Biological Studies

Kerstin Cullen and Megan Cimino collect zooplankton.

Within the ocean model was an "NPZ" ecosystem model to predict Nutrients, Phytoplankton and Zooplankton. To calibrate the model, researchers used water samples and net tows to collect reference samples of nutrients (nitrate, phosphate and silicate), phytoplankton and zooplankton. They also conducted bird and mammal observations to help evaluate the potential impact of an oil spill.

Trajectories of two Argosphere surface drifters released in Prince William Sound during the Field Experiment continue to update their positions in real-time.

What's Next

The 2009 Field Experiment has officially ended, but two Argosphere surface drifters have continued to report data as they ride the current out of PWS and into Cook Inlet (above).

The AOOS field team, the data team in Fairbanks, and modelers in California will spend the next several months analyzing the data acquired during this unprecedented field exercise. The team will prepare journal papers and symposium presentations, and meet with stakeholder groups to help decide what pieces of the Prince William Sound observing system structure are critical to meeting future needs. Stay tuned…

Many Thanks

Dr. Carl Schoch and Dr. Yi Chao provided the text for this special AOOS Update. Figures were provided by Dr. Chao and his colleagues at NASA's Jet Propulsion Lab.

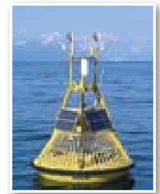
Thanks to Leslie Abramson, Mark Halverson, Deborah Mercy, Scott Pegau, Capt. Dave Rentel and Hank Stascewich for the photos of the Field Experiment in this newsletter.

Leslie Abramson and Jim Pettigrew with one of many drifters deployed in the Sound during the Field Experiment.

The HF Radar team of Hank Stascewich, Steve Sweet, Rachel Potter and Mark Johnson takes a break from setting up the instruments.

Instruments at Work

The 2009 Field Experiment assembled more than 65 scientists and a multitude of field assistants who braved rough seas, rain and wind to deploy, redeploy, install, and repair various instruments used to collect data. Some data are used to improve model forecasts while other data are used to evaluate the forecast skill. A sampling of the instruments used in the Field Experiment appears below.

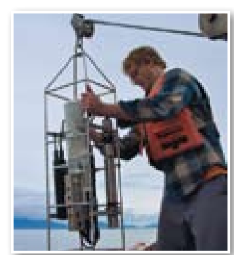


NDBC Buoys

National Data Buoy Center (NDBC) weather buoys carry instruments that measure wind speed and direction, air temperature, air pressure, and sea surface temperature. Data are used to predict ocean circulation.

REMUS (top) and Slocum Glider (bottom)

Autonomous underwater vehicles (AUVs) like the REMUS and the Slocum gliders can collect nearly continuous measurements of temperature and salinity. These measurements contribute to a regional scale view of water column structure to 200m depth, and help evaluate and improve ROMS performance.

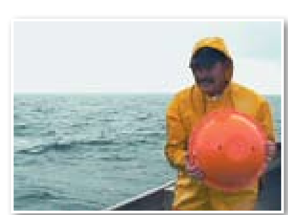


Ship CTD

A Conductivity-Temperature-Depth (CTD) sensor is the primary tool for determining essential physical properties of sea water. It provides profile measurements of water column temperature, salinity, and density. The three vessels chartered for the Field Experiment was fitted with a CTD sensor to measure the salinity and temperature of surface water as they traveled the Sound.

HF Radar

High Frequency (HF) radar uses Doppler frequency shifts to determine the speed of surface currents. HF radar stations can transmit and receive radio waves traveling as far as 60km (37 miles) across the Sound.



Drifting Buoys

These instruments make direct measurements of pathways taken by passive tracers such as spilled oil. The field team collected nearly 100 tracks from more than 40 drifting buoys that were deployed and redeployed during the Field Experiment.

Visit www.aoos.org/fieldexp/ to learn more about the 2009 Field Experiment. Read the blog, see pictures and video, and learn more about the tools and methods the team used to improve the ability to forecast changes in Alaska's oceans.

ALASKA OCEAN OBSERVING SYSTEM

AOOS

The Eye on Alaska's Coasts and Oceans

www.aoos.org

Update
Summer 2009

Sound Predictions 2009

A demonstration of the Alaska Ocean Observing System in Prince William Sound

Scott Pegau ventures ashore to retrieve a wayward drifter during the Field Experiment.

AOOS provides access to real-time weather and ocean observations as well as model generated forecasts for Prince William Sound (PWS) and other coastal Alaska regions from one data portal, www.aoos.org.

