This table format was used to compile and evaluate potential indicators for the kelp forest and rocky reef habitat in Monterey Bay National Marine Sanctuary. For each indicator, information was compiled for the six screening considerations as well as additional notes and comments included during internal reviewers. This table is provided to illustrate the type of information that was compiled during the indicator evaluation process; this is an interim product and not the final indicator portfolio for this habitat. Green shading denotes indicators that were highly supported during internal review; yellow denote those with moderate support; red denote those that were poorly supported. The final indicator portfolio for kelp forest and rocky reef is available in Appendix C: Table C4.

			Data Considerations		Primary Considerations		Other Considerations	Post-hoc Considerations	
			Spatial coverage of data	*Temporal coverage of data*	*Theoretically-sound*	*Relevant to management concerns*	*Regionally compatible*	*Complements existing indicators*	
Tier 2: Focal Component	**Tier 3: KEY ATTRIBUTE**	**Tier 4: INDICATOR**	Ideally, data for each indicator should be available throughout the spatial domain including MBNMS; coverage over a large portion of the targeted habitat preferred.	Indicators should be supported by existing data to facilitate current status evaluation; long-time series preferred to allow comparison with past conditions.	Scientific, peer-reviewed findings should demonstrate that indicators acts as a reliable surrogate for ecosystem attribute(s).	Indicator provides information related to condition report questions (Text Box 1) or sanctuary management concerns.	Indicator comparable to those indicators used by partners along the West Coast to contextualize current status and changes in status relative to the region.	A post hoc consideration, based on whether the indicator complements, and is not duplicative or redundant to, others within the indicator suite.	**Initial Notes and Internal Review**
Habitat	***Quantity***		**Spatial coverage**	**Temporal coverage**	**Theoretically-sound**	**Management**	**Compatible**	**Complementary**	
Habitat	*Quantity*	Canopy area of biogenic species - kelp	data covers most of California	PISCO monitoring data (since ~ 2000); CDFG kelp canopy data (may not be on-going)	Dayton 1985, Graham 2004; additional sources in indicator portfolio reports (see notes)	Q10: major habitat integrity; Q12: status keystone & foundation spp.	CCMP; NCCMP; SCMP; WAMSP; GFNMS-OCI; CCIEA; Essential Fish Habitat (Sustainable Fisheries Act); Steneck et al. 2002; Babcock et al. 1999	Preferred over kelp stipe density	WAMSP using as a indicator of habitat and of ecosystem health - trophic structure. Kelp forests form diverse communities tied directly to the production of energy from the kelp. Changes in kelp forest coverage affect recruitment of invertebrates and other species (rockfish in particular), such that kelp forest coverage could anticipate recruitment of older life stages into the bottom trawl surveys or into the fishery; canopy is a good indicator of a critical, foundational species; good monitoring data; management relevance (Essential fish habitat); high interest to and understood by the public
Habitat	*Quantity*	Cover of biogenic species - sub-canopy algae	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	see notes	Q10: major habitat integrity; and maybe Q6: eutrophic condition	CCMP (add-on); NCCMP; SCMP (add-on); WAMSP; CCIEA	Cross-habitat indicator (rocky reef); important indicator of primary production in reef areas without kelp	Important foundational/biogenic habitat species, especially when giant kelp absent, but more difficult to sample than surface canopy; given the preponderance of other indicators, less inclined to prioritize this over surface canopy; many sites with no surface canopy but thick understory and a 'kelp forest' assemblage of fish and inverts so this info important for those sites - suggested to use sub-canopy kelp as indicator of biogenic structure independant of giant kelp. Changes in primary productivity, as measured by changes in primary producer biomass, can indicate changes in the lowest trophic levels of the food web, the potential for harmful algal blooms, and the success of management actions to mitigate the impacts of climate change on the coast and ocean region.
Habitat	*Quantity*	Cover of biogenic species - sessile invertebrates	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	see notes	Q10: major habitat integrity	CCMP (add-on); SCMP (add-on); GFNMS-OCI	Cross-habitat indicator (rocky shore, seamount, deep seafloor)	Biogenic habitats are associated with diverse benthic communities, but similar to kelp forests, they are limited in their distribution within the California Current; Harter & Ribera 2009 show no differences in species composition or diversity between coral habitats and other hard-bottom structure. Sensitive to human activities (bottom-contact); management relevance. Need to further explore evidence that relative biogenic cover is good indicator
Habitat	*Quantity*	Stipe density - kelp	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	Dayton 1985, Graham 2004; see notes	Q10: major habitat integrity; Q12: status keystone & foundation spp.	CCMP; NCCMP; SCMP (add-on); WAMSP; CCIEA; GFNMS-OCI: Essential Fish Habitat (Sustainable Fisheries Act)	Less preferred than kelp canopy area	Kelp forests form diverse communities tied directly to the production of energy from the kelp; however, most kelp forests only exist in waters less than 60 m deep, so, at the scale of the California Current, community composition may not be tied to the abundance of kelp along the coasts; Changes in kelp forest coverage affect recruitment of invertebrates and other species (rockfish in particular), such that kelp forest coverage could anticipate recruitment of older life stages into the bottom trawl surveys or into the fishery. Aerial extent of canopy (above) preferred measure compared to stipe density.
