MPA news

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Bringing MPAs Online: The Use of Webcams for Education, Monitoring, and Other Purposes

A fundamental challenge in MPA management is that the resources being protected are often remote — located underwater, out of human eyesight, sometimes kilometers from shore. This can make monitoring, education, and other management activities relatively difficult, compared to parks on land. To address this challenge, some practitioners are using webcam technology: unmanned cameras that transmit live video or still imagery from MPAs to the World Wide Web. On the Web, people can access this footage — resource managers, educators, scientists, enforcement personnel, and the general public. In some cases, individuals at their computers can even operate the cameras from where they sit, moving the webcams up and down an anchor line, or rotating them for a 360-degree view.

The technology offers substantial opportunities for MPA management. As you might expect, it can also involve significant financial investment and maintenance requirements, as well as various logistical limitations. This month, *MPA News* explores how some managers have implemented this technology, what their experiences have been, and under what conditions webcams may be most appropriate to use.

Race Rocks: Tidal-powered webcams

MPA News first reported in November 2000 on webcams in the Race Rocks Ecological Reserve, a small nine-island archipelago 17 km from the city of Victoria on Canada's Pacific coast (*MPA News* 2:5). The context was MPA enforcement. Although a series of webcams in the reserve was intended primarily to monitor wildlife and educate visitors about Race Rocks, the webcams had also proven to be handy as a surveillance tool. Management agencies had received e-mail messages from visitors to the Race Rocks website, http://www.racerocks.com (where webcam videos can be viewed), notifying officials about illegal activity observed around the islands. Fishing in the reserve, or entering it when whales are present, are both off-limits.

The site's four webcams are each above water, stationed on the main island of the archipelago. Because visibility is better in air than water, and because the reserve is so small, the array of cameras provide excellent views of the surface of the entire reserve. The webcams have been used to report tagged sea lions and monitor other wildlife, record work being done on the reserve's technical infrastructure, and check if sea conditions onsite are adequate for practitioners to access the reserve by boat. They have also been used to instruct school groups on ecology: a new program co-developed by the Race Rocks website team provides interactive exercises on wildlife tracking using the cameras.

The website and webcams are operated by nearby Lester B. Pearson College, which has made Race Rocks an integral part of its programs. (The reserve as a whole is overseen by the Ministry of Parks of the province of British Columbia.) Pearson College employs a full-time staff member to live on the main island, responsible for maintaining and securing the equipment involved in 24-hour webcasting, including regular cleaning of the cameras (fouled by sea spray and guano). A retired faculty member of the college, Garry Fletcher, manages the Race Rocks website and works with students to produce images and educational information for it. Fletcher considers the cameras to be just one component in allowing people to "adopt" the sensitive Race Rocks ecosystem from afar — enabling them to use it for education and research with minimal environmental impact on the actual site. He is working to present all aspects of the ecosystem, with weather data displayed in real time on the Race Rocks website and an underwater array of sensors scheduled for deployment in the coming months.

One of the main considerations in installing webcams in MPAs is what their source of energy will be. Although cameras close to shore can be wired to the mainland power grid, ones further from shore often require their own energy sources. At Race Rocks, since 2000, a diesel-powered generator on the main island has provided power for the cameras as well as for staff lodging and a marine science facility onsite.

As of November 2006, however, the webcams are now running on energy from tidal currents and an auxiliary solar panel array. Installation of the new integrated power system, including a tidal energy generator, was funded by two private companies and a federal grant, and is part of a long-term effort by Pearson College to make its Race Rocks operation financially sustainable. "To

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Reminder: Please participate in our reader poll for the chance to win an *MPA News* tote bag

Have you participated yet in our quick online poll on the relationship between MPAs and ecosystem-based management, announced in last month's issue? One respondent will be picked at random to win an official *MPA News* canvas tote bag. To participate, please visit *www.mpanews.org*. Poll results will be reported in next month's *MPA News*. Thank you to all who have responded so far.

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continue our work on helping to protect this ecosystem while making it accessible for education and research, we needed to ensure our continued presence there," says Fletcher. "To make that financially sustainable, it was necessary to achieve energy self-sufficiency."

More changes are occurring. Pearson College has upgraded its onsite telecommunications network to address a problem of inadequate bandwith, which had sometimes resulted in choppy footage onscreen for the growing number of web visitors. In addition, new remote-control cameras are planned for an underwater installation and for the side of the island where harbor seals give birth, an area not thoroughly covered by the present cameras.

Endeavour Hydrothermal Vents: Monitoring the deep sea

Whereas the Race Rocks webcams monitor that protected area's surface, a system of webcams planned for installation in the Endeavour Hydrothermal Vents Marine Protected Area will be on the ocean bottom — more than 2 km under the sea. This MPA, designated by Canada in 2003, protects a highly biodiverse ecosystem associated with "vent fields" in the Endeavour area. In these vent fields, superheated plumes of water and particulates jet up through the seafloor. Distinctive for their large chimney-like structures of accreted minerals and metals, the vents provide the basis for abundant communities of chemosynthetic microbes, giant tube worms, crabs, and spiders in an otherwise light-free environment. The 93-km^2 MPA is located 250 km southwest of Vancouver Island on Canada's Pacific coast.