In July and August 2009, AOOS partnered with NASA, the Oil Spill Recovery Institute, the University of Alaska and many other local and national organizations to sponsor a field experiment in the Sound. The objective was to test the accuracy of model forecasts and demonstrate the utility of an ocean observing system for oil spill response, search and rescue, and fishery management.

Developing the observing infrastructure in PWS, the statewide data management system, and forecast models took five years to complete and together with the Field Experiment brought together more than 65 scientists from eight states.

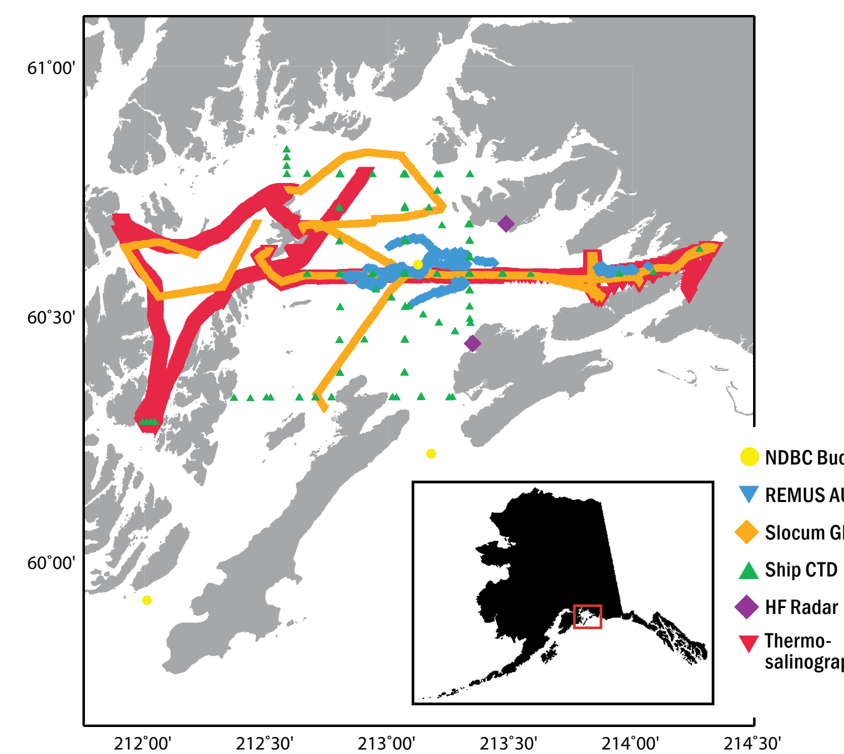
Observing System Components

The ocean observing system in PWS includes a dense spatial array of telemetered weather stations, wave gages and ocean sensors, including salinity and temperature recorders, current velocity profilers, and sensors to measure chlorophyll fluorescence. Instruments were used to develop and test the performance of numerical models for forecasting weather, waves, and ocean conditions.

This experiment was designed to evaluate how well the models could predict actual conditions. The experiment supplemented the fixed array of AOOS instruments with radar surface current measurements, vessel mounted instruments for measuring temperature and salinity, underwater drones to profile the water column, and drifting buoys to measure current direction and velocity.

The experiment focused on validating models of surface and deeper currents in the central basin. The field team collected nearly 100 tracks of drifting buoys during a two week period that spanned spring and neap tides. Most drifter deployments occurred within the field of view of radar surface current measurements. Additional deployments occurred around the perimeter of the Sound to validate the velocity of surface currents forced mostly by fresh water runoff from melting snow fields and glaciers.

Participants also had opportunities to test new sensors and platforms, and to evaluate models in the context of other questions or applications such as fishery management, oil spill response, and search and rescue.



Right: Locations of in situ sensors and platforms during the two-week field experiment.

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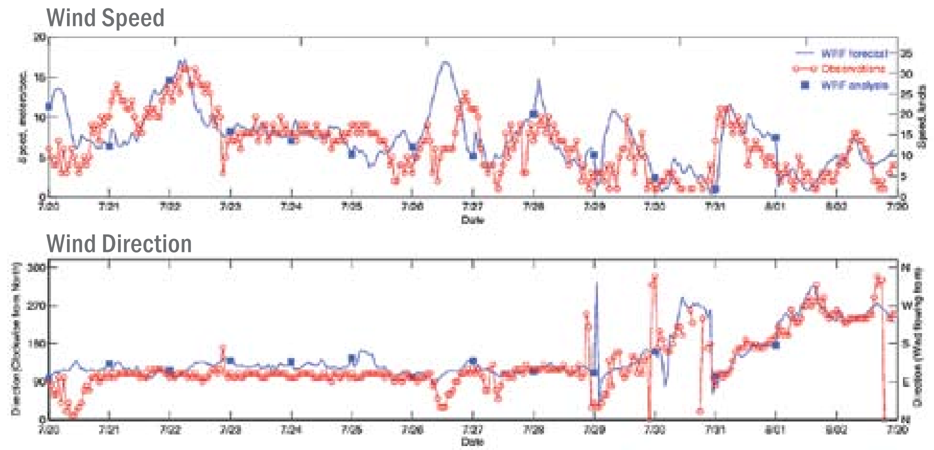
Right: Time series of wind speed (top) and direction (bottom) during the two-week field experiment as measured (red circles and line) and predicted by WRF (blue square is nowcast; blue line is hourly forecast) at the NDBC buoy 46060 location in the central Sound. This comparison shows that the WRF model realistically predicts wind speed and direction.