Habitat	*Quantity*	Areal extent rocky reef habitat	Fine-scale substrate data available for much of nearshore in MBNMS (MBNMS has compiled GIS layer); CCIEA can downscale their data to MBNMS region	Mapping and characterization product, but not a time series		Q10: major habitat integrity	WAMSP; CCIEA	Cross-habitat indicator (rocky shore, deep seafloor)	Less important; change not imminent or threatened; no time series
Habitat	*Quantity*	Spatial extent of biogenic species - turf algae cover (e.g., fleshy red, brown)	is monitoring data available?	is monitoring data available?		Q10: major habitat integrity	CCMP (add-on), SCMP (add-on)		How is spatial extent measured or mapped? Seems like a difficult sampling question. Does the spatial extent of algal species respond to ecosystem changes and is this metric linkable to any management target ?
Habitat	***Quality***								
Habitat	*Quality*	Size structure - kelp	is monitoring data available?	is monitoring data available?	Dayton 1985, Graham 2004 see notes	Q10: major habitat integrity; Q12: status keystone & foundation spp.	WAMSP; Essential Fish Habitat (Sustainable Fisheries Act)	Kelp canopy area available and preferred	Kelp forests form diverse communities tied directly to the production of energy from the kelp; however, most kelp forests only exist in waters less than 60 m deep, so, at the scale of the California Current, community composition may not be tied to the abundance of kelp along the coasts; Changes in kelp forest coverage affect recruitment of invertebrates and other species (rockfish in particular), such that kelp forest coverage could anticipate recruitment of older life stages into the bottom trawl surveys or into the fishery. Canopy cover preferred
Habitat	*Quality*	Rugosity of substrate	finescale substrate data available for much of nearshore in MBNMS (MBNMS has compiled GIS layer)	Mapping and characterization product, but not a time series	Tupper & Boutilier 1997; Lindholm et. al. 2001; Rodwell et al. 2003; Andrews & Anderson 2004; Kuffner et al. 2007; Friedlander et al. 2007; Muth 2012	Q10: major habitat integrity	CCIEA; Habitat complexity and trawl bottom disturbance		Rugosity is often used as a proxy for habitat complexity which tends to explain a large amount of variation observed in species richness, biomass and abundance. Effects of rugosity have been used to explain differences between MPAs and incorporated into monitoring design; As rugosity increases, habitat quality increases as evidenced by increases in species richness, biomass, and abundance; Management actions such as spatial closures allow biogenic habitat to recruit and grow, creating more structurally complex habitats with rugosity as a measure of structural complexity. No time series data to show change over time
Population	***Size***								
Living Resources	*Population size*	Population biomass / density - sea urchins (purple & red)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000); CDFW	Paine 1966; Dayton 1971; Menge 2000; Fulton et al 2005	Q12: status keystone & foundation spp.	CCMP; NCCMP; SCMP; WAMSP; GFNMS-OCI; CDFW managed species		A keystone species with critical effects on kelp canopy; good monitoring data in sanctuary; red sea urchins are harvested; high interest by managers and the public
Living Resources	*Population size*	Population biomass / density - sea stars (*Pisaster, Pycnopodia*)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	Paine 1966; Duggins 1983	Q12: status keystone & foundation spp.	CCMP; NCCMP; SCMP; WAMSP; GFNMS-OCI	cross-habitat indicator (ocher star in rocky intertidal)	Important benthic predator, considered a keystone species in rocky intertidal; sea stars are a particularly important group to include now due to SSWS; extensive monitoring effort due to SSWS
Living Resources	*Population size*	Species status & trends - sea otter	entire range of sea otter in MBNMS	USGS-WERC biannual survey data (1985-present)	Boyd and Murray 2001; Carretta et al. 2007; Sergio et al. 2008; Heithaus et al. 2008 (see note)	Q12: status keystone & foundation spp.	CCMP; SCMP (add-on); WAMSP; ESA managed species	cross-habitat relevance (estuary)	Apex predators are often suggested as reliable sentinel species (also called "condition indicators") owing to their position at the top of the food chain and to a number of life history traits (low density, low fecundity, extended periods of juvenile dependence, etc.) that make them particularly vulnerable to human-induced alterations of their supporting ecosystems (Sergio et al. 2008); predators tend to exhibit changes in populations, diet, reproductive performance, and foraging behavior that reflect status of their food supply (Boyd and Murray 2001); Sergio et al. 2008 showed that top predators can often be good indicators of ecosystem structure and function; top predators, and prominent, charismatic consumers considered fundamental component in California Current (CCIEA); ESA listed species with recovery targets and history of reporting; sea otters are a keystone species in this habitat; good monitoring data in sanctuary; high interest to and understood by the public
Living Resources	*Population size*	Population biomass / density - abalone (red)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	see notes	Q13: other key species	CCMP; NCCMP; SCMP; WAMSP; GFNMS-OCI; CDFW managed species	cross-habitat relevance (black abalone in rocky intertidal)	Economically important/harvested species; protected (ESA threatended) species; can have critical effects on kelp canopy; good monitoring data in sanctuary; high interest by the public

Living Resources	*Population size*	Total abundance - YOY rockfish	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	see notes	Q13: other key species	CCMP (add-on); WAMSP		Ideal indicator; Linked to oceanographic conditions and recruitment has important implications to kelp community. Strong management implications (harvested species) and sensitive to ecosystem attributes. Data collected in MBNMS by PISCO since 2000. Important prey species.
