Autonomous Vessels for International Polar Year Studies in the Ross Sea, Antarctica

OBJECTIVE 1: AIR-SEA INTERACTION – HEAT & SALT FLUX

The International Polar Year physical oceanography program SASSI, Synoptic Antarctic Shelf–Slope Interactions Study, involves around monitoring production of Antarctic bottom water via heat and salt fluxes over the continental shelf involved with ice production and export. Ice production occurs principally at the Mertz, Terra Nova, and McMurdo Polynyas. The Terra Nova Bay polynya has the simplest conformation, and a tractable size (order 50km), which make it the easiest to monitor. Measurements by SASSI ship transects and moorings will provide point data in the water column. These data would be amplified if the spatial extent of data could also be monitored by autonomous vehicles with hydrographic sensors.

Abstract

Use of several types of autonomous vehicles are discussed as part of a proposed collaborative International Polar Year (IPY) program to monitor dynamics in the Western Ross Sea, Antarctica, from 2007-2009. IPY studies in the Ross Sea will focus on monitoring brine production at the Terra Nova Bay, Ross Sea, and McMurdo polynyas resulting from ice production and export from these areas. A second objective is to monitor off-shelf transport of brine and associated carbon and nutrients to assess its’ contribution to the production of Antarctic Bottom Water. Understanding the contribution of lower salinity waters formed by melting of the Ross Ice Shelf is also critical. IPY plans for monitoring Ross Sea ocean dynamics from ship transects and current meter moorings can use autonomous vehicles to abet time-space monitoring of the frequently event-based dynamics at the Ross Sea polynyas. Capabilities for AUVs to collect water samples for gas and radiotracer tracers are also possible in terms of available and developing technology. Finally, multibeam mapping can be used to contribute to the recently initiated International Bathymetric Charting of the Southern Ocean program (IBCSO), which will be ongoing during the IPY period.

METHODS: AUTONOMOUS VEHICLE MEASUREMENTS

AUVs such as the Scripps Bluefin can measure hydrography and multi-beam bathymetry on transects of 10km for periods of a day or more before battery servicing. The less expensive FETCH can map hydrography over a polynya scale (50km) before battery servicing.

Giders, eg SeaGlider. They are used to collect continuous data on temperature and salinity in the water column over periods of months.

The FETCH Autonomous Underwater Vehicle has been used extensively in the Southern Ocean for biological studies around Palmer Peninsula.

OBJECTIVE 2: SEA ICE PRODUCTION AND THICKNESS

Measurements of sea ice thickness are closely related to heat and salt fluxes. Upward-looking AUV sensors can provide sea ice thickness in conjunction with satellite data to improve estimates of sea ice production and melting during seasonal dynamics.

OBJECTIVE 3: BIOGEOCHEMICAL FLUXES

A third part of the IPY SASSI effort is use of autonomous vehicles to monitor integrated biogeochemical fluxes from shelf waters to the slope and deep sea. Fluorometers for chlorophyll measurement have already been developed and tested for Giders and AUVs like FETCH. Fluorometer deployment from ASVs is simple, and provides carbon estimates. Water samplers for AUVs/ASVs are under development for estimation of iron and other nutrient elements.

OBJECTIVE 4: BATHYMETRIC CHARTING

Improving bathymetric charts is the focus of the International Bathymetric Charting of the Southern Ocean project. Many charts are long out of date, and new data is needed. As a priority for the future, ASVs can be equipped to map shallow, nearshore waters hazardous to ships, and small multibeam AUVs could be used for data under the Ross Ice Shelf.

SUMMARY AND CONCLUSIONS

Syntopic long-term measurements of Southern Ocean dynamics are critical for understanding physical and biological processes around Antarctica, as well as the Southern Ocean’s role in global climate dynamics. Funding for ships is limited, and greater data collection would be facilitated by use of autonomous vehicles. Underwater vehicles remain expensive, but cheaper ($50k) autonomous surface vehicles can provide twice-daily hydrographic and atmospheric data for months without service. Existing PICOSATs can provide cost communications, and use of recent advanced wireless communications will provide extended range, increased bandwidth, and accommodate error-prone transmission conditions.

METHODS: ADVANCED WIRELESS AND PICOSAT COMMUNICATIONS

Advanced Wireless Communications Protocols. Wireless technologies are developing rapidly to standardize 802.16 protocols. These include Delay-Tolerant Networking (DTN) wireless protocols for areas with unreliable or interrupted communications. Protocol extensions to DTN also improve ASV communications by providing order of magnitude increases in both bandwidth and distance.

PICOSAT Communications Capabilities. Small student-built communications satellites are already used for polar data communications. Additional PICOSATs are available, easily equipped with new DTN and related software that increase data communication periods, and provide additional bandwidth capacity.

MIT has built and demonstrated a mini-armada of inexpensive SCOUT “Robo-kayaks” which carry GPS-directed motors, and variable arrays of ocean sensors below.