Categorization of Responses

We categorized the survey responses for all free response and short answer questions prior to analysis. For each question, all three authors reviewed each of the categories to which responses were assigned and when disagreements occurred the categories were discussed until a consensus was reached. Similarly, responses to free response and short answer questions were reviewed collectively and placed within categories after the authors reached agreement. Responses were categorized for the following 11 questions: 3, 7, 9, 10, 12, 14, 17, and 20–23.

Question 3: Please list up to three fields/scientific disciplines (e.g., fisheries biology, historical ecology) with which you identify. Fields and disciplines listed by respondents were grouped into five categories: *Fisheries Science*, *Marine biology*, *Conservation and environmental sciences*, *Earth and atmospheric sciences*, and *Other*. The use of keywords by respondents facilitated this categorization. For instance, any response including "fishery" (e.g., fisheries biology, fishery management) was categorized as *Fisheries science* and any inclusion of "conservation" or "restoration" (e.g., conservation biology, ecological restoration) was considered *Conservation and environmental sciences*. *Marine biology* was applied generally and was inclusive of responses such as "marine ecology" and "estuarine ecology". The *Earth and atmospheric sciences* category included responses such as "Geography" and "Geology". Responses grouped as *Other* included "biogeochemistry," "genetics," and "molecular biology."

Question 7: Please describe your work as it relates to marine conservation in one sentence or less. Responses to this question were grouped into six categories — *Research*, *Education*, *Management (conservation)*, *Management (resources)*, *Administration*, and *Other* — and were not mutually exclusive. Many respondents indicated that they conducted *Research* (e.g., "I am a marine ecologist studying…) and also filled *Education* (e.g., "Educating bay stewards") or *Management* roles. Keywords were particularly useful when distinguishing between *Management (conservation)* and *Management (resources)*. Responses were grouped under *Management* (*conservation*) when the emphasis was on the preservation or restoration of biodiversity or ecosystems (e.g., "Assess status and trends of ecosystem health in our local estuaries") whereas responses in the *Management* (*resources*) category focused on ecosystem services and fisheries activities (e.g., "...implement resource management actions…"). *Administration* was differentiated from these categories based on the level at which the respondent was working. For example, "Chair of several science or technical advisory committees to coastal policy groups" was considered *Administration* and "…developing strategies to protect and restore salmon habitat" was considered *Management (resources)*. Responses categorized as *Other* were generally too vague to fit any of the aforementioned categories (e.g., "Working hard today to ensure a better future tomorrow").

Question 9: Please list up to three primary goals in the field of marine conservation (e.g., preservation of biodiversity). Responses were categorized into six categories: *Maintenance of biodiversity*, *Maintenance of ecosystem services*,

Maintenance of ecosystem structure and function, *Habitat protection*, *Sustainability*, and *Other*. These groupings were not mutually exclusive, as responses such as "Conservation of ecosystem function and services" were considered both *Maintenance of ecosystem services* and *Maintenance of ecosystem structure and function*. *Maintenance of biodiversity*, which was taken to be inclusive of all types of diversity (e.g., genetic, species, ecosystem), *ecosystem services*, and *structure and function* were distinguished based on phrasing and keywords used by respondents — most prominently the category names themselves. *Habitat protection* was applied in a general sense (i.e., not necessarily implying human exclusion from nature). The *Sustainability* category included responses mentioning management practices in a general sense (e.g., "smart management") as well as responses that explicitly mentioned sustainability (e.g., "long-term sustainability"). We acknowledge that the concept of sustainability can be complicated (Callicott and Mumford, 1997), but use it here in a broad sense to mean the current and continued coexistence of humans and the ecosystems in which they are embedded. Several respondents also included educational goals (e.g., "education"), focused on research (e.g., "To study the impact we have had…"), or gave vague responses (e.g., "Understand marine ecosystems"); these were considered *Other*.