Living Resources	*Population size*	Population biomass / density - lingcod	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	All stock assessments, Fulton et al. 2005, see notes	Q13: other key species	CCMP; NCCMP; WAMSP; CCIEA (groundfish mgt threshold); Fishery Management Plans for all assessed species; Miller et al 2009		WAMSP uses as indicator of ecological components population size and condition because lingcod are generally the top fish predator in kelp forests or shallow rocky reefs; aggregate "groundfish" biomass is not necessarily indicative of the state of the groundfish community due to the biomass of a few large components of the community; Groundfish surveys and stock assessments are already performed, but not at a scale much larger than a sanctuary. Perhaps include as some composite index of fish assemblage.
Living Resources	*Population size*	Population biomass / density - black rockfish	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	All stock assessments, Fulton et al. 2005, Link 2005	Q13: other key species	CCMP; NCCMP; WAMSP; CCIEA (groundfish mgt threshold); Fishery Management Plans for all assessed species; Miller et al 2009		aggregate "groundfish" biomass is not necessarily indicative of the state of the groundfish community due to the biomass of a few large components of the community; Groundfish surveys and stock assessments are already performed - no further data collection is necessary. This species less important relative to other taxa; perhaps useful as some composite index of fish assemblage.
Living Resources	*Population size*	Population biomass / density - blue rockfish	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	All stock assessments, Fulton et al. 2005, Miller et al 2009	Q13: other key species	CCMP; NCCMP; SCMP; CCIEA (groundfish mgt threshold); Fishery Management Plans for all assessed species; Miller et al 2009		aggregate "groundfish" biomass is not necessarily indicative of the state of the groundfish community due to the biomass of a few large components of the community; Groundfish surveys and stock assessments are already performed - no further data collection is necessary. This species less important relative to other taxa; perhaps useful as some composite index of fish assemblage.
Living Resources	*Population size*	Population biomass / density - cabezon	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	All stock assessments, Fulton et al. 2005, Miller et al 2009	Q13: other key species	CCMP; NCCMP; SCMP; CCIEA (groundfish mgt threshold); Fishery Management Plans for all assessed species; Miller et al 2009		aggregate "groundfish" biomass is not necessarily indicative of the state of the groundfish community due to the biomass of a few large components of the community; Groundfish surveys and stock assessments are already performed - no further data collection is necessary. This species less important relative to other taxa; perhaps useful as some composite index of fish assemblage.
Population	***Condition***								
Living Resources	*Population Condition*	Size structure / mean length - sea urchins (purple & red)	Is size structure monitoring data available?	Is size structure monitoring data available?	Jennings & Kaiser 1998; Link 2005; Rochet & Trenkel 2003	Q12: status keystone & foundation spp.	CCMP; NCCMP; SCMP; WAMSP; GFNMS-OCI; CDFW managed species		Keystone species with critical effects on kelp canopy; Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004). ... even if the change cannot be directly attributed to fishing, the indicator should still be monitored more closely, with initial steps taken to mitigate the change. Management relevance (harvested species)
Living Resources	*Population Condition*	Size structure / mean length - abalone	Is size structure monitoring data available?	Is size structure monitoring data available?	Jennings & Kaiser 1998; Link 2005; Rochet & Trenkel 2003	Q13: other key species	CCMP; NCCMP; SCMP; WAMSP; GFNMS-OCI; CDFW managed species		Economically and threatened species with critical effects on kelp canopy; Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004) . ... even if the change cannot be directly attributed to fishing, the indicator should still be monitored more closely, with initial steps taken to mitigate the change. Responds to management changes
Living Resources	*Population Condition*	Size structure / mean length - sea stars	size structure data not collected	size structure data not collected	Jennings & Kaiser 1998; Link 2005; Rochet & Trenkel 2003	Q13: other key species	CCMP; NCCMP; SCMP; WAMSP; GFNMS-OCI	Possible cross-habitat indicator (rocky shore)	Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004). Important benthic predator and possible cross-habitat indicator, but size data not collected
Living Resources	*Population Condition*	health/condition measures - sea otter	over range of species including MBNMS	USGS-WERC & CDFW annual sea otter stranding data	Burton & Idler 1987; Kjesbu et al. 1991; Marshall et al. 1998; Rideout et al. 2000; Marteinsdottir and Steinarsson 1998; Marshall and Frank 1999; Lambert and Dutil 2000 (see notes); Morgan 2004	Q12: status keystone & foundation spp.	ESA managed species		perhaps worth integrating in to the population size indicator
Living Resources	*Population Condition*	Size structure / mean length - cabezon	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	Jennings & Kaiser 1998; Link & Brodziak 2002; Link 2005; Rochet & Trenkel 2003	Q13: other key species	CCMP; NCCMP; SCMP; WAMSP; CCIEA (groundfish age at length)		Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004). This spp less important relative to other taxa; perhaps useful as some composite index of fish assemblage.