The webcams will be part of the NEPTUNE program, a joint Canada-US initiative to deploy a cable-linked monitoring network in an active seafloor-spreading zone, the Juan de Fuca tectonic plate. (The Endeavour Hydrothermal Vents are just one small part of the plate, which otherwise extends from Canada down the coast of the US states of Washington and Oregon.) NEPTUNE will consist of a massive series of miniature observatories, each equipped with multiple sensors, instruments, and robots. In real time, the observatories will transmit their data back to land to enable studies of a wide range of oceanographic, geological, and ecological processes. (The cables by which the data are transferred will supply the observatories with energy.)

Kim Juniper is co-chair of science for NEPTUNE Canada, the Canadian portion of the project (http://www.neptunecanada.ca), and also serves on the management committee for the Endeavour Hydrothermal Vents MPA. Although the MPA must still formally approve the deployment of cameras and other instruments inside its boundaries, Juniper anticipates Endeavour will be among the first sites linked to the NEPTUNE network. The main purpose of the cameras will be to monitor ecosystem changes.

"We know from experience with Endeavour and elsewhere that the physical environment can change substantially over weeks or months," says Juniper. "Habitat changes provoke major shifts in the composition of the vent fauna. Within the field of view of the camera, we expect to observe growth of chimneys and the colonization of new chimney surfaces by the vent fauna. We will see individual vents increase or decrease their visible discharge, new vents appear, and other vents shut down completely. The habitat is also prone to more rapid, sometimes catastrophic changes. This ecosystem is, after all, sitting in a major earthquake zone. There are hundreds of minor earthquakes per month in this area."

Kevin Conley, who oversees the MPA for Canada's Department of Fisheries and Oceans, says the webcams could be an invaluable aid in outreach. "It would be hard to overstate the outreach potential for a web camera in a place like Endeavour, given the remote location," he says. "Imagine having a window to such a novel, dynamic ecosystem right in your classroom, office, or home."

Conley also notes the cameras may help monitor anthropogenic effects on the MPA, including impacts from research activities. Because no sunlight normally reaches the vent ecosystem, the introduction of sustained artificial light for video could cause algal growth where there is normally no plant life at all. The appearance of algae could change natural ecological interactions and also biofoul instruments, including cameras. To minimize this impact, NEPTUNE will rely on still cameras, taking flash photos at intervals, rather than video cameras that would require constant lighting. Juniper says, "Occasional flashes from a digital still camera are unlikely to cause such problems. Our rule of thumb is to avoid more than 30 minutes per day, total, of artificial lighting." NEPTUNE researchers are planning future experiments to quantify the impact of different sustained lighting regimes on algal growth in the deep sea. The results will be used to evaluate future proposals for the deployment of video cameras at Endeavour.

Monterey Bay: Developing "telepresence"

The US National Marine Sanctuary Program (NMSP) holds a long-term goal of providing live underwater video streams from its MPAs nationwide. (The program manages 13 national marine sanctuaries and the recently designated Northwestern Hawaiian Islands Marine National Monument.) The idea is to connect the American public with these MPAs through what the NMSP calls "telepresence", giving individuals the opportunity to visit these ocean places virtually.

The pilot site for this telepresence program is the Monterey Bay National Marine Sanctuary (MBNMS), where three webcams have been in operation since 2002. One is stationed above the surface, while a second is tethered to a remote-operated vehicle (ROV) that transits up and down a buoy line underwater. The third camera sits on a stand underwater and is trained on the ROV. Video feeds are transmitted via Internet2, an advanced networking consortium of 200 universities, corporations, and other institutions operating a high-performance version of the standard Internet (http://www.internet2.edu). Internet2 allows for transmission of high-definition content in real time, in contrast to the somewhat-fuzzy, low-definition content generated by most webcams. The underwater webcam in MBNMS, for example, has allowed aquarium visitors on the East coast of the US to interview divers at work in MBNMS, located thousands of kilometers across the country. Viewers can also move the underwater camera up and down its tether line.

To broaden availability of this content, the NMSP is developing a standard Internet-based, lower-definition portal as well, at http://www.oceanslive.org. Dan Basta, NMSP director, says, "Soon, anyone with access to a computer will be able to take a virtual dive in a national marine sanctuary."

The framework for this telepresence was developed in conjunction with the Mystic Aquarium & Institute for Exploration, the JASON Foundation for Education, and Mote Marine Laboratory. It is based on technology pioneered in the 1980s for exploration of the *Titanic* shipwreck. Dawn Hayes, education and outreach coordinator for MBNMS, says telepresence will make the sanctuaries vastly more accessible to the public at large, without the potential side effects of increasing real visitation rates. "The public can learn about and hopefully come to appreciate the sanctuaries without the added [physical] impact of a million more users," she says.

