

ARGOS FORUM # 73

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TRACKING POLLUTION WITH ARGOS

ENVIRONMENTAL MONITORING



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Photo courtesy of Koki Nishizawa

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European Commission Directorate General for Maritime Affairs and Fisheries.

As the planet's human population rises we are beginning to realize the limits of what the land can provide and are looking to see what the oceans can offer to humanity in terms of food, energy, minerals and medicine.

Yet unleashing the potential of the ocean whilst ensuring that an increasing human presence does not harm the prospects of future generations to enjoy these benefits will require a deeper understanding than we have now.

This understanding will not only require more observations, it will require smarter observations; observations of parts of the ocean that are deeper or further from shore than have hitherto been explored or observations that reach the analyst faster, with less operator intervention.

The value of observations of the movements of marine species was demonstrated earlier this year.

The European Commission had to decide what to do about imports of fish from the Pacific following the tragic accident at Fukushima. Levels of radioactivity in the sea outside the plant were high in the aftermath of the accident but mathematical simulations indicated that the radionuclides would progressively dilute as they were carried northwards and along the Kuroshyo current. Experts felt that the levels of radioactivity outside the vicinity of the stricken reactor would not be high enough to contaminate fish significantly but that predatory fish such as albacore or skipjack might feed in the area and be caught outside it. Confidence in calculations to estimate the likelihood of contamination of these fish being above safety levels depends on careful comparison with observations of movements of water and fish.

Therefore the technologies that are illustrated in this ArgosForum not only help the research community understand the mysteries of the ocean but are also vital tools in protecting the health of consumers.

All ARGOS publications are available at:
www.argos-system.org

IN THE AFTERMATH OF THE GREAT TSUNAMI: TRACKING THE CHAOTIC MOVEMENT OF MARINE DEBRIS

By
Koki Nishizawa,
the Sustainability Research Institute,
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After the Great Earthquake on March 11, 2011, 3 million tons of debris were washed out from the coastal region of Tohoku Japan and are currently drifting in the Pacific Ocean. Until April 14, 2011, the debris was visible by satellite, but over time, the pieces of marine debris have broken into smaller bits and sunk, making it difficult to observe where the debris is heading. At the Sustainability Research Institute, Tottori University of Environmental Studies, Japan, a team of scientists are conducting research on the Tsunami debris from the Great Earthquake using an Argos transmitter placed into a plastic bottle. The plastic bottle will provide a realistic idea of how tsunami debris travels on currents and wind and offer in situ data to help scientists understand the chaotic movement of marine debris, as Koki Nishizawa explains.

Researchers at the International Pacific Research Center, University of Hawaii at Manoa, have developed a model that projects where this tsunami debris may head in the coming years. They predict that it will arrive at the coast of Hawaii in 2012, and reach the U.S. West Coast sometime in 2014. Many variables will affect the debris trajectory; it is impossible to accurately predict ocean currents and winds very far into the future. While the model gives a very good idea of where the debris will end up, the data collected by scientists at Tottori University of Environmental Studies using plastic bottles equipped with Argos transmitters provide an original approach to understanding the movement of marine debris.

ARGOS TRANSMITTER – OR TRASH?

Actually, these transmitters were manufactured by Nomad Science, Inc., before the Great Earthquake. The objective of the scientists was to solve the problems caused by the huge amount of solid waste coming to the Sea of Japan Coast from domestic inland areas and foreign countries. But then came the Great Earthquake and tsunami and the research focus was changed.

In June 2011, three Argos transmitters were released from the three worst-hit areas.



The Argos transmitter disguised as an ordinary plastic bottle was designed and developed by Nomad Science. The transmitters were deployed in the aftermath of the Great Earthquake and Tsunami.

Trash—or Argos transmitter? This plastic bottle looks and behaves like trash, but transmits valuable data on its movements to scientists at Tottori University.

WHERE DOES THE DEBRIS GO?

The yellow marks in Figure 1 show the positions of the first transmitter, as it floated in the Pacific Ocean from June 3rd, 2011, to August 31st, 2011. This transmitter was released at a location 20 km off the coast of Miyako City, Iwate Prefecture on June 3rd. Near Erimomisaki in Hokkaido, it shifted and floated Northeast. Its position as of August 31st was 1200 km away from the release point.

This transmitter was released from 20km off the coast of Souma City, Fukushima Prefecture on June 19th. It arrived at Natori City in a month.

