence in this estimate is MODERATE due to the reliance on high-quality data but a lack of comprehensive sampling coverage and accepted thresholds ([Table 2.1.7](#)).

Chl a

Chlorophyll *a* is a pigment used by plants to capture light during photosynthesis. It is a commonly used measurement of the concentration of phytoplankton in oceanography. This indicator is measured by five-year averages of Chl *a* concentrations, integrated to a depth of 60m, and the frequency of reoccurrence of samples with high concentrations. High concentrations were defined as 20 μ g/L and are based on long-term coastal datasets from the region (Seubert et al. 2013; Kim et al. 2009). Data are available through quarterly monitoring in Santa Monica Bay by LACSD, CLA-EMD, and CalCOFI. CalCOFI data from Santa Monica Bay are compared with data from a CalCOFI site off Del Mar (San Diego, CA). In future assessments, comparisons will be made to data from additional stations in the Southern California Bight.

The frequency of occurrence of Chl *a* samples above the five-year average (20 μ g/L) in the 2010–2014 time period is 0.9%. There has been considerable variability in this metric since 1999, but this is less frequent than in the 2005–2009 time period (1.6%) and down from a high of 2.3% in the 1998–1999 time period. The five-year averages for each time period from 1999 (a two-year average) to 2014 remain relatively constant. However, the variability of samples within time periods and the maximum Chl *a* concentrations observed are increasing. Based on this, algal populations (biomass) as measured by Chl *a* concentrations appear to be in GOOD and CONSTANT condition. Confidence in this assessment is MODERATE due to high-quality data, as well as the lack of a good reference for an upper threshold ([Table 2.1.7](#)).

HABs

Certain phytoplankton species are capable of producing high concentrations of neurotoxins and other toxic or noxious compounds. The neurotoxins accumulate through the food web and have resulted in the illness and death of marine life (Gulland et al. 2002, Kudela et al. 2005). However, not all blooms of potentially toxic species result in the production of these toxins, complicating the prediction and monitoring of toxic events (for more, see Section 4.6). This indicator is measured by evaluating the concentration of toxin-producing species of diatoms in the genus *Pseudo-nitzschia* and other toxin-producing species (*Alexandria* spp., *Dinophysis* spp.), and in other harmful or noxious species (*Lingulodinium polyedrum*, *Akashiwo sanguinea*, *Cochlodinium* spp., *Phaeocystis* spp., and *Prorocentrum* spp.). Data on toxins are also considered. Data are from the

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Southern California Coastal Ocean Observing System (SCCOOS) harmful algae and red tides monitoring program (<http://www.sccoos.org/data/habs/>). Data from the Santa Monica Pier station are compared with average values from the rest of the Bight (San Diego, Newport Beach, Santa Barbara, and Goleta). However, established thresholds do not exist. If additional toxins are added to this program, they will also be included in our assessment.

While blooms in Santa Monica Bay do not always coincide with blooms in the rest of the region, there is no apparent difference between the Bay and the rest of the Bight from the period 2008 to 2014 across all metrics. The condition of HABs in the Bay is considered FAIR and CONSTANT. Confidence in this assessment is LOW due to the lack of established thresholds and some uncertainty in the way the data are tabulated ([Table 2.1.7](#)).

Biological Response: FAIR and DECLINING (low confidence)

This category measures the response of marine life to conditions in the Bay at various levels of the ecosystem. The indicators that comprise this category are: (1) forage fish, (2) coastal sharks, (3) marine mammals, and (4) seabirds. Only the forage fish and coastal sharks indicators were used in this assessment. Based on these two indicators, the condition of the biology of the coastal pelagic habitat in the Bay is in FAIR and DECLINING condition. Confidence in this assessment is LOW due to incomplete data, a lack of thresholds, and the reliance on only two of the four indicators for this category ([Table 2.1.7](#)).

