Building Capacity and Linking Infrastructure in the Lake and Coral Reef Scientific Communities

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Report of Coral Reef Working Group

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There were three main goals the Coral Reef Working Group had for the workshop:
(1) Identify the science questions that can be addressed using a global network of sensor data,
(2) Identify the core variables for sensor measurement, and
(3) Develop a concrete plan for implementation of a scalable coral reef sensor network.

Science questions and research opportunities afforded by a global network:

The Coral Reef Working Group did not attempt to prioritize the most important research questions for coral reef ecosystems. Rather; it identified that understanding the responses and recovery of coral reef ecosystems to environmental disturbances is a fundamentally important goal that is being pursued by many different research groups around the world. Within that general context, several more specific research themes were recognized, including coral bleaching, ocean acidification, coral-algal phase shifts, and the causes and consequences of outbreaks (e.g., disease, natural enemies). Data from a variety of ocean sensors are frequently utilized to address these research issues at localized research sites. However, there are also a number of unique and valuable science opportunities that could arise if a global coral reef sensor network was in place. For example, networked sensor data would allow researchers to assess not only local responses of reefs to environmental perturbations, but also global patterns of response among reefs of different types and across environmental gradients. Real time data from a sensor network would allow adaptive sampling, both on local and global scales. The participation of diverse research groups in a network effort would lead to increased standardization of sensors used and the quality and types of data collected, thus enhancing the ability of data streams from different sites to be rapidly incorporated into models or readily used in hypothesis testing. A global sensor network would greatly facilitate international collaborative science and policy projects. It would also stimulate advances in sensor development and network technologies to meet scientific demand for cost-effective, energy-efficient marine sensors. Finally, the value of archived network data will increase over time due to the potential for retrospective studies as time series data accumulate.

Core variables for sensor measurement:

The Working Group identified the suite of sensor-measured variables that are most commonly utilized in the study of the four identified research themes (coral bleaching, ocean acidification, coral-algal phase shifts, and the causes and consequences of outbreaks). These variables are listed in Table 1. There was general agreement that only about half of the variables could be readily measured with sensors using existing technology on a sustained basis. These variables were designated as core variables, because a sensor network based on them could be implemented more-or-less immediately. The remaining "desired" variables, although potentially of great value for inclusion in a sensor network, pose various technical or logistical challenges (e.g., fouling of sensor, too labor intensive to operate continuously, sensor technology not advanced enough) and these variables were deemed to not be practical for inclusion in a sensor network effort at this time.