WHY MOVEMENT IS DIFFICULT TO PREDICT

From these results, it is evident that marine debris moves in chaotic patterns. One of the reasons is that marine debris is affected by not only ocean currents,



Dr. Koki Nishizawa releases a plastic bottle equipped with Argos transmitter into the Pacific Ocean.

The red marks in Figure 1 show the positions of the second transmitter, from June 11th to August 31st. This transmitter was released from 20 km off the coast of Kesenuma City, Miyagi Prefecture on June 11th. It has been caught in currents and is moving around within 400 km from the release point.

The blue marks show positions of the third transmitter from June 19th to July 19th.

but also wind. While model projections provide a good idea of how the tsunami debris may travel in the ocean, at Tottori University of Environmental Studies, we hope the results of our experiment will provide additional data to take into consideration when predicting marine debris movement. It is necessary to incorporate simulation results with tracking data to complement each other.

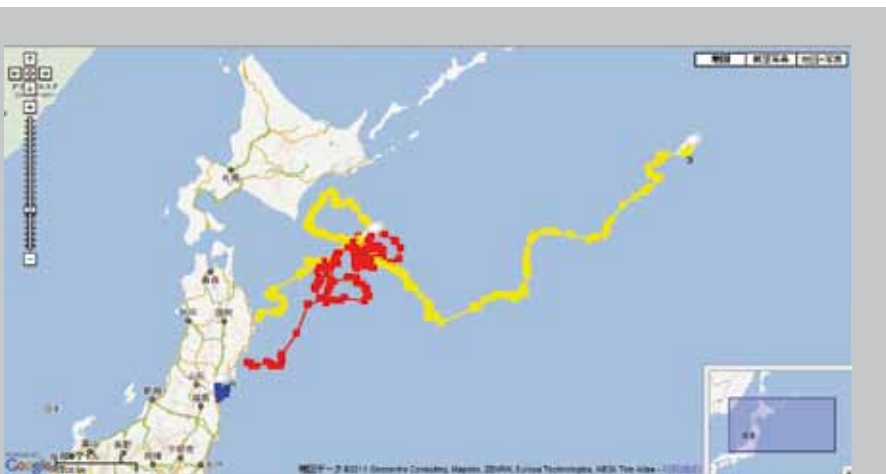


Figure 1: The trajectories of three Argos-equipped plastic bottles deployed in the Pacific Ocean illustrate the diversity of movement of marine debris. The first bottle (yellow track) floated 1200 km over a three-month time period. The second (red track) got caught in currents only 400 km from its release point. The third (blue track) floated a month in the ocean before returning to shore.



Koki Nishizawa

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Koki Nishizawa studied at The University of Tokyo, where he obtained his Doctor's degree in 2006. After working at National Institute of Advanced Industrial Science and Technology (AIST) and Tohoku University, he joined the Department of Information Systems, Faculty of Environmental and Information Studies, Tottori University of Environmental Studies, where he has investigated computer science and marine debris.

OIL AND SEABIRDS DON'T MIX: NEW TECHNIQUE FOR TRACKING WESTERN GREBES AFTER OIL SPILLS

By

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A pair of Western Grebes recovering in an indoor pool at the University of California Davis, after being implanted with satellite transmitters. The pair will test a tracking technique that will hopefully make it possible to track Grebes after rehabilitation from injuries resulting from oil spills.

The Western Grebe is an aquatic bird that seems more like a figment of the imagination than a real bird. They are strikingly beautiful, almost ethereal, in a sense. Mostly a black and white bird, the features of the Western Grebe (and the related species, Clark's Grebe) that really stand out are the orange or greenish bill and the deeply crimson red eyes. But the Western Grebe population has declined precipitously over the past decade. While there is no "smoking gun" that fully explains this decline, one possible contributing factor is that Western Grebes often fall victim to marine oil spills in their wintering grounds along the west coast of North America, as Kyra Mills-Parker explains.

Western Grebes have an interesting life history that unfortunately makes them extremely vulnerable to oil spills. First of all, grebes are so tied to the aquatic environment that they are unable to walk well on land, as their legs are so far back in the body. This adaptation makes them perfectly suited for surface swimming and underwater propelling, but makes them extremely awkward on land. Second of all, while breeding occurs in inland lakes in the western half of North America, after breeding, the northern populations migrate to Pacific coastal ocean environments where they spend the winter and early spring (roughly September through April/May).