Forage Fish

Schooling fish and invertebrates, such as sardines, anchovies, and market squid, are prey for larger piscivorous fish, marine mammals, and sea birds. They are also commonly used as bait in recreational and commercial fisheries. Market squid also supports one of the largest commercial fisheries in California (for more on fishing, see Section 3.4). While changes in this indicator may be due to coast-wide factors, such as fishing pressure or oceanographic conditions, the presence or absence of these fish in the Bay can indicate how much food may be locally available for piscivorous species residing in the Bay. Due to the lack of robust fishery-independent population data, this indicator is measured by the species-specific landed weight of forage fish commercially caught in the Bay. Data come from the California Department of Fish and Wildlife Marine Region Statistical Unit. These data are subject to changes in commercial fishing efforts that might not reflect changes in the number of forage fish in the Bay. In the future, fishery-independent sources of data for this indicator should be considered.

Total landings of forage fish in the Bay have varied considerably in the last 10 years. While no trend is present over the entire period, landings have declined over the last five years, from 24,079 MT (metric tons) to 8,860 MT. Furthermore, declines in Pacific sardine landings since 2007 (15,633 MT to 103 MT) were replaced by an increase in landings of market squid (1,268 MT in 2008 to 16,039 MT in 2010). Market squid, however, have a lower caloric content per gram of body weight in comparison to sardines and anchovies. Therefore, this transition indicates a reduction in forage fish quality. Based on this, forage

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fish in the Bay are in FAIR but DECLINING condition. Confidence in this assessment is LOW due to the use of low-quality data, as these data are not normalized for effort; the lack of thresholds; and some disagreement between experts on the use of these data ([Table 2.1.7](#)).

Predatory Fish

Piscivorous fish, as the name implies, eat other fish, but they are also preyed on by larger predators. As such, they are a mid-level in the coastal pelagic food web. Juvenile thresher sharks (*Alopias vulpinus*) were selected as an indicator of predatory fish because they reside in the near-shore coastal pelagic zone during this phase of their life (Cartamil et al. 2010); primarily consume forage fish, such as anchovies (Preti, Smith & Ramon 2001); and high-quality, fishery-independent data are collected about them. Thresher shark presence in the Bay is measured as catch per unit effort (CPUE) by size class (0–49cm, 50–99cm, 100–149cm, and 150–199cm) during annual targeted research surveys. These data are compared to similar data collected in the rest of the Southern California Bight. Data come from the National Marine Fisheries Service Southwest Fisheries Science Center.

Data from 2006 to 2014 reveals that cohorts of juvenile thresher shark remain in the shallower waters of the Bay until they are ready to migrate to their adult habitat, as evidenced by distinct recruitment peaks that travel through the distribution of size classes over time. This is not apparent in the data from the rest of the Bight. In addition, nearly all size classes of juvenile thresher shark in the Bay exhibit comparable CPUEs during this time, whereas in the rest of the Bight, only the smallest and largest size classes do. Furthermore, CPUE for all size classes has been variable, ranging from 0.013 sharks per 100 hooks per hour to 0.038, but exhibits no trend. However, the CPUE of the smallest size class, indicative of new recruitment, has been zero in the Bay since 2008. In contrast, the CPUE of this same size class has been on the rise in the rest of the Bight since 2010. Finally, the CPUE of the largest size class has been declining in the Bay and Bight-wide since 2006. This could be due to a variety of reasons, including earlier migration into adult habitats. Based on this, the condition of predatory fish in the Bay is GOOD but DECLINING. The confidence in this estimate is MODERATE due to the limitation on the sample frequency and sample size of the data, the lack of any kind of threshold, and some disagreement among experts on the use of these data ([Table 2.1.7](#)). One disagreement comes from the recent anecdotal observations and limited tagging that the abundance of other predatory fish in the Bay, such as white shark, has been increasing since 2005.

Marine Mammals

The presence of marine mammals of all types indicates the availability of food and other features that may attract them. Some, such as harbor seals (*Phoca vitulina*) and female California sea lions (*Zalophus californianus*), tend to be resident. Others, such as the large whales, common dolphin (*Delphinus spp.*), and bottlenose dolphin (*Tursiops truncatus*), are not resident, but use this area as a foraging hotspot, therefore spending a large amount of time inside the Bay (Bearzi & Saylan 2011). The distribution, frequency of occurrence, seasonality, and behavior of these animals will be used as an indicator of this feature of the coastal pelagic ecosystem in future reports. The Ocean Conservation

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Society, National Marine Fisheries Service, and Southern California Cascadia Research Collective collect data on these animals. However, we were not able to obtain these data in time for this report and so this indicator was not scored.