Question 10: What are the cutting-edge approaches currently being practiced in marine conservation to achieve the goals you mentioned in question 9? List no more than three. Responses to this question were variable and ranged from data collection tools (e.g., drones) to practices (e.g., adaptive management) and

management actions (e.g., marine protected areas). Thus, responses were grouped into the broad categories of *Management*, *Technology*, *Mathematics*, *Research*, and *Other.* Many of responses included multiple types of approaches and others described approaches that spanned more than one of the approach categories (e.g., the response, "…statistical and modeling approaches combined with field data from long term studies…", was categorized as *Mathematics* and *Research*). Responses in the *Management* category included decision making (e.g., "utilization of diverse data sets to make management decisions") and management actions (e.g., "Marine Protected Areas") as well as policy changes (e.g., "use laws and politics to control the human activities"). *Technology* approaches referred to improving (e.g., "greater computing power") as well as adapting existing technology to conservation practice (e.g., "use of drones"). *Mathematics* approaches were most commonly related to improved modeling (e.g., "Modeling approaches combined with community-based monitoring…") and analysis (e.g., "spatial analysis"). The *Research* category primarily included descriptions of applying data to conservation practice (e.g., "interdisciplinary collaborative research…studying how major river freshwater plumes effect [sic] early life stage survival in marine environments"), some more theoretical considerations (e.g., "ecosystem processes understanding"), and citizen science (e.g., "Developing crowd-sources data [sic] and information products). The *Other* approaches included responses that were too broad to fit other categories (e.g., "genetics") or did not fit the previous categories (e.g., "education").

Question 12: In your opinion, what is the importance of long-term temporal data for achieving the goals of marine conservation? Responses to this question were classified into one of three commonly described categories (Strayer et al., 1986; Lindenmayer et al., 2012; Dietl et al., 2015) — *Baselines*, *Trends and patterns*, *Range of variability* — and a fourth category, *Other*, for miscellaneous responses. In many cases responses included components of multiple categories and were tallied in each of those categories. Responses in the *Baseline* category typically referred to using LTD to inform decision making in the future (e.g., "To combine with known conditions to be able to model and predict future outcomes"). Responses classified as *Trends and patterns* implied that LTD are important for determining trajectories and removing short-term variation (e.g., "identifies long-term trends in populations or water quality. Eliminates the noise of year-to-year variation…"). *Range of variability* most commonly included responses that highlighted the dynamic nature of populations and ecosystems (e.g., "critical for detecting natural dynamics of ecosystems…"). The vast majority of responses fell in one of these three categories and two remaining responses were grouped as *Other* (e.g., "Convincing policy makers…").

Question 14: Please list five sources of long-term data and indicate whether you have used each one in your own research. The respondent-provided sources of long-term data were grouped into four categories, *Modern observational*, *Historical*, *Geohistorical*, and *Other*, related to those described for sources of data in marine historical ecology (Jackson and McClenachan, 2009; Lotze and McClenachan,

2014). In marine historical ecology, 'archaeological' is given equivalent status as a data source, however, here it was subsumed under *Geohistorical* due to similarities in timescales and the small number of responses including these data. *Modern observational* included monitoring data and any contemporaneously collected data such as "seabird productivity data," "Weather station data," and "fishery catch data." *Historical* (e.g., "historical documents") was distinguished from *Geohistorical* (e.g., "Paleontological") by its association with records kept by people (e.g., "historical documents"), as opposed to records in nature (e.g., "sediment cores"). The *Other* category included various responses including organizations (e.g., "NOAA") and variables (e.g., "pH") that were too broad to categorize otherwise.

Question 17: Given that these stressors interact in complex ways, please identify and describe the interaction that is most pressing to understand in marine conservation, in your opinion (e.g., the additive interaction between invasive species and climate change)? In 2005, the Millennium Ecosystem Assessment identified five stressors — pollution, habitat change, climate change, overexploitation, and invasive species — as the most important threats to ecosystems and it has subsequently been noted that these stressors often interact in complex ways (Crain et al., 2008; Darling and Côté, 2008). Many respondents identified multiple interactions or interactions between three or more stressors they found to be important. Consequently, responses to this question were assessed in two ways. First, the total number of mentions for each stressor was tallied. Second, interactions between stressors were tallied. When three or more stressors

were mentioned, each unique pairing was tallied (e.g., a respondent mentioning climate change, habitat change, and pollution resulted in tallies for climate change-habitat change, climate change-pollution, and habitat change-pollution).