POOR TIMING FOR WINTER MIGRATION

The migration of the Western Grebe from its breeding to its wintering environment just happens to coincide with the period when the most oil spills occur in California. As oiled wildlife responders, we refer to this time as the "Spill Season" because winter storms and foggy conditions translate to more spills during this time of year. Unfortunately for the Western Grebes, they are flightless after arriving at their ocean wintering grounds, which makes them extremely vulnerable to a spill.

Given the dwindling population and high vulnerability to oil spills, scientists from the Oiled Wildlife Care Network, SeaDoc Society, California Department of Fish and Game - Office of Spill Prevention and Response, and the U.S. Geological Survey decided to collaborate on a study that has several goals in mind, with the ultimate goal of developing a technique that will allow scientists to reliably track Western Grebes after rehabilitation from oil spill impacts.

MONITORING REHABILITATED BIRDS

Substantial amounts of money are spent on oil spill response, including capture and care of impacted wildlife. However, there is ongoing debate (and a dearth of data) about how birds do in the wild once they are released and the one previous study focusing on grebe post-release monitoring was greatly unsuccessful likely due to transmitter attachment technique.

The hope is that this study will provide oiled wildlife responders in California with a technique for monitoring post-rehabilitation survival and movement of grebes impacted by oil spills. In addition, little is known about migration patterns of Western Grebes between their breeding (freshwater) grounds and their wintering (marine) environments, so we hope that this study will be a good step for advancing knowledge regarding migration.

FINDING A TECHNIQUE TO TRACK WESTERN GREBES

When choosing a device that can track a Western Grebe, there are many things that need to be kept in mind.



Photo courtesy of Joseph Gaydos (SeaDoc Society)

Western Grebes are light birds (weighing between 800-1800g), so a heavy device would not be feasible without compromising the survival of these birds. In addition, because grebes fly as well as dive, attaching an Argos satellite transmitter to the back is not a desirable option, as this would add drag in both media.

These were the main considerations for choosing an internal satellite transmitter using a fairly new technique that implants the transmitter inside the body cavity of the bird, with an external percutaneous antenna.

We captured 10 Western Grebes in San Francisco Bay, California in early December 2010. These birds were surgically implanted with satellite transmitters (Argos PTT-100, Microwave Telemetry Inc., Columbia, Maryland, USA). The birds were released in San Francisco Bay one or two days post-surgery, after they were given a thorough health examination by our veterinarians.

Preliminary results show that most of the Western Grebes that we were tracking remained in San Francisco Bay for most of the period. To date, we have two grebes that are still transmitting, one of which remains in San Francisco Bay, and the other

migrated north to Oregon's Upper Klamath Lake (a distance of nearly 635 km), most likely to breed, and returned to San Francisco Bay in November 2011.

PROVIDING IMPORTANT DATA ABOUT MIGRATION

This study has been successful on several counts. First of all, the grebes that were fitted with Argos transmitters all seem to have survived past the time that one would expect them to survive had they exhibited issues with the surgery.

So from a veterinarian point of view, the surgical techniques (and modifications to the first study) that were used appear to be successful. Even though we only had one grebe migrate to its breeding ground, this is the first time that a Western Grebe has been successfully tracked from its wintering to its breeding ground and back again, in itself an important piece of information.

It is our hope that this initial study will provide a stepping stone for future tracking of Western Grebes to better understand the factors that affect the survival of this species when impacted by oil spills.



Kyra Mills-Parker
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Kyra is the Oiled Wildlife Recovery and Transportation Co-Coordinator for the Oiled Wildlife Care Network in California, USA. Raised in Ecuador, Kyra received her graduate degree from the University of California, Irvine, where she studied the feeding behavior of seabirds in the inshore waters of the Galápagos Islands, including the foraging ecology of Galápagos Penguins. Kyra worked as lead seabird biologist on the Farallon Islands, California, between 1999-2001. Since then, Kyra has been involved in a number of different projects as part of PRBO Conservation Science Marine Division and working as staff biologist for the Farallon Institute for Advanced Ecosystem Research.