Sea Birds

Sea birds, such as pelicans, terns, cormorants, and storm petrels, forage in the coastal pelagic zone, most commonly for fish. Because they are not targeted directly by human activities and are relatively easy to survey, they are good indicators of coastal pelagic health. Densities of seabirds will be used to measure this indicator. Data were collected during CalCOFI and SCCOOS research surveys. However, we were not able to obtain these data in time for this report and so this indicator was not scored.

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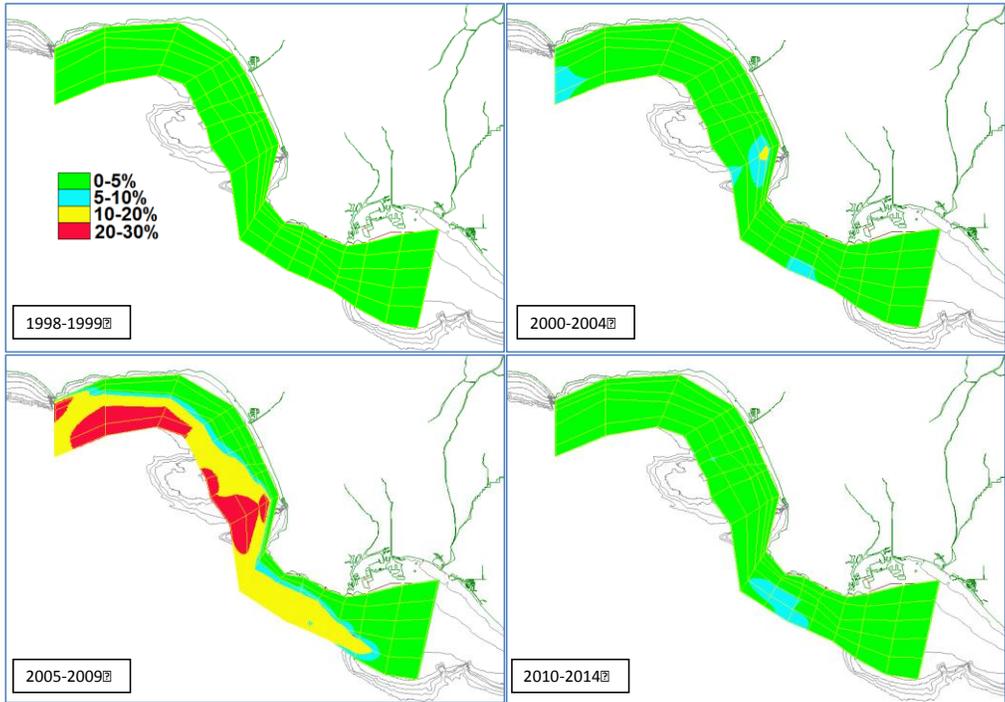
Table 2.1.7. Indicators, Related Management Actions, and Status and Trends for Coastal Pelagic Habitat.				
INDICATOR	METRIC	RELATED MANAGEMENT	SCORE	CONFIDENCE
1 Habitat Extent (Spatial Indicators related to extent, accessibility, availability, and temporal variability)				MODERATE
1.1 Hypoxia	Area with and frequency of excursions into low DO in the bottom 5m of casts (or 100m)	SMBRC: Objective 10.2	STATUS: Good TREND: Improving	MODERATE
2 Habitat Vulnerability (Spatial Indicators related to disturbance potential) The indicators for this category still need to be developed.				MODERATE
2.1 Ocean Acidification	Area with and frequency of excursions into low pH in the bottom 5m of casts (at bottom or 100m)	SMBRC: Milestone 4.7e	STATUS: Good TREND: Constant	MODERATE
3 Structure & Ecological Disturbance (Physical, chemical, and biological properties that impact condition of habitat)				MODERATE
3.1 Nitrogen and Phosphorous	Five-year averages of DIN and DIP concentrations at 30m.		STATUS: Fair TREND: Increasing*	MODERATE
3.2 Chlorophyll	Five-year averages of Chl <i>a</i> concentrations integrated across all depths.		STATUS: Good TREND: Constant	MODERATE
3.3 Harmful Algal Blooms (HABs)	Seasonal averages of domoic acid concentrations and concentrations of P-N, toxic species, and all other HAB species (cells/Liter) in the Bay.	SMBRC: Objective 10.2	STATUS: Fair TREND: Constant	LOW
4 Biological Response (Changes to individuals, populations, communities, and ecosystems in response to changes in habitat quality)				LOW
4.1 Forage Fish	Landings by weight of forage fish caught (commercial) in the Bay by species.	CDFW: Management of market squid. NMFS/PFMC: Coastal Pelagic Fishery Management Plan.	STATUS: Fair TREND: Declining	LOW
4.2 Predatory Fish	CPUE of young thresher shark by size category.	NMFS: Highly Migratory Species Fishery Management Plan.	STATUS: Good TREND: Declining	MODERATE
4.3 Marine Mammals	Data for this indicator were not available.			NOT SCORED
4.4 Sea Birds	Data for this indicator were not available.			NOT SCORED

