AUTONOMOUS SENSORS FOR MARINE PROTECTED AREA MONITORING

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1. INTRODUCTION AND OBJECTIVE

Newly designated marine protected areas (MPA's) designated for California's coastal region are a bold step forward in protecting and restoring the habitat and protecting species, however they are sometimes viewed with some skepticism by the general public. The impact of these areas is of great concern to the coastal communities, tourism as well as the health of the marine environment. Such protections have been shown to be successful elsewhere, improving populations of marine fish and invertebrates [1,2] and acting as seed areas acting to rejuvenate populations in surrounding regions [3]. In order to evaluate the impact of the California system as well as to manage and adapt to optimize the system, monitoring will be a crucial component. Our objective is to develop an innovative monitoring system to respond to the challenges presented by these innovative environmental protections. Challenges presented by the monitoring of MPA's include the broad range of desired information, high temporal and spatial resolution and the long term monitoring needed to assess impacts. Some methods of data collection, e.g. diver surveys, provide high levels of information at high resolution but are synaptic by nature and not well suited for persistent monitoring over long time scales (months to years). The use of autonomous sensor platforms is well suited for the challenges presented, but the systems presently available are expensive and may not be well suited for many of the environmentally challenging areas that need to be covered. These areas include shallow regions within or near the surf zone and areas near or within kelp forest. Further, some regions within the MPA's may be too dangerous or ill suited for the use of divers because of currents, kelp, wave action and sharks. Our goal is to provide new methods to collect the needed data by developing smaller, lower cost, autonomous platforms or vessels than are currently available, to develop new software algorithms for adaptable deployment strategies and to develop or adapt sensors for these platforms to create a highly adaptable and versatile marine sampling architecture.

2. MOBILE AUTONOMOUS SENSOR PLATFORM

A first stage prototype sensor platform previously developed to carry a downward looking hyper-spectral sensor provides the groundwork for the next generation development. The platform control electronics, diagram in Figure 1, are designed for low power and high flexibility. Custom designed micro-thrusters provide efficient control of platform position, course and speed. Navigational sensors include a tilt-compensated digital compass, three-dimensional inertial sensors and global positioning system (GPS). Communications systems employ either 900 MHz for shorter range or 27 MHz for longer range communication of data, facilitating communication between sensor nodes for adaptive or optimal sensor network strategies or communication of sensor status, position or data to a central node or shore-based station. This prototype development was designed for surface operation thus eliminating the need for active buoyancy control and facilitating continuous radio frequency communication including GPS. Further development specific to MPA monitoring needs to be adaptive to the required measurements. The prototype backbone can be applied to subsurface sensors as needed.

The first stage prototype was developed for deployment within region of Monterey Bay. It was designed with sufficient maximum speed for maintaining position once deployed or adjusting position in response to analyses of data in real time. A preliminary deployment has verified the design concept demonstrating control of heading and top speed as designed. Data are presented that demonstrate the effectiveness of the navigational control algorithm and structure and electronics. Initial results provide real data for estimating power budget in actual at sea conditions. These results will guide the next generation development of more versatile sensors for practical monitoring applications.

3. SECOND GENERATION PROTOTYPE FOR MPA MONITORING

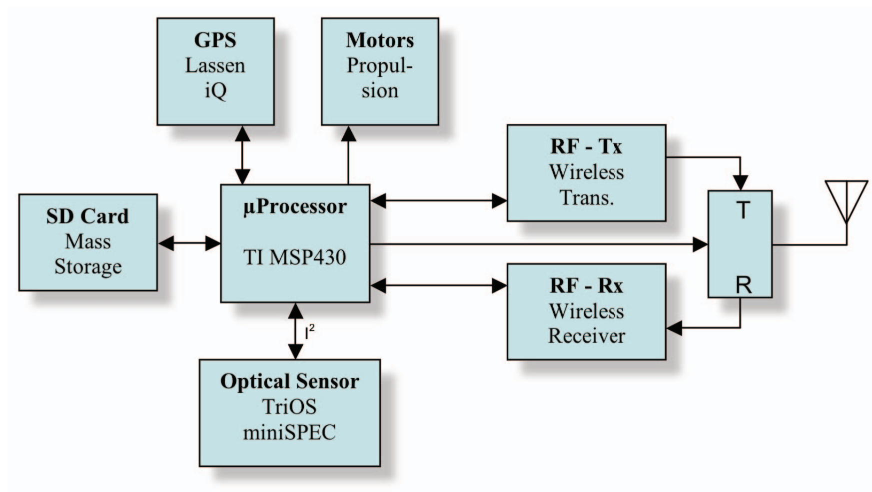

Figure 1. System electronics block diagram

While the advantages for sampling strategies are general and adaptable, a specific sensor deployment pertaining to MPA monitoring is addressed. The key sensor is active acoustic and the target attribute of ecosystem health is fish population throughout the water column. Active acoustic methods have previously been demonstrated effective for estimating fish populations, e.g., [4,5]. For this sensor, the sensor platform is surface-based. This facilitates simplicity of design, low cost and ease of communications including GPS. Using a network of sensor nodes, each providing continuous acoustic survey, a region of interest is mapped out. By surveying regions both inside and outside the protected area boundaries we enable quantifiable assessment of protection impact and a method to assess effects of changes of protected area parameters such as area size separation and degree of regulation restriction.

4. CONCLUSIONS

Results demonstrate innovative development in sampling strategies for marine protected areas. These developments provide a strategy for obtaining higher temporal and spatial resolution of acoustic survey data at a lower cost and with greater flexibility than previously obtainable. Prototype versions of the small autonomous surface vehicles as sensor platforms have been developed and tested. Preliminary results suggest the effectiveness of a control algorithm for navigation for acoustic surveys in real ocean conditions and provide data for estimating power budget constraints. Results demonstrate applicability of a sensor network based on this platform for monitoring of MPA's and assessment of MPA effectiveness for the California coastal region.

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