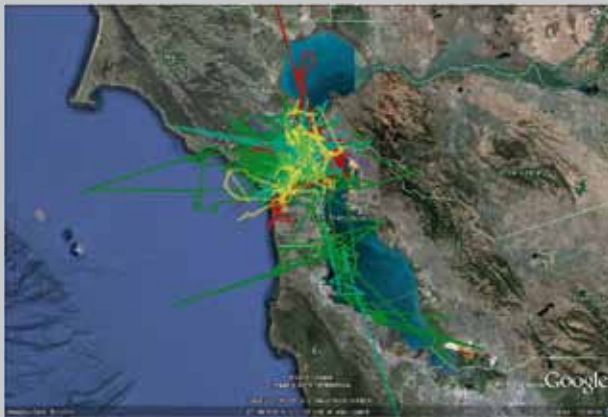
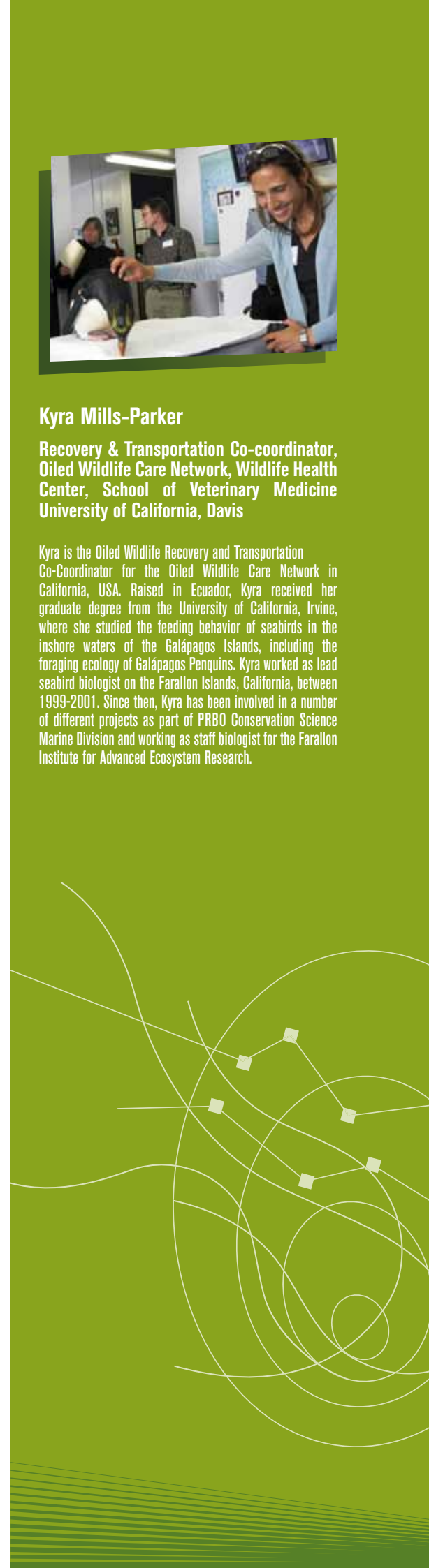


Figure 1: Tracks made by Western Grebes in San Francisco Bay, CA (December 2010-October 2011). Each line of color represents a different bird.



Figure 2: Track path made by the Western Grebe that migrated to Oregon's Upper Klamath Lake.



ARGOS DATA PLAY ROLE IN UNDERS- TANDING THE GREAT GARBAGE PATCH

By

Dr Nikolai Maximenko,
International Pacific Research Center,
School of Ocean and Earth Science and
Technology, University of Hawaii at Manoa

Marine debris is a serious problem. Composed mostly of miniscule pieces of plastic (less than 5 mm), marine debris is extremely harmful to the marine ecosystem, especially when it concentrates in zones referred to as garbage patches. Larger objects can pose serious threats to the safety of navigation. Today, very little is known about where marine debris come from. In this article, adapted from their recent paper, "Pathways of marine debris derived from trajectories of Lagrangian drifters", published in the *Marine Pollution Bulletin* (2011), Dr. Maximenko et al. use for the first time the global set of historical trajectories of Argos drifting buoys deployed in the Surface Velocity Program and Global Drifter Program to study the pathways of marine debris. Their method makes it possible to better understand the movement of marine debris and identify the probable locations of five Marine Garbage Patches in the global oceans today.

Utilized in this work are the trajectories of 10,561 drifters released during the Surface Velocity Program (SVP) that later developed into the Global Drifter Program (GDP). This network of drifting buoys uses the Argos satellite system to transmit data and provide a unique dataset (Niiler, 2001) spanning the period from February 15, 1979 through January 1, 2007 to the present.