*While the values are increasing, it is not clear whether this indicates an improving or declining trend.

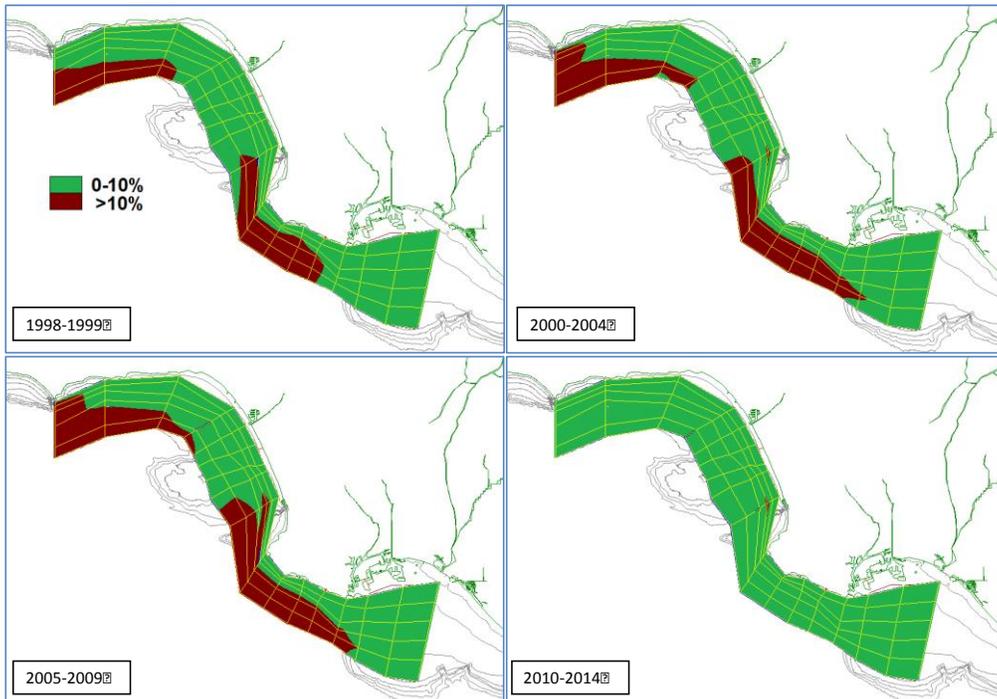
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Figure 2.1.7. Maps depicting the frequency of low oxygen (top) and corresponding high-density water (bottom) in the bottom 5m of the water column in Santa Monica Bay. The oxygen saturation panel (top) shows the frequency that low levels of oxygen (<30% saturation) occur spatially in the Bay. The density panel (bottom) shows the frequency that high-density seawater associated with incursions of deeper water with lower levels of oxygen ($>26.2 \text{ kg/m}^3$) occur spatially in the Bay. *Data Source: LACSD and CLA-EMD.*