Living Resources	*Population Condition*	Size structure / mean length - lingcod	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	Jennings & Kaiser 1998; Link & Brodziak 2002; Link 2005; Rochet & Trenkel 2003	Q13: other key species	CCMP; NCCMP; WAMSP; CCIEA (groundfish age at length)		Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004). This spp less important relative to other taxa; perhaps useful as some composite index of fish assemblage.
Living Resources	*Population Condition*	Size structure / mean length - rockfishes (e.g., black, blue, B&Y, gopher, kelp, brown, copper)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)	Jennings & Kaiser 1998; Link & Brodziak 2002; Link 2005; Rochet & Trenkel 2003	Q13: other key species	CCMP: NCCMP; WAMSP; CCIEA (groundfish age at length)		Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004). Perhaps more useful as some composite index of fish assemblage.
Living Resources	*Population size & condition*	Density & size structure - surf perch (e.g., Embiotoica jacksoni & E. lateralis)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)		Q13: other key species	CCMP		Responsive to changes in kelp forest structure. Size structure may be good indicator for this species since they are live-bearers and year-class strength will immediately be affected by local prey availability / conditions.
Living Resources	*Population size & condition*	Density & size structure - painted greenling (Oxylebius pictus)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)		Q13: other key species	CCMP		Is this species highly responsive to changes in local ecosystem conditions? Both indicators may have large noise-to-signal ratio and poorly understood spatial/temporal variation. Are there linkable targets and how does painted greenling density/size structure respond to ecosystem changes?
Living Resources	*Population size & condition*	Density & size structure - black & yellow rockfish, gopher rockfish	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)		Q13: other key species	CCMP		As important species with relevant management concerns, seems reasonable, but what data source will be used to measure density? May also have large noise-to-signal ratio and poorly understood spatial/temporal variation. Size structure and stock assessment data might be easier to come by.
Living Resources	*Population size & condition*	Density & size structure - Kelp greenling (Hexagrammos decagrammus)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)		Q13: other key species	CCMP (add-on)		Though strong interactor in neashore communities, not highly responsive to changes in local ecosystem conditions (e.g., Graham 2004). May also have large noise-to-signal ratio and poorly understood spatial/temporal variation.

Living Resources	*Population size & condition*	Density & size structure - Señorita (Oxyjulis californica)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)		Q13: other key species	CCMP (add-on); SCMP		What data source will be used to measure density? Both indicators may have large noise-to-signal ratio and poorly understood spatial/temporal variation. Are there linkable targets and how does Senorita density/size structure respond to ecosystem changes?
Living Resources	*Population size & condition*	Density & size structure - Tubesnout (Aulorhynchus flavidus)	monitoring sites throughout central and southern CA	PISCO monitoring data (since ~ 2000)		Q13: other key species	CCMP (add-on)		What data source will be used to measure density? Both indicators may have large noise-to-signal ratio and poorly understood spatial/temporal variation. Are there linkable targets and how does tubesnout density/size structure respond to ecosystem changes?
Living Resources	*Population size & condition*	Breeding pop size, fledging rate, diet - Pelagic and Brandt's Cormorant & Pigeon Guillemot	data available for Ano Nuevo and Farallon Islands	Ano Nuevo Island (1994-present); Farallon Islands (1970-present)		Q13: other key species	CCMP (add-on); SCMP (add-on); CCIEA (seabirds)	possible cross habitat indicator	Seabird indicators are often excellent early indicators of ecosystem conditions, especially those that measure successful reproductive output or condition. Need for information on value as indicator for kelp forest habitat specifically. Breeding population size of long-lived species like this might be prohibitively delayed (lagged) to adequately reflect ecosystem conditions in a timely manner.
Living Resources	*Population condition*	Health/condition measures - abalone/sea stars	central and southern CA	Yes - PISCO/MARINe monitornig efforts	Burton & Idler 1987; Kjesbu et al. 1991; Marshall et al. 1998; Marteinsdottir and Steinarsson 1998; Marshall and Frank 1999; Lambert and Dutil 2000 (see notes); Rideout et al. 2000; Morgan 2004	Q13: other key species			Could be useful to develop some sort of indicator that tracks marine disease outbreaks in the sanctuary
Living Resources	*Population condition*	Foraging rate & diet - sea otters	central CA	some USGS-WERC & CDFW studies, but not part of monitoring program		Q12: status keystone & foundation spp.	CCMP; ESA managed species		Good, anticipatory indicator of ecosystem change; concrete, well understood by public, and high-profile protected species. data on foraging rate and diet???