STUDYING DRIFTER TRAJECTORIES

A look at the historical data shows that a large number of drifters was deployed at or near the equator in the Pacific Ocean, but these buoys were quickly removed to higher latitudes by the strong wind-driven equatorial divergence. On the contrary, not many drifters were released in the five subtropical regions, but many more were collected there by converging currents. Three of these regions (North Atlantic and eastern North and South Pacific), together with two other areas in the South Atlantic and Indian oceans, where the effect of currents is not so distinct in the unprocessed dataset, are discussed in this paper as the areas of potential aggregation of marine debris.

The distribution of drifters in space depends not only on ocean currents but also on locations and intensity of drifter sources. In the case of marine debris, such sources are not well documented and understood. However, a simple model experiment can be carried out to detect locations of main regions where floating matter accumulates on a long run.

PREDICTING THE LOCATION OF GARBAGE PATCHES

For this study, Dr. Maximenko and his team

developed a probabilistic model to eliminate the bias existing due to the highly heterogeneous distribution of data in space. Possible impact of unknown distribution of sources of debris in the real ocean was mitigated by the model integration over long time periods.

For example, maps of the solution indicate that drifters are quickly (in 1 year) washed away from the equatorial and coastal areas, associated with strong wind-driven upwelling. In three years, tropical and subpolar regions are essentially cleared from the model drifters, most of which are pushed into the five subtropical gyres. In ten years (Figure 1), drifters are redistributed within and between the subtropical gyres to form more compact clusters, centered around 30° latitude. The North and South Pacific clusters are located in eastern parts of corresponding subtropical gyres, while the North and South Atlantic as well as the South Indian cluster are elongated zonally across the entire basins. The dissipation of the model solution in time is remarkably slow; 70% of the tracer remains in the ocean after 10 years of integration.



Marine debris which has washed ashore in Hawaii.
Photo courtesy of Nikolai Maximenko.

Marine debris can pose threats to navigational safety. Photo courtesy of U.S. Navy.

Location of the North Pacific cluster in Figure 1 coincides with the location of the so-called Great Garbage Patch (e.g., Moore et al, 2001). Location of the North Atlantic cluster is also consistent with the observations revealing high concentration of defragmented plastic (Law et al., 2010). To the authors' best knowledge, observations of marine plastic or any other kind of debris in the three other clusters, seen in Figure 1 in the Southern Hemisphere, were completely missing until very recently. As a result of collaborative effort, Dr. M. Eriksen confirmed the South Indian patch in March–April 2010 and South Atlantic patch in September–December 2010, and J. Mackey collected in January 2011 microplastic southeast of Easter Island, at locations close to the ones predicted by Figure 1.

CONCLUSIONS

Results have been presented at the 5th International Marine Debris Conference, and corresponding publications are pending. While the accumulation zone in the South Pacific is the strongest in terms of the intensity and steadiness of the convergence of surface currents, the observed concentration of debris there appears to be much lower than in the North Pacific. This can be explained by the fact that, while in Figure 1 larger oceans receive more debris because of the homogeneous initial condition, in reality majority of plastic, originating from the land, has larger distances to travel. In addition, total consumption of plastic in the more economically developed Northern Hemisphere is expected to be higher.

WHY ARGOS BUOYS PROVIDE SUCH AN INTERESTING DATA SET FOR STUDYING MARINE DEBRIS?

Dynamics of the upper ocean and its mixed layer, where much of marine debris floats, is tremendously complex. Previous studies of marine debris have been based on ship drift data, but the resulting model simulations are noisy because of the low quality of the ship drift data. Dr. Maximenko and his team chose to base their model on the historical trajectories of drifting buoys because the trajectories of the drifting buoys reflect the complexity of the mixed layer. Each drifter is initially comprised of a large 'holey-sock' drogue, attached to the surface float. At calm sea, the drogue can extend to 18 m. Because of the drogue, drifting buoys are subject not only to waves, surface winds and currents, but also deeper ocean circulation. Dr. Maximenko and his team compare between two designs of the drifters (drogued and undrogued) to prove the robustness of the conclusions of this study on the basin scale.

Contrary to what was expected, both drogued and undrogued drifters aggregate in the same areas on the long run. Locations of these convergences in the North Pacific and North Atlantic (Law et al., 2010) also correspond to regions of observed high concentration of defragmented plastic. This suggests remarkable robustness of the pathways of marine debris that still needs to be explained.



Nikolai Maximenko, Ph.D.