Oxygen saturation – Frequency of saturation < 30% in bottom 5m



Density – Frequency of density $> 26.2 \text{ kg/m}^3$ in bottom 5m (Red areas are $>10\%$)



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Conclusions and Next Steps

Overall, the condition of coastal pelagic habitat in the Bay ranges from FAIR to GOOD with mixed trends. In addition to encouraging the collection of better data to be used in this assessment, present baselines against which to measure future changes for nearly all indicators and action levels for some indicators need to be developed in order to better interpret the data for effective management decisions. Developing these baselines and action levels through increased monitoring and research will be difficult but should be a priority. In addition, high-precision, high-frequency pH measurement or some other metric, such as saturation of the carbonate mineral aragonite, is needed to fully understand the trend in ocean acidification.

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References

- Alin, S. R., R. A. Feely, A. G. Dickson, J. M. Hernández-Ayón, L. W. Juranek, M. D. Ohman, and R. Goericke (2012). "Robust Empirical Relationships for Estimating the Carbonate System in the Southern California Current System and Application to CalCOFI Hydrographic Cruise Data (2005-2011)." *Journal of Geophysical Research* 117 (5). doi:10.1029/2011JC007511.
- Bograd, S. J., M. P. Buil, E. D. Lorenzo, C. G. Castro, I. D. Schroeder, R. Goericke, C. R. Anderson, C. Benitez-Nelson, and F. A. Whitney (2015). "Changes in Source Waters to the Southern California Bight." *Deep Sea Research II* 112. Elsevier: 42–52. DOI:10.1016/j.dsr2.2014.04.009.
- Cartamil, D., N.C. Wegner, D. Kacev, N. Ben-Aderet, S. Kohin, and J.B. Graham (2010). "Movement Patterns and Nursery Habitat of Juvenile Thresher Sharks *Alopias vulpinus* in the Southern California Bight." *Marine Ecology Progress Series* 404: 249–58. DOI:10.3354/meps08495.
- Gulland, E. M. D., M. Haulena, D. Fauquier, M. E. Lander, T. Zabka, R. Duerr, and G. Langlois (2002). "Domoic Acid Toxicity in Californian Sea Lions (*Zalophus Californianus*): Clinical Signs, Treatment and Survival." *Veterinary Record* 150 (15): 475–80. DOI:10.1136/vr.150.15.475.
- Kim, H., A. J. Miller, J. McGowan, and M. L. Carter (2009). "Coastal Phytoplankton Blooms in the Southern California Bight." *Progress in Oceanography* 82 (2). Elsevier Ltd: 137–47. DOI:10.1016/j.pocean.2009.05.002.

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- Kudela, R. M., G. Pitcher, T. Probyn, F. Figueiras, T. Moita, and V. Trainer (2005). "Harmful Algal Blooms in Coastal Upwelling Systems." *Oceanography* 18 (2): 184–97. DOI:10.5670/oceanog.2005.53.
- Orr, J. C., V. J. Fabry, O. Aumont, L. Bopp, S. C. Doney, R. A. Feely, A. Gnanadesikan (2005). "Anthropogenic Ocean Acidification over the Twenty-First Century and Its Impact on Calcifying Organisms." *Nature* 437 (7059): 681–86. DOI:10.1038/nature04095.
- Preti, A., S. E. Smith, and D. A. Ramon (2001). "Feeding Habits of the Common Thresher Shark (*Alopias Vulpinus*) Sampled from the California-Based Drift Gill Net Fishery, 1998-1999." *CalCOFI Rep.* 42: 145–52.
- Seubert, E. L., A. G. Gellene, M. D. A. Howard, P. Connell, M. Ragan, B. H. Jones, J. Runyan, and D. A. Caron (2013). "Seasonal and Annual Dynamics of Harmful Algae and Algal Toxins Revealed through Weekly Monitoring at Two Coastal Ocean Sites off Southern California, USA." *Environmental Science and Pollution Research* 20 (10): 6878–95. DOI:10.1007/s11356-012-1420-0.