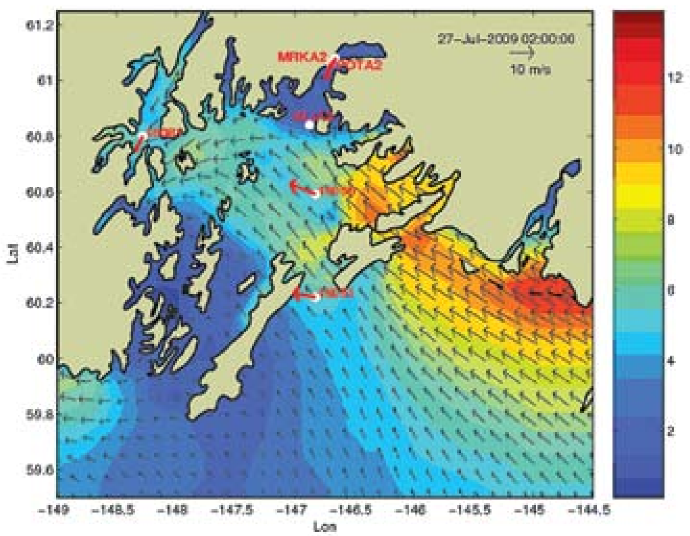


Weather Forecasting

How strong is the wind blowing in the central Sound? How much heat is exchanged between the ocean and atmosphere? What is the rainfall around PWS? These questions are being addressed in real-time by the Weather and Research Forecasting (WRF) model operated by the Alaska Experimental Forecast Facility at the University of Alaska Anchorage.

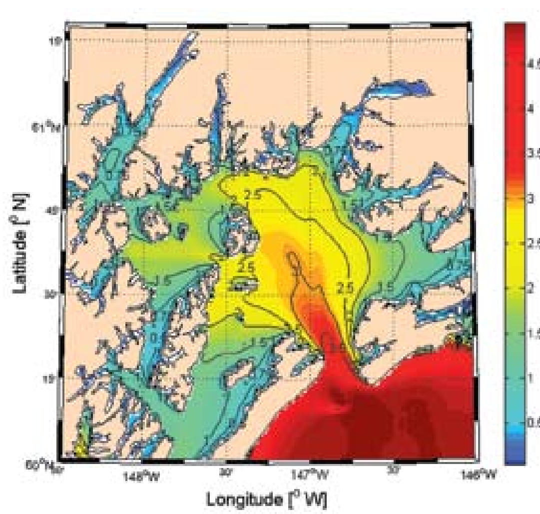
Weather observations to validate the forecasts were provided by eight land-based SnoTel weather stations telemetered via the Alaska Meteor Burst Communication System as well as five buoy mounted and three land-based weather stations operated by the National Data Buoy Center (NDBC).

Right: This weather map, updated hourly during the field experiment, shows surface winds predicted by the WRF model (black arrow and color contours), and measured by three ocean buoys and three shore stations (red arrows). The weather map at 2:00 GMT on July 27, 2009 shows a strong southeasterly wind in the central Sound and a moderate easterly wind in the northern Sound.

