What Next

Challenges

1. **How to amortize and prioritize the unknown?** - Census 2010 created an accessible baseline for what we know about life in the ocean, but, perhaps more importantly, it also defined what we don't know. Most excitingly, it demonstrated a wide array of successful technologies for turning most of the unknowns into knowns, so we can continue the age of discovery and exploration efficiently. A decade was not enough to complete the work, but now we know that it can be completed with time and money. Most of the projects laid out systematic programs for efficiently gathering representative pictures of their habitat or realm. There is not enough time or money to sample every football field of the seafloor or every seamount for Census 2020, but we know that that is not necessary. Unfortunately, we also know that some habitats are under extreme pressure from global climate changes that cannot be reversed. Unless nations globally decide to pull out all the stops and invest in a "race to the ocean" on the scale of the "race to the moon", the first challenge for Census 2020 has to be to amortize and prioritize the unknown. How do we balance the complete unknown, like the meso- and bathypelagic against easier, but more critical unknowns? There are some realms that are unlikely to be impacted in 50 years and others that will be impacted in 5. Can we identify 50 regions of the global ocean that absolutely must be preserved, or provide guidance for triage? The imminent effects of warming and acidification on coral reefs for example mean that they have to be a priority or species will likely disappear before we know they exist. The ice oceans are another clear priority. Similarly, other coastal habitats have been shown to be severely impacted by removals and pollution that are reversible, and these need to be monitored.

2. **How to balance discovery and monitoring?** - Census 2010 has provided a legacy of protocols that will allow the Ocean Observing community to monitor changing biological patterns as cheaply and efficiently as it monitors physical and chemical changes – on a global scale. These will work most effectively in the coastal regions and in the shallows of the open ocean. These are the areas that are most impacted, but also most accessible to regulation that has been shown capable of reversing negative trends. Clearly, monitoring is essential both to understand rates of change and to document that regulations are producing desired effects. Unfortunately, we know that governments place a higher priority on resolving crises than on pleasant surprises from the unknown, so Census 2020 will have to work very hard to ensure a balance between discovery and monitoring. This is a potentially divisive issue among the Census community that we have worked so hard to create and grow. We cannot let governments focus only on the cheap, short-term answers, when we have identified the big questions.

3. **Can we frame the Census as a 'macroscope'?** - One way to ensure that funding flows in a balanced way to Census 2020, is to make sure society recognizes that it is more than "stamp collection", an accusation frequently heard in the early days of Census 2010. Most government agencies charged with managing the ocean globally now recognize that they must manage whole ecosystems not just single species. Providing such "ecosystem based management" remains a challenge, but it is becoming clear that you must know both what species are in the system and how and when they interact. Census 2010 showed that it could provide such information. One concept that emerged in the Highlights report was the Census as a 'macroscope' – a way of seeing the big picture by sharing and merging information from a wide range of technologies using a wide range of analytical approaches. Complex analyses of OBIS data are one

macroscopic approach, but the idea of an 'ecoscope', the hardware for a macroscope, developed in early meetings of the Census 2020 group. This could be a ship outfitted to look at a variety of unique sites identified by Census 2010 looking from top to bottom and microbes to whales using technologies from microbial DNA to sonar to ROVs to satellite tracking to understand the interactions at all trophic levels in particular ecosystems. Are ecosystems linked vertically as well as horizontally? This approach would provide balance between new discoveries and management applications and could be a valuable 'Trojan Horse' to reach funding agencies globally.

4. **How to deliver effective ocean management as a Census output? -** The press generally acknowledges that Census 2010 has done extremely well at diversity and distribution, but is less convinced that it was very good a counting fish – abundance. This is a challenge that Census 2020 must deal with. One counterargument has been that agencies globally spend billions of dollars annually counting fish, but it really hasn't done much good. One reason that the Census 2010 showing on abundance was less than expected was that agencies were much less willing to share their abundance data with OBIS than other kinds of data. One approach may be that, since OBIS is now an arm of the IOC to which countries donate their physical data through National Ocean Data Centres, they should also be obliged to submit abundance data by the same route. The macroscope concept could be linked to this approach in two ways: first by pointing out that past management failures can often be traced to not looking a the big picture and second by ensuring that when the 'ecoscope' is pointed at a particular habitat it acquires abundance data at multiple trophic levels. Clearly, the next step toward making Census 2020 relevant and ensuring regular decadal assessments is to demonstrate direct applications for effectively managing the ocean.

5. **How much biodiversity is enough? –** This is an often asked question by the media and agencies. It is a double-edged sword that agencies like to interpret as, "If we have all of the commercial species, why do we need all that other stuff?" A popular recent media quote was, "Suppose you are looking out the window of a plane and a rivet pops out of the wing. A while later another one pops out. You ask the flight attendant how many rivets can pop out before the wing falls off. She doesn't know." This is really the fundamental scientific question of biodiversity. What are all the species doing out there? Do they all matter in delivery of ecosystem services or are some more important than others? How can we use the resources created by Census 2020 to begin answering this question in a serious way for a wide variety of marine habitats?

Grand Challenge
Can we frame the Census as an "essential service"? - Census 2010 proved that it can be done, Census 2020 needs to prove that it must be done. Society must recognize that it cannot survive without the ocean and that recovery of the ocean cannot be assured unless we monitor it on a regular basis and continue to discover its deep biodiversity secrets. There is a pressing need for greater investment in both exploration and monitoring, but to justify this the Census community needs to move from being a club of peers to an organization providing essential services. Census 2010 has left these peers uniquely qualified to tackle this Challenge because of its demonstrated ability to share data and think macroscopically.