Living Resources	*Population size & condition*	Density & size structure - California sea cucumber (Parastichopus californicus)	is monitoring data available?	is monitoring data available?		Q13: other key species	CCMP; CDFW managed species		What is the literature that documents the theoretical basis for this indicator (is this an indicator of harvest intensity)? How do sea cucumber densities and size structure respond to ecosystem change?
Community composition									
Living Resources	*Community composition*	Diversity indices - biogenic species	central and southern CA	may be able to calculate using PISCO monitoring data (since ~ 2000)	Gislason et al 2000; Samhouri et al. 2009	Q15: status of biodiversity	CCMP (add-on); SCMP (add-on); NCCMP; WAMSP; CCIEA	Cross-habitat indicator (rocky shore, seamount, deep seafloor)	Samhouri et al. 2009: Kemption's Q, Shannon-Wiener & Simpsons index not richness. Widely used diversity index; used by CCIEA. Samhouri notes that the indicator-attribute relationship can switch depending upon the type of fishing pressure used in the model. This result might make the indicator-attribute relationship unpredictable in the real world. Sensitive to human activities (bottom contact); management relevance. Kelp likely the most important biogenic species in this habitat.
Living Resources	*Community composition*	Diversity indices - demersal fishes	California (PISCO); or downscale to MBNMS region (CCIEA)	use PISCO monitoring data (since ~ 2000); CCIEA data	Gislason et al 2000; Samhouri et al. 2009	Q15: status of biodiversity	CCMP (add-on); NCCMP; SCMP (add-on); WAMSP; CCIEA		Samhouri et al. 2009: Kemption's Q, Shannon-Wiener & Simpsons index not richness. Widely used indicator. Samhouri notes that the indicator-attribute relationship can switch depending upon the type of fishing pressure used in the model. This result might make the indicator-attribute relationship unpredictable in the real world. Good composite indicator if available from PISCO monitoring data
Living Resources	*Community composition*	Top predator biomass (trophic level > 4) - demersal fishes	central and southern CA	may be able to calculate using PISCO monitoring data (since ~ 2000)	Link 2005 (indicators chosen, in part, based on known effects of fishing); Pauly et al. 1998; Ward & Myers 2005; Estes et al. 1998; Estes & Duggins 1995;	Q15: status of biodiversity	WAMSP; CCIEA; Link 2005		The removal of top predators from ecosystems typically results in a trophic cascade in which consumers are released from pressure and decrease the abundance of heterotrophs in the system, eventually reducing community composition; When top predators are introduced back into the system (management action), consumers are controlled and the composition of the community reverts back (i.e. otter/urchins/kelp); Perhaps worth using as integrative measure of important top predators; especially if available from PISCO monitoring data. Integrative measure of important top predators
Living Resources	*Community composition*	Density & size structure - Omnivorous Fishes (e.g., kelp, gopher, B&Y rockfish, cabezon, painted greenling, striped and black perch)	central and southern CA	PISCO monitoring data (since ~ 2000)	Jennings & Kaiser 1998; Rochet & Trenkel 2003; Link 2005	Q15: status of biodiversity	CCMP	composite index to include many individual species from above	Composite index for important mid-trophic level species, management relevance (harvested), responds to management changes. Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004).
Living Resources	*Community composition*	Density & size structure - Piscivorous Fishes (e.g., black rockfish, copper rockfish, lingcod)	central and southern CA	PISCO monitoring data (since ~ 2000)	Jennings & Kaiser 1998; Rochet & Trenkel 2003; Link 2005	Q15: status of biodiversity	CCMP	composite index to include many individual species from above	Composite index for important mid- to high- trophic level species, management relevance (harvested), responds to management changes. Mean size (l, as length) of all species caught in either fishery-independent surveys, fishery-dependent surveys, and/or landings is a useful and simple indicator to evaluate the overall effects of fishing on an ecosystem (Link and Brodziak, 2002; Link et al., 2002; Rochet and Trenkel, 2003; Nicholson and Jennings, 2004; Sala et al., 2004).
Living Resources	*Community composition*	Herbivore biomass - benthic inverts	central and southern CA	may be able to calculate using PISCO monitoring data (since ~ 2000); CCIEA can downscale their data to MBNMS	McClanahan 1995; Dulvy et al. 2006 (see notes); Monaco et al. 2007; Ardiwijawi et al. 2008; Walker et al. 2008; Patterson et al. 2009; Samhouri et al. 2009 (see notes); Hamilton et al 2010	Q15: status of biodiversity	NCCMP; SCMP; WAMSP; CCIEA	covered by abalone, urchin indicators above	The composition of these groups is defined in Samhouri et al 2009 Supplemental; Herbivore biomass is highly correlated with several measures of diversity, mean trophic level, target group biomass, and Avg relative change in ecosystem (Samhouri et al. 2009); Changes in Herbivore biomass will obviously affect community composition, but variation in overall community composition may not be detected by variation in this trophic level alone; Changes in Herbivore biomass across seven food web models (six in the north Pacific Ocean) were correlated with measures of diversity after perturbing the systems with various levels of fishing pressure; perhaps worth using as integrative measure of important kelp consumers; especially if available from PISCO monitoring data.