Senior Researcher at the International Pacific Research Center (IPRC) and affiliate researcher in the Department of Oceanography, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa.

Dr. Maximenko has been with the IPRC since 1999, coming from the P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences in Moscow. Since obtaining his PhD in 1986 he built up expertise in ocean circulation, starting from the data processing of Eulerian current meters during polygon experiments to measuring currents with Lagrangian drifting buoys to synthesizing in situ and satellite observations as a member of the NASA Ocean Surface Topography and Ocean Salinity Science Teams.

The new technique that he developed in collaboration with Prof. Peter Niiler produced accurate maps of the mean dynamic topography and lead to the discovery of «striations», quasi-zonal jet-like features of so-far not understood physics, covering large areas of the ocean. Dr. Maximenko has been also heading up a team that is developing computer models of ocean currents to chart the likely paths of floating marine debris and where such debris collects in the World Ocean. Using his models, he predicted the presence of 5 major "garbage patches," which now have all been found. Since the March 11, 2011 tsunami in Japan, Maximenko and his team have been using up-to-date information about currents and winds to predict debris trajectories. These predictions are now confirmed by observations and will help to better prepare for the debris impact on Hawaii and the North Pacific coast line.

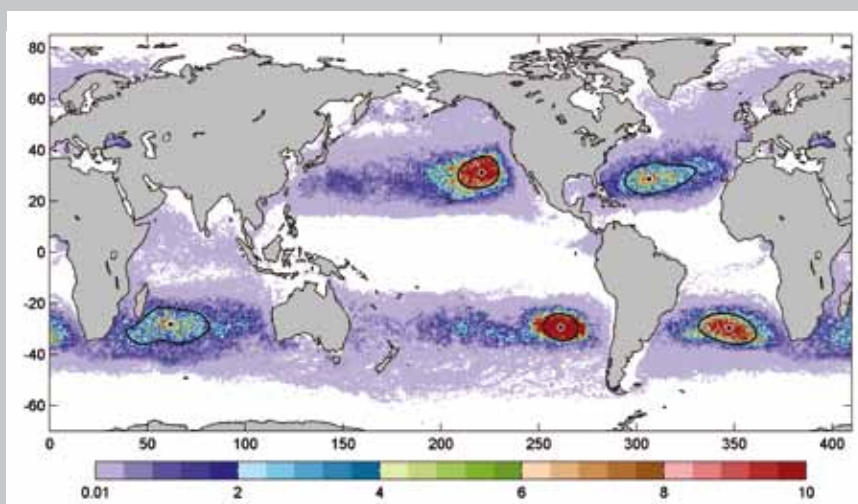


Figure 1: Map of the model solution C after ten years of integration from the initially homogenous state, $C=1$. Dots mark positions of five subtropical maxima, and contours are isopleths, corresponding to halves of these maximum values, calculated after smoothing the solution with the two-dimensional Hanning filter with 1000 km half-widths.

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ARGOS TRACKS GREEN TIDE OFF THE CHINESE COAST

By
Wei Hu, North China Sea
Marine Forecast Center (NMFC)

Coastal phytoplankton blooms are a worldwide problem. The exact cause of “green tide” blooms is still unknown. Most likely green tide results from a combination of factors, including too much nitrogen input (from agriculture and urban discharges), inflow, rise of SST (sea surface temperature) and light reflection on shallow sea bottoms, and slow turnover of marine waters. These conditions can be found in many coasts of the world and green tide blooms have been reported off the coasts of Brittany in France, in certain fjords of Denmark, in the Veerse Meer in the Netherlands, in the lagoon of Venice, and in the Chinese coastal waters of the Yellow Sea. In the Yellow Sea, if the green tide reaches the beach and begins to rot, coastal environments will be seriously damaged. So, it is necessary to forecast the track and landing time of green tide, as Wei Hu, of the North China Sea Marine Forecast Center (NMFC) reports.

A group of researchers in China propose an innovative approach to the problem, involving monitoring and predicting green tide drift with Argos SVP-B drifters (the structure of drifters is shown in Fig. 1). As we know, green tide drifts under the force of sea surface current and the wind. The drifters are also driven by the sea surface current and the wind. By adjusting the size of the hydraulic sail and the length of the cable, we simulate the same proportion of current force to wind force with green tide. After these modifications, the tracks of green tide and drifters are very close. In combination with satellite images, the Argos tracks will provide near real-time in situ observations of the green tide movements, for assimilation into models for disaster prevention and mitigation.