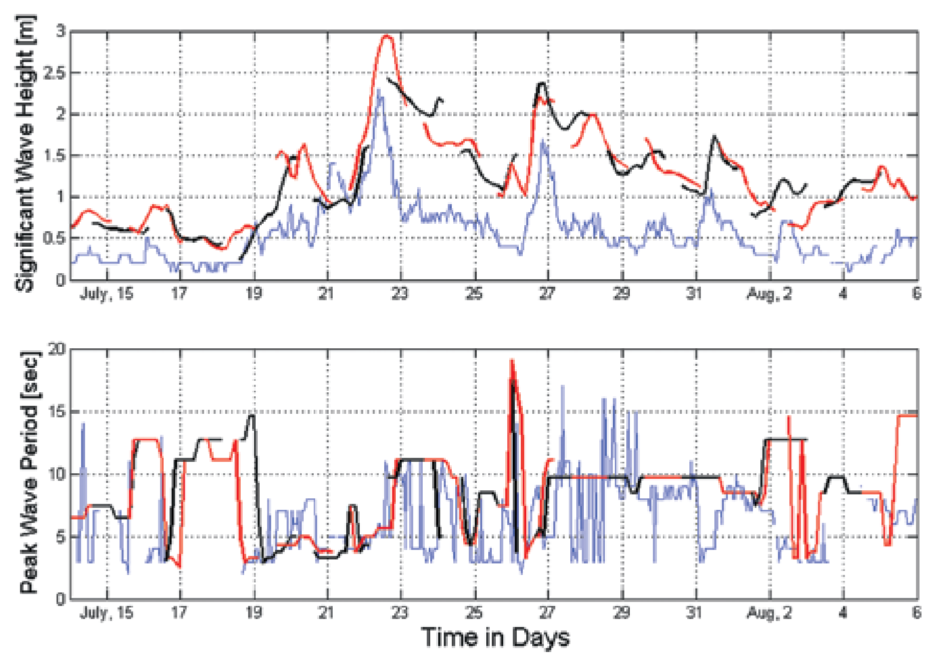


Wave Forecasting

Wave forecasts are made using the Simulated Waves in the Nearshore (SWAN) model developed at Texas A&M University. The SWAN model uses data collected from three NDBC buoys for ongoing validation in PWS, as well as data from the Cape Suckling and Cape Cleare buoys to validate Gulf of Alaska waves. The model tracks and predicts wave heights every 12 hours. New technology is also being developed to allow for real time wave forecasts that are nearly exact for up to six hours at a time.



Contour map of predicted significant wave heights on July 22, 2009 at 06:00 in PWS. Numbers represent wave height in meters.



Comparison of measured significant wave height (top panel) and peak wave period (bottom panel) at Buoy 46060 with model predictions. Blue curve represents measured data. Alternate red and black lines represent 36-hour model forecasts made daily from July 14–August 6, 2009.

The 2009 Field Experiment in Prince William Sound used some of the most sophisticated technology available and the expertise of a team of scientists from across Alaska and the nation.

Ocean Forecasting

Forecasts of ocean conditions were made using the Regional Ocean Modeling System (ROMS) developed for PWS by the University of California at Los Angeles and the NASA/Caltech Jet Propulsion Laboratory. Ocean circulation forecasts are based upon a nested series of three spatial domains and grid sizes encompassing the whole Gulf of Alaska (11 km grid), the southcentral coast of Alaska (4 km grid), and PWS (1.2 km grid).

The state of the art in forecasting ocean conditions is to incorporate real time data into model simulations to enable better nowcasts and forecasts. Forecasting errors are estimated by making multiple ROMS forecasts using slightly different initial conditions.

Surface current measurements from the high frequency (HF) radar are used in real time by ROMS, which can then make realistic forecasts for PWS. During the first week of the experiment, easterly winds and northward surface currents dominated the central Sound (right, top). The wind weakened during the second week of the field experiment, and the central PWS circulation was characterized by a cyclonic (or counter-clockwise) eddy very similar to that seen during the 2004 field experiment (right, bottom).

Drifter trajectories as measured from release time on July 25 at 02 GMT to recovery time on July 28 at 02 GMT (above, left) and as predicted by a cluster of ensemble ROMS forecasts (above, right).

It is very challenging to use drifters to evaluate model forecasts. As this figure shows, trajectories can vary significantly from one prediction to the next by using slightly different initial conditions. To capture this uncertainty, multiple ROMS forecasts are made daily. The observed drifter trajectory can then be compared to those predicted by the ROMS ensemble forecasts. The difference among these ensemble forecasts represents the uncertainty of the ROMS forecast. This uncertainty can be attributed to our ability to forecast the weather, our knowledge of fresh-water runoff from rivers and glaciers, a limited number of instruments deployed, and data processing errors associated with HF radar.

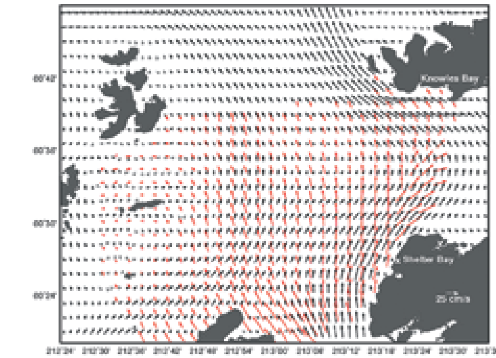
How Did We Do?