Living Resources	*Community composition*	Mean trophic level	central and southern CA	may be able to calculate using PISCO monitoring data (since ~ 2000)	Included in Convention of Biological Diversity list of indicators (Pauly & Watson, Stergiou & Tsikliras 2011); Caddy & Garibaldi 2000; Fulton et al. 2005; Samhouri et al. 2009;	Q15: status of biodiversity	CCIEA		There has been substantial discussion of the indicator (Pauly et al 1998, Essington et al 2006, Sethi et al 2010, Branch et al 2011, Stergiou & Tsikliras 2011). In general MTL highlights the idea of fishing down the food web -- although other process may also occur such as fishing through the food web. However, these alternative process are mostly a problem for Catch MTL, which is calculated from fisheries dependent data. Ecosystem MTL, which is calculated from Fisheries Independent data will correctly track changes in the trophic structure of the ecosystem. While the metric tracks changes in trophic structure it is often necessary to distinguish between changes in high and low TL taxa. For example, a decrease in MTL could be the result of a decrease in high TL fishes or a increase in the abundance of low TL fishers or both. See Essington et al 2006, Branch et al 2010. But also see Stergiou & Tsikliras 2011. Included in Convention of Biological Diversity list of indicators (Pauly and Watson 2005, Stergiou & Tsikliras 2011). Exact values will depened on local foodweb, but general trends will be comparable. Many issues with this indicator, but possible if data resides in PISCO database?

Living Resources	*Community composition*	Piscivorous/Zooplanktivorous fish biomass ratio	central and southern CA	may be able to calculate using PISCO monitoring data (since ~ 2000)	Caddy & Garibaldi 2000; Fulton et al. 2005; Samhouri et al. 2009	Q15: status of biodiversity	This ratio and its constituent parts are increasingly reported around the world (Caddy and Garibaldi 2000, Fulton et al. 2005, Kaplan et al. 2011)		The composition of these groups is defined in Samhouri et al 2009 Supplemental; Piscivorous/Zooplanktivorous ratio was highly correlated with two measures of diversity and total biomass (Samhouri et al. 2009); Changes in the ratio of piscivorous to zooplanktivorous biomass will obviously affect community composition, but variation in over community composition may not be detected by variation in the ratio of these two trophic levels alone; Changes in the ratio of Piscivorous to Zooplanktivorous biomass across seven food web models (six in the north Pacific Ocean) were correlated with measures of diversity after perturbing the systems with various levels of fishing pressure; data from PISCO?; theoretical evidence less compelling than other indicators....
Living Resources	*Community composition*	Diversity - sea stars	central and southern CA	PISCO monitoring data (since ~ 2000)		Q15: status of biodiversity; Q12: status keystone & foundation spp.			See sea star density/biomass; wouldn't necessarily distinguish between species; currently getting a lot of attention due to sea-star wasting disease
Human Activities									
Human Dimensions	*Human Activities*	Eutrophic status /Nutrient loading (TN, TP)	CCAMP and CCLEAN have nutrient loading data for Pajaro, Salinas, and other central CA river systems; some nutrient loading by stream/basin data available (USGS)	CCAMP data 1998-present; CCLEAN data 2001-present	USEPA 2002; additional sources in notes	Q2: activities that impact WQ; Q6: eutrophic condition	WAMSP; PFMC-CCE; CCIEA (habitat and pressure indicator)	Cross-habitat indicators (estuary); only indicator in suite for Q6	WAMSP using 'Nitrogen: phosphorus ratio' as indicator of habitat quality and 'Fertilizer input' as indicator of nutrient input as a land-based activity. Elevated nutrient concentrations are a leading cause of contamination in wetlands, estuaries, coastal waters and ground water of the United States (USEPA 2002). Harmful algal bloom events have been linked with freshwater runoff events (Kudela and Chavez 2004) and may be associated with nutrient loading from coastal watersheds in the Monterey Bay (Kudela et al. 2008a, Kudela et al. 2008b). Responds to management, history of reporting; likely pressure on associated fish/invert community
Human Dimensions	*Human Activities*	Fishery removals - recreational fishing landings	CDFW landings data (PFMC-CCE shows time series for all California); likely available by port or block	RecFin data available 2005-present	Recreational fishery removal represents a large portion of the removals for many kelp forest species	Q4: activities that impact living resources	CCIEA (pressures); WAMSP (lumps all fishing together); PFMC-CCE; SCMP; CCMP	Cross-habitat indicator (deep seafloor, sandy seafloor, pelagic); more applicable than commerical to this habitat	CCMP: Spatially reference landings (number and weight) and CPUE by CPFVs of nearshore finfish (e.g., cabezon, lingcod, rockfish); cascading effects associated with removal of large predators (e.g., trophic cascades); see Size-based, top predator indicators associated with trophic position (NWFSC groundfish trawl survey); Duggins et al. , etc.