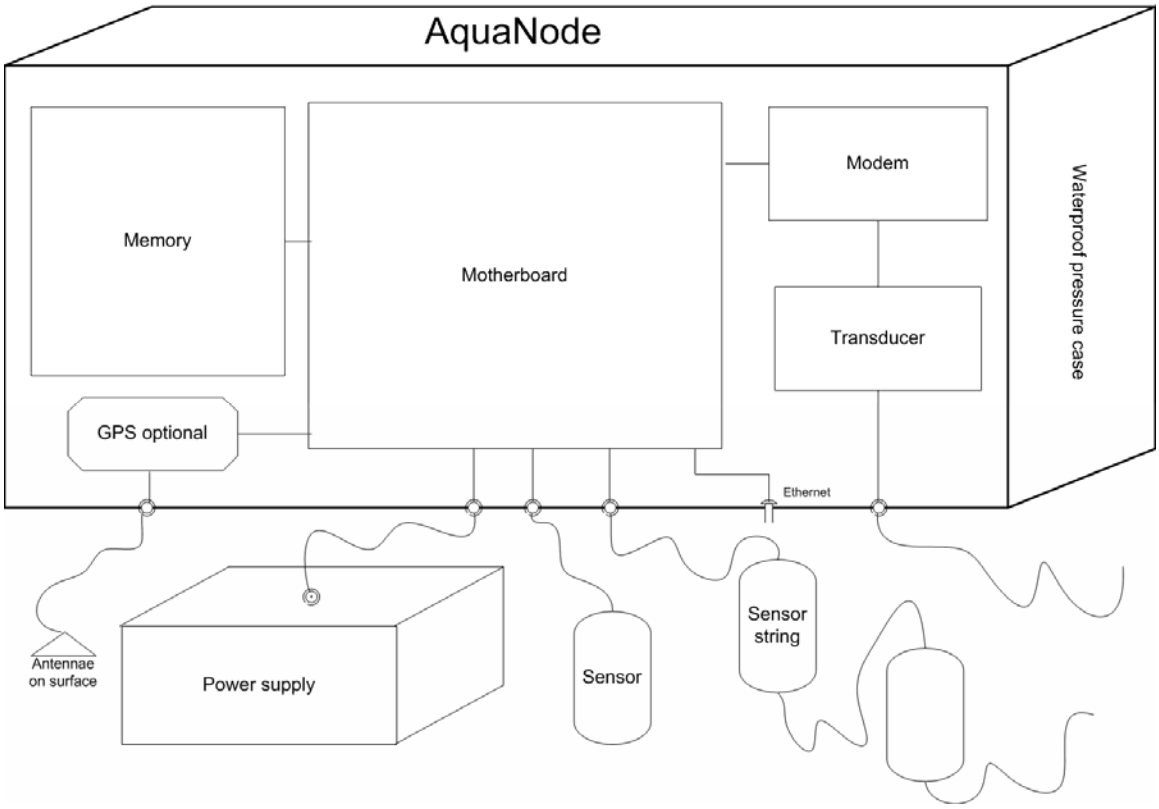
Table 1
Sensor Measured Variables

Core	Desired
PAR – surface	PAR – at depth
UV – surface	UV – at depth
Meteorological variables	CO_2, pH
Water temperature	PAM fluorometry
Salinity	Turbidity
Water O_2	Nutrients (N, P)
Pressure	Video
Currents	

The group identified a series of sensor development research and development priorities. These included general issues of power, fouling, and data transmission and communications (including underwater wireless), and further development and refinement of specific technologies such as underwater video, CO_2 measurement, and PAM fluorometry. It was also recognized that development of a cost-effective platform and use of common instruments would have a number of advantages, including potential cost savings and data consistency. A variety of measures of performance of instruments was identified, and there was general agreement that instruments needed to be accurate, power-efficient, reasonable cost and robust enough for long (months or more) field deployments.

Plan for implementation of a scalable coral reef sensor network:

The group developed a schematic representation of the hardware and software necessary to implement a coral reef sensor network. The hardware would be based on a standard configuration tentatively called the 'aquanode'. This would be a water proof robust container of electronics that could have a range of inputs such as multiple sensors, external power, GPS antennae as well as act as a transmitter using wireless transmission. Both wireless and wired modes of aquanodes were considered, and the group placed priority on development of underwater wireless capability for use in the sensor network.



The software required to operate the hardware would require the following properties: real time OS, reliable OS language, support one of java, C or MicroJava, energy efficient and using TCP/IP.

The group laid out a series of goals over a five-year period to serve as a "roadmap" for implementation of a scalable coral-reef sensor network. Initially, the network could contain four sites: Great Barrier Reef, Florida Keys, the Kenting Coral Reef ILTER site, and the Moorea Coral Reef LTER site, with later addition of some or all of the World Bank Centers of Excellence sites (MesoAmerica, East Africa, Philippines, Great Barrier Reef). Specific goals are as follows (persons leading each effort are indicated in parentheses):

YEAR 1 (March 2005-March 2006

One month:

(1) Produce report of the workshop (Holbrook, Kininmonth)
(2) Data standards group established (Bainbridge, McIntyre, Washburn, Durnota)
(3) Data management group established (Bainbridge)
(4) Platform group formed (Rodoplu)
(5) Liaison group formed – representatives of each site (Holbrook, Kininmonth to coordinate)

Six months:

(1) Data management group meets (Bainbridge)
(2) Establish web presence for the group (CoralReefNet)
(3) Acoustic modem prototype developed (Kastner, Iltis)

YEAR 2:

(1) Standards document produced (data QA/QC)
(2) ORB, SRB (Atkinson, McMullen, Pailthorpe)
(3) MAC/topology control, DLL (Rodoplu, Iltis)
(4) Application layer demo (Durnota)
(5) Portal (McMullen)
(6) UW video (Fujikawa)
(7) Group meets

YEAR 3:

(1) Standardized Data Delivery Method established

YEAR 4:

(1) Aquanode mass produced
(2) Group meets

YEAR 5:

(1) An operational sensor network for four sites that are global, networked nodes producing data that are integrated and archived. Conceptually these nodes should support the LTER science.

Table 2
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