Our demonstration of an ocean observing system in Prince William Sound was a success in terms of collecting field observations and generating model forecasts of weather, wave and ocean conditions and providing these in near real-time through the Internet. The experiment was qualitatively successful in also demonstrating the benefits of an ocean observing system for boaters, oil spill response, and search and rescue operations.

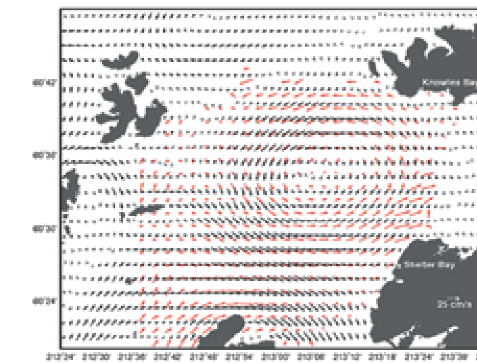
The utility of the system for fishery management will be evaluated as we quantitatively evaluate the model forecasts over the next few months. We will present our results at the January 2010 Alaska Marine Science Symposium.

This experiment used some of the most sophisticated technology available and the expertise of a team of scientists from across Alaska and the nation. The organizational and logistical obstacles we encountered were formidable, due to the extreme remoteness of the study area and the distributed nature of the resources focused on PWS for two weeks. Planning took more than two years; monthly teleconferences for all the participants began six months before the experiment and continued twice daily during the experiment.

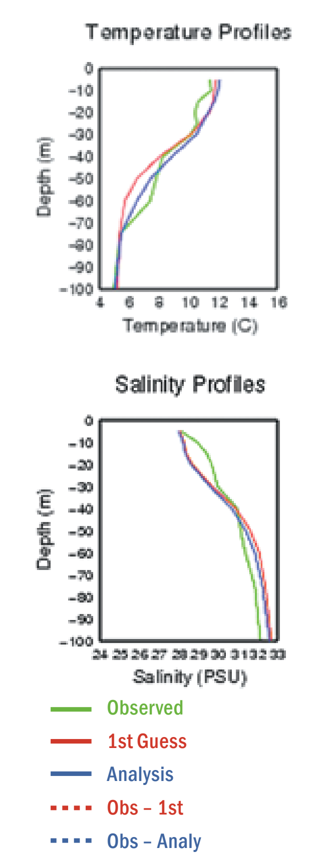
Operating an ocean observing system in the harsh environment of Prince William Sound is challenging. Field teams encountered unseasonably stormy weather as well as equipment malfunctions and logistical hurdles. Modeling teams had data transport issues from remote observational platforms and gaps in some crucial datasets. However, our adaptive design and very resourceful personnel successfully met these challenges.



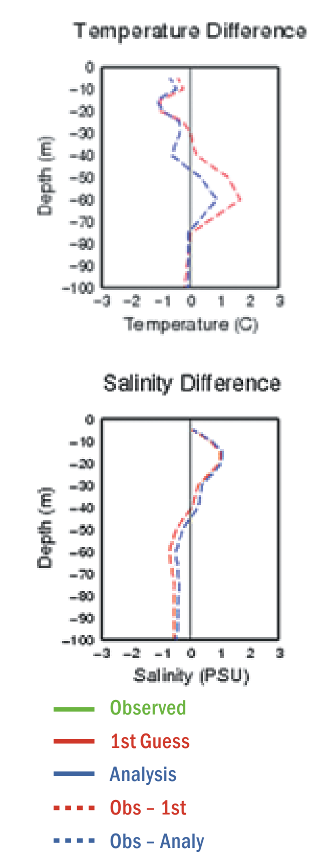
Surface current map as measured by the HF radar (red arrow) and predicted by the 3D ROMS circulation model (black arrow) during the first week of the field experiment (July 18 – 21).



Surface current map as measured by the HF radar (red arrow) and predicted by the 3D ROMS circulation model (black arrow) during the second week of the field experiment (July 31 – Aug 3).



Vertical profiles of temperature and salinity as measured from a ship and the profiles predicted by ROMS at a location near the Hinchinbrook Entrance on July 28. The major feature of the temperature and salinity is reproduced by the ROMS model.



Vertical distributions of temperature and salinity errors (i.e., the difference between observational data and the ROMS nowcast) show the positive impact of assimilating these particular data: ROMS forecast error with these data included (blue) is significantly smaller than the error without this data (red). The impact of salinity data is somewhat smaller than the impact of temperature. This suggests that there is room for improvement in representing the salinity and freshwater process in the ROMS model.