Human Dimensions	*Human Activities*	Fishery removals - Commercial fishing landings	CDFW & NMFS data; PFMC-CCE shows time series for all California; likely available by port or block	PacFin data available 1981-present	Commercial fishery removal represents a portion of the removals for many kelp forest species	Q4: activities that impact living resources	CCIEA (pressures); WAMSP (lumps all fishing together); PFMC-CCE; SCMP; CCMP	Cross-habitat indicator (deep seafloor, sandy seafloor, pelagic); less applicable than rec fishing to this habitat	CCMP: Spatially referenced landings (weight & value) of nearshore finfish (e.g., rockfish, cabezon) and red sea urchin for the commercial fishery
Human Dimensions	*Human Activities*	Marine Debris abundance	most data is collected in watersheds, beaches, deep seafloor and pelagic habitats. No known data from kelp forest habitat	N/A	Howell et al. 2012 (MarPollBull); Keller et al. 2010 (MarPollBull); Ribic et al. 2012; Andrews et al. 2013	Q3: activities that impact habitat; Q4: activities that impact living resources	WAMSP; PFMC-CCE; CCIEA (habitat and pressure indicator)	Cross-habitat indicator for most other habitats	debris loading; intertidal and rocky reefs, subtidal habitats, beaches; trend: Likely increasing based on Japan tsunami debris, shipping traffic, and population increase; coastal trash standardized sampling; of increasing interest and concern by MBNMS stakeholders
Human Dimensions	*Human Activities*	Contaminant levels in tissues - mussels [levels of POPs (e.g., DDT, PCBs, PAHs, dieldrin) exceeding health standards]	some sample locations in MBNMS	NOAA Mussel Watch data (1986-present but varies depending on location); CA Dept Public Health; CCLEAN data (since 2001)	Mussel tissue contaminant data nationally supported indicator with known thresholds	Q2: activities that impact WQ; Q7: risks to human health; Q11: Contaminants in habitats	CCIEA (habitat indicator); SFBay	Possible cross-habitat indicators (estuary); need indicators for Q7 and Q11	SFBAY - the "safe for aquatic life" water quality indicator measures toxicity of estuary waters in laboratory tests, and concentrations of chemicals. Unclear what effect on kelp, if any; definite impacts on associated communities, however.
Human Dimensions	*Human Activities*	contaminants in tissues - fish	Limited sample locations in MBNMS	some SWAMP data on contaminant levels in nearshore ([not deep] fishes (but samples not taken in regular time series)	See notes	Q2: activities that impact WQ; Q7: risks to human health	CCIEA (habitat indicator); SFBay; PSP	Possible cross-habitat indicators (estuary); need indicators for Q7	PSP - target is that contaminant levels in demersal fish are below health effects thresholds (levels considered harmful to fish health, or harmful to the health of people who consume them). Reporting on PCBs, PBDEs, ; SFBAY - the "safe for aquatic life" and "fish safe for eating" water quality indicators measure mercury and POP (e.g., PCB, DDT, dieldrin, arsenic, cadmium, PAHs, PBDEs) concentrations in small fish (e.g., in food web) and common fished species (e.g, human safety). Benchmark for these measures have been established by the Regional Water Quality Control Board and/or the California Office of Environmental Health Hazard Assessment (OEHHA) to protect public health.
Human Dimensions	*Human Activities*	Intakes - average daily withdrawal volumes (power plants, desalination, other)		Andrews et al. 2013	See notes	Q4: activities that impact living resources	CCIEA		The entrainment and impingement of fish and invertebrates in power plant and other water intake structures have immediate as well as future impacts to estuarine and marine ecosystems (Johnson et al. 2008). Not only is fish and invertebrate biomass removed from the aquatic system, but the biomass that would have been produced in the future would not become available to the ecosystem. Water intake structures, such as power plants and industrial facilities, are a source of mortality for managed-fishery species and play a role as one of the factors driving changes in species abundance over time. Organisms that are too large to pass through in-plant screening devices become stuck or impinged against the screening device or remain in the forebay sections of the system until they are removed by other means. Theoretical underpinnings of linkage between kelp communities and larval removals are not conclusive...
Human Dimensions	*Human Activities*	contaminants - levels of radioactivity and contaminants in kelp	limited sample locations in MBNMS	Kelp watch (radioactivity) & Garske research (trace metals) but none are long-term monitoring program		Q3: activities that impact habitats; Q4: activities that impact living resources			Kelp is an integrative sample of contaminants in water; Kelp Watch project description https: //sanctuarysimon.org/dbtools/project-database/index.php?ID=100400
Climate and Ocean drivers									
Water Quality	*Climate and Ocean Drivers*	Upwelling Index	available for 15 locations along the west coast, 1 site in MBNMS (southern region) and one site to the north of MBNMS	Pacific Fisheries Environmental Laboratory generates monthly upwelling indices at each site 1967-present	Gunsolus 1978; Nickelson 1986; Iles et al 2011	Q8: climate change	CCIEA; WAMSP		WAMSP using upweling as an indicator of oceanographic drivers; MBNMS lies within the California Current ecosystem, which is an eastern boundary current system largely driven by upwelling forces that bring deep, cold, nutrient-rich waters to the surface and the nutrients support kelp growth. Upwelling influences water temperature and timing and intensity of recruitment in kelp forest.