Question 20: If you use reference conditions or baselines in your research/conservation work, please list three types of data sources that you use to produce them (e.g., references sites, monitoring records, etc.)?

Responses were categorized into five groups: *Modern observational*, *Reference sites*, *Historical*, *Geohistorical*, and *Other*. These categories were chosen to reflect those used in Question 14. Responses classified as *Modern observational* commonly included mentions of monitoring (e.g., "monitoring records"). "Reference sites" was also a frequently given response and formed the basis for the *Reference sites* category; such responses were not considered *Modern observational* because they implied a spatial component rather than continued observation at one or a few sites. Similarly, responses in the *Reference sites* category were distinguished from responses in the *Historical* and *Geohistorical* categories by the mention or implication of spatial rather than temporal data. *Historical* included baselines from human-produced sources including "Literature," "historical data," and "historical accounts." Responses in the *Geohistorical* category often included mentions of paleontological data (e.g., "paleobiology") and geological sources (e.g., "sediment cores"). The *Other* category included responses giving methods (e.g., "Hindcast Circulation and Climate Models") or variables (e.g., "ocean conditions") that could not be linked unequivocally to one of the aforementioned categories.

Question 21: In your opinion, are spatial and temporal data of equal value in establishing reference conditions and baselines? Please explain briefly. Responses to this question were categorized at two levels. First, responses were split into three groups — *Yes*, *No*, and *It depends* — with respect to whether respondents found spatial and temporal data to be of equal value. Second, the *No* category was also subdivided into two groups based on whether respondents found *Temporal* or *Spatial* data to be of greater value for establishing baselines.

Question 22: Are there types of long-term data that would be useful, but that aren't currently available or you would want more of? If so, please give an example. Responses to this question were assessed at three levels. First, responses were divided into those saying *Yes*, *No*, or *Unsure* to the initial question. Second, *Yes* responses were categorized into *Abiotic*, *Biotic*, or *Other* (e.g., "rate or process data") groups. Third, the *Abiotic* and *Biotic* groups were further subdivided into the specific types of data identified by respondents. For the *Abiotic* subgroup, data types included *Temperature* (e.g., "Deep-ocean temperatures."), *Water Chemistry* (e.g., "Nutrient concentration of seawater."), and *Other* (e.g., "seismic"). For the *Biotic* subgroup, data types included *Species Abundance* (e.g., "abundance of key species"), *Species distribution* (e.g., "species distribution data …"), *Interactions* (e.g., "predator-prey relationships"), and *Other* (e.g., "species extinction rates").

Question 23: What barriers (e.g., communication, funding, data availability, etc.) have you experienced (or do you perceive to exist) in applying long-term data to marine conservation? Responses to this question were grouped into four categories — *Funding*, *Data availability*, *Communication*, and *Institutional* — similar to those identified by conservation biologists (e.g., Strayer et al., 1986; Lindenmayer et al., 2012) and a fifth category, *Other*, for miscellaneous responses. Many respondents identified multiple barriers and each was tallied under the appropriate category (e.g., "Funding and agency interest" was categorized as *Funding* and *Institutional*). Responses categorized as *Data availability* discussed barriers related to data accessibility or lack of data (e.g., "lack of data availability", "True long-term data is often not available"). The *Communication* category encompassed responses at the level of disciplines (e.g., "…communication may be one barrier, with researchers not recognizing how certain other disciplines might value their contributions") as well as general challenges such as "Communicating long term data can also be difficult if the data is collected on timescales not easily processed by human minds." Responses classified as *Other* included such impediments as education (e.g., "educational barriers") and politics (e.g., "Playing political small ball…").