From 2009 to 2011, NMFC deployed Argos drifters to observe the movement of green tide. With the satellite images, locations of big areas of green tide can be found. We reach the location, find the green tide, and deploy the drifters (see image, left). Then, we know the position and track of the green tide by receiving the location of drifters. This approach is useful to enhance the forecasting precision (see Figure 2).

In 2012, NMFC will start a new project, which involves the deployment of 6 Argos buoys and 2 BeiDou drifters off the coast of Qingdao, in the Yellow Sea. The drifters will allow researchers to follow the drift of the tide, to better understand its movements and origin and to set up preventive measures as it approaches coastal regions.

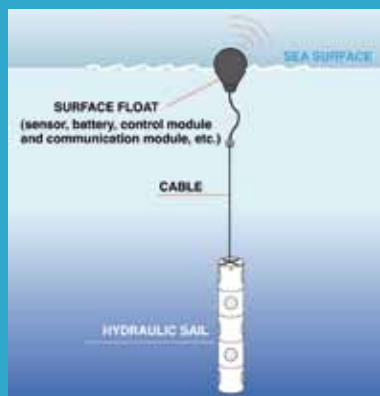


Figure 1: The structure of the drifters used in green tide observation in the Yellow Sea.



Figure 2: The tracking data.

Marlin Yug Argos-3 SVP-B Buoy deployed in Tasman Sea. (photo courtesy J. Fletcher)



THE BENEFITS OF ARGOS-3 FOR THE DATA BUOY COMMUNITY: DBCP Pilot Project Results

By
Michel Guigue,
CLS coordinator for the DBCP
Argos-3 Pilot Project

News on Argos-3:

The third generation Argos system, Argos-3, is operationally available on the METOP-A satellite. More Argos-3 systems are scheduled to be launched in mid-2012, on-board the SARAL and METOP-B satellites.

Composed of over 1250 drifting buoys and 400 moored buoys, the Data Buoy Cooperation Panel (DBCP) network provides measurements such as sea-surface temperature, surface current velocity, air temperature and wind information. Argos-3 functions, such as high data rate and downlink messaging capabilities, are important to the community because they promise to enhance buoy performance and improve data collection, as Michel Guigue explains.

Since 2008, the DBCP has been actively involved with the "Argos-3 Implementation Plan", a project designed to test Argos-3 technology for different oceanography applications.

PROJECT OBJECTIVES

The objectives of this project are to independently and objectively evaluate Argos-3 for use by the global data buoy community, to foster Argos-3 integration by buoy manufacturers, and to provide Argos-3 equipped drifting buoys to the community for evaluation.

PARTICIPATING MANUFACTURERS

Today, several manufacturers have completed the implementation of the Argos-3 Platform Messaging Transceiver (PMT) into their drifters: Clearwater, Marlin Yug, Metocean and Pacific Gyre. These drifting buoys use the interactive data collection mode with Argos-3 and the "pseudo-ack" mode with Argos-2 (message transmitted N times under one satellite pass) since the PMT modem calculates satellite pass predictions.

METHODOLOGY

The first Argos-3 buoys were deployed during the summer of 2009. Since then, a total of 60 drifters have been deployed worldwide (see Map below) for Argos-3 system evaluation. CLS processes the Argos-3 buoy data in real-time and uploads the

data onto the GTS via the National Weather Service (in the U.S.) and Météo France (in France).

BENEFITS OF ARGOS-3

The results of the experience with Argos-3 reveal the following benefits for the data buoy community:

- A high performance for collecting hourly sensor acquisitions (>95%) for those buoys that are operating,
- A large reduction (~75%) of the power consumption used for the data transmission allowing a reduction in the size of the battery pack and/or 50% increase in the drifter lifetime,
- Improved synoptic measurements (on average, more than 22 hourly observations collected per day),
- Optimization of the transmission leading to a better use of the satellite network and then better performance for users,
- Secure uplink transmission with an automatic checksum control,
- Remote commands via the Argos-3 downlink to change the mission parameters,
- A day to day support in terms of integration, deployment and monitoring.

A final Argos-3 Pilot Project report will be prepared by the project Chairperson, Dr. Luca Centurioni, which will be available to the public.

Map of Argos-3-equipped drifting buoys for the DBCP pilot project with their location as of November 3, 2011.



Note: This project was implemented by the DBCP and CLS with the support and collaboration of the French Space Agency (CNES).

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