Water Quality	*Climate and Ocean Drivers*	Sea surface temperature	Satellite data but limited availability nearshore; nearshore stations (e.g., Santa Cruz pier, CDIP, Monterey Bay Aquarium intake)	3-25+ yrs; lenght of time series varies depending on source [available through CeNCOOS portal]	Peterson and Shwing 2003; Mantua et al. 1997; additional sources in indicator portfolio reports (see notes)	Q8: climate change	CCIEA; WAMSP; GFNMS-OCI; CalCOFI; PFMC-CCE	Cross-habitat indicator (all other habitats)	Used in WAMSP as indicator of Climate and Habitat quality; sea surface temperature (SST) is a key parameter because it is a direct indicator of climate change and an indirect indicator of changes in upwelling, water transport, habitat suitability, and nutrients (GFNMS-OCI); Sea Surface Temp Anomaly is a indicator in the CalCOFI report
Water Quality	*Quality*	Water quality index	Data exist and some reporting for some regions.	need to know variables to determine data availability - will get input from WQ experts during CR process	Krembs 2012; Rogers & Greenaway 2005; EPA 2002; NRC 2000; Heinz Center 2008	Q6: eutrophic condition; Q7: water and human health; and Q8: changes in climate	PSP; CCIEA	Potential cross-habitat indicator; indicators of eutrophic condition needed	The Marine Water Conditon Index by Washington Department of Ecology integrates numerous water quality measurements and is used as a "Vital Sign" by the Puget Sound Partnership on their dashboard of indicators; EPA EMAP National Coastal Assessment, Data for 1999 - 2006 (http: //www.epa.gov/emap/index.html) includes water column, sediment contaminants, benthic macroinvertebrates and demersal fish, contaminants; NCA data appears to be entire west coast. Depth strata unclear. Benthic Grabs. Sampling design not readily clear from EMAP website. Possible cross-habitat indicator; will get input from WQ experts thru Condition Report update process

Water Quality	*Climate and Ocean Drivers*	Dissolved Oxygen and Hypoxic events (area of hypoxia)	a few nearshore stations (e.g., Santa Cruz pier, Monterey pier, Monterey Bay Aquarium intake); not much data available from within kelp forest habitat area in MBNMS	2-10+ yrs; lenght of time series varies depending on source [available through CeNCOOS portal]	Krembs 2012; Diaz and Rosenberg 1995; EPA 2002b; Rogers & Greenaway 2005; EPA 2002; National Research Council 2000; Heinz Center 2008	Q8: climate change; Q10: major habitat integrity	WAMSP; PSP; GFNMS-OCI; PFMC-CCE, CCIEA	Potential cross-habitat indicator, but habitat-specific data preferred	WAMSP uses DO as an indicator of habitat quality in kelp forest & deep seafloor environment; Low dissolved oxygen in marine waters can create significant problems, such as extensive fish kills. Inputs of nutrients from human activities are often suspected of creating, or exacerbating, the conditions that lead to low oxygen in Puget Sound (PSP); DO is a key biologically-influenced water property that can indicate changes in habitat suitability, water quality, primary productivity, and degradation of organic matter (GFNMS-OCI)
Water Quality	*Climate and Ocean Drivers*	Aragonite saturation (Ocean Acidification)	a few nearshore stations (e.g., Santa Cruz pier, Monterey pier, Monterey Bay Aquarium intake); not much data available from within kelp forest habitat area in MBNMS	2-10+ yrs; lenght of time series varies depending on source [available through CeNCOOS portal]		Q8: climate change; Q10: major habitat integrity	WAMSP; PFMC-CCE	Potential cross-habitat indicator, but habitat-specific data preferred	A key indicator of OA effects is aragonite saturation state, a measure of how corrosive seawater is to organisms with shells made of aragonite (a form of calcium carbonate). Values <1.0 indicate conditions that are corrosive for aragonite, and have been shown to be stressful for many species, including oysters, crabs, and pteropods.
Water Quality	*Climate and Ocean Drivers*	Pacific Decadal Oscillation	Pacific basin scale (not specific to MBNMS)	1900-present; available through CCIEA websites (but not specific to this habitat)	Mantua et al. 1997; Hare et al. 2000	Q8: climate change; Q9: other stressors	WAMSP; CalCOFI; PFMC-CCE		The PDO is derived from the pattern of sea surface temperature anomalies (SSTa) in the northeast Pacific; these patterns often persist over many years and are referred to as "regimes." During positive PDO regimes (positive PDO values), coastal SST anomalies in the Gulf of Alaska and the CCE tend to be warmer, while those in the North Pacific Subtropical Gyre tend to be cooler. Warm regimes are associated with lower productivity in the CCE.