Biological Indicator #2: Mid-Trophic Level Species Abundance, Biomass, & Phenology

BACKGROUND

Changes in mid-trophic level species abundance, biomass, and phenology can indicate changes in the health of the middle trophic levels of the food web. This indicator is intentionally broad because it provides the flexibility needed to choose the best possible selected species for each habitat within the study region.

Figure 6: Giant green anemone

The Indicators Working Group identified selected species for major habitat types within the study region, and these are provided in Table 20 below. In identifying these selected species, working group members focused on native species and avoided selecting fished species except when they were key to an ecosystem's health. Note that these selected species were identified based on currently available monitoring data, and they represent a shortlist among many possible mid-trophic level species in the North-central California coast and ocean region. The abundance of rocky intertidal selected species is a reflection of the relatively long history of monitoring in this habitat. Some species, which would provide valuable information if long-term datasets were underway or already available, have been designated as promising species and are provided in Appendix F.

TABLE 20: Selected mid-trophic level species by habitat type

SELECTED MID-TROPHIC LEVEL SPECIES	
SANDY BEACH	
	Mole crab (*Emerita analoga*)
ROCKY INTERTIDAL	
	California mussel (*Mytilus californianus*)
	Ochre sea star (*Pisaster ochraceus*)
	Gooseneck barnacle (*Pollicipes polymerus*)
	Giant green (*Anthopleura xanthogrammica)* & Sunburst anemone (*Anthopleura sola*)
	Volcano barnacle (*Tetraclita rubescens*)
ESTUARIES & BAYS	
	Gaper clam (*Tresus capax* and/or *Tresus nuttalli*)
	Staghorn sculpin (*Leptocottus armatus*)
	Shiner surfperch (*Cymatogaster aggregata*)
NEARSHORE SUBTIDAL	
	Blue (*Sebastes mystinus*) and Gopher (*Sebastes carnatus*) rockfish
	Cabezon (*Scorpaenichthys marmoratus*)
OFFSHORE (BENTHIC & PELAGIC)	
	Copepods (e.g., *Pseudocalanus mimus* in boreal and *Calanus pacificus* in transition zone)

Biological Indicator #4: Seabird Phenology, Productivity, & Diet

BACKGROUND

Seabird phenology, productivity, and diet provide a year-round picture of health of one category of higher trophic levels. It is important to note that seabirds are being used as indicators of higher trophic level organisms rather than pinnipeds, sharks, or other apex predators because the species listed below are less migratory and can be more effectively and directly linked to changing climate. There exist long-term monitoring data for other regionally important apex species such as sharks and pinnipeds, collected by universities, NGOs like Point Blue Conservation Science, and agencies that include NMFS, and NPS (Crocker et al. 2008; Lee and Sydeman 2009; Allen et al. 2011). Monitoring of these additional apex species will likely continue.

Figure 9: Brandt's cormorant

Figure 10: Common murre

Changes in seabird phenology, productivity, and diet can indicate changes in primary productivity. Furthermore, simultaneous monitoring of seabird phenologies and environmental conditions can provide information about potential mismatches in species phenology in the North-central California coast and ocean region (e.g., Wells et al. 2008). Seabird mortality events (as part of seabird phenology) can indicate changes in prey, atmospheric or oceanic conditions, or the presence of harmful algal blooms. Changes in seabird productivity can indicate changes in prey availability or environmental conditions (Wells et al. 2008; Field et al. 2010). Monitoring of seabird diet can be used to identify and track changes in prey availability (Roth et al. 2007).

Factors beyond anthropogenic climate change that can also impact seabird phenology, productivity, and diet include changes in human use, disturbances, and non-anthropogenic climate forcings that impact primary productivity and atmospheric or oceanic conditions.

As with Biological Indicators #2 and #3 (mid-trophic level species abundance, biomass, and phenology and the spatial extent of habitat-forming organisms), this indicator is intentionally broad because it provides the flexibility needed to choose the best possible indicator for relevant habitats within the study region.

TABLE 26: Selected seabird species by habitat type

SELECTED SEABIRD SPECIES	
	Brandt's cormorant (*Phalacrocorax penicillatus*)
	Cassin's auklet (*Ptychoramphus aleuticus*)
	Common murre (*Uria aalge*)

Biological Indicator #3: Spatial Extent of Habitat-Forming Organisms

BACKGROUND

The spatial extent of habitat-forming organisms, also known as "biogenic habitat," provides key information about changes in habitat availability for other species that depend on these resources. Reductions in biogenic habitat availability can have large impacts on organisms at all trophic levels in the North-central California coast and ocean region. Beyond providing habitat, macroalgae, seagrasses, and kelp are also important primary producers providing a trophic base to portions of the ecosystem food web. As climate change alters the physical conditions in the marine environment, it can reduce the success of habitat-forming organisms like mussels, kelp forests, and seagrasses in areas in which they were previously productive.

As with Biological Indicator #2 (mid-trophic level species abundance, biomass, and phenology), this indicator is intentionally broad to allow the flexibility to choose the best possible indicator for relevant habitats within the study region. Key habitat-forming organisms to monitor are organized by habitat type below:

Figure 7: California mussels

Figure 8: Seagrass bed along North-central California coast

TABLE 23: Selected habitat-forming organisms by habitat type

SELECTED HABITAT-FORMING ORGANISMS	
ROCKY INTERTIDAL & ISLAND	
	Mussel beds (*Mytilus californianus*)
	Surfgrass (*Phyllospadix scouleri* and/or *Phyllospadix torreyi*)
NEARSHORE SUBTIDAL	
	Bull kelp (*Nereocystis luetkeana*)
ESTUARIES & BAYS	
	Pickleweed (*Salicornia virginica* and/or *Sarcocornia pacifica*)
	Eelgrass (*Zostera marina*)
	Cordgrass (*Spartina foliosa*)
OFFSHORE (ROCKY BENTHIC)	
	California hydrocoral (*Stylaster californicus)*

HABITATS OF INTEREST

The spatial extent of habitat-forming organisms is a particularly useful indicator where the organisms are most frequently found: in rocky intertidal, nearshore subtidal, estuarine, and offshore benthic habitats.