Although MBNMS has no direct authority over the webcams on-site (installation and maintenance is carried out by the national program office and the Institute for Exploration), the sanctuary has been able to access video feeds for public presentations. It is also exploring use of the video in classrooms in the region and in the sanctuary's forthcoming visitor center. David Bizot of the National Marine Sanctuary Program says MBNMS was a good pilot site for telepresence due to its visually compelling habitat (kelp forests) and its physical location, just meters from the coastline of the city of Monterey, California. "From a technical perspective, it was relatively easy to install and maintain the infrastructure required to make the broadcasts happen," he says. "Sanctuaries further offshore will bring increasingly difficult technical challenges." Bizot says these challenges may mean that camera and equipment installations in other sanctuaries might be portable and deployed seasonally rather than permanently. "The focus on high-quality, live broadcasts will not change, however," he says.

More webcams

Other examples of webcams in MPAs include:

Lundy Marine Nature Reserve — English Nature, the UK's statutory advisory body for nature conservation in England, installed an underwater webcam in Lundy Marine Nature Reserve in 2004. The goal was to raise public awareness of the protected area, the UK's first no-take zone for biodiversity. Technical difficulties arose, however. The reserve surrounds an island that is 12 nm offshore, so the video required a satellite link for transmission. The satellite allowed for only a still image to be transmitted every 30 seconds, not an ongoing stream of video. Chris Davis of English Nature (which is now part of a larger organization called Natural England), says the choppy footage was unimpressive to web visitors. Combined with the expense of the satellite transmission, as well as the difficulty of regularly cleaning and maintaining such a remote installation, the webcam became too much of a hassle. English Nature shut it down in 2005 and Davis says the organization has no plans to deploy another underwater webcam in the immediate future.

Macquarie Island — The Australian Antarctic Division operates a video camera that looks upon its research station on Macquarie Island, a subantarctic island in the Southern Ocean. Although the webcam is not technically inside an MPA, the narrow island is a Tasmanian state reserve and is surrounded by the 160,000-km^2 Macquarie Island Marine Park, a federal MPA. The webcam provides a year-round view of the coastal station, refreshed every 15 minutes. Its website (http://www.aad.gov.au/asset/webcams/macca/default.asp) also offers a selection of photos of extreme weather days on-site, including the coldest and windiest since 2004. Peter Yates, telecommunications manager with the Australian Antarctic Division, says that although the webcam is not considered essential to the running of the station, it is a "fantastic promotion and website entry point." It advertises the program to web visitors from around the world. In addition, it allows friends and family to see what expeditioners on the island are doing, and enables head office staff to monitor weather conditions and special events on the island (e.g., ship visits). The main challenge involved, says Yates, is keeping the plastic enclosure around the camera clean. "On a great number of days, it just isn't worth the effort: it will be wet and covered with smudge from the wind right away," he says. Allocating enough server space for the 35,064 images produced by the camera each year is also a challenge, he says.

Aquarius Reef Base — Located 3.5 miles offshore in the Florida Keys National Marine Sanctuary (US), the Aquarius undersea laboratory rests on a sandplain next to coral reefs. It is 60 feet (18 m) below the water surface in one of the sanctuary's no-take zones. Akin to the International Space Station, Aquarius periodically

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serves as home to researchers on missions of up to 10 days, studying a range of coral reef science issues. In addition to its living chamber (called the "habitat"), the base includes a seafloor observatory and a telecommunications buoy capable of sending data, live video, and audio wirelessly to the Web. During missions, three webcams document life inside Aquarius and research on the reef, and transmit the information via the buoy's radio system. A recent mission also included the use of two diver-mounted helmet-cameras. Visitors to the Aquarius website (http://www.uncw.edu/aquarius) can observe the activity in real time. Aquarius is operated by the National Oceanic and Atmospheric Administration's Undersea Research Center, hosted by the University of North Carolina Wilmington.

Andrew Shepard, director of the Undersea Research Center, notes the Aquarius webcams support the safety of the saturation diving operations. The cameras have also enabled scientists to monitor their seafloor experiments from labs on land. Shepard says Aquarius Reef Base benefits the Florida Keys sanctuary in several ways. "We are the largest coral reef research program in the Keys and we tailor our requests for research proposals to sanctuary management priorities," he says. Resulting research has shed understanding on nutrient sources, coral diseases, and other issues that apply to the base's adjacent reef, the surrounding Florida Keys sanctuary, and the Caribbean basin as a whole.

Costs and Challenges Involved with Webcams: Interview with Daniel Senie of Caribbean Webcams

If you conduct a Google search for "underwater webcam", one of the first sites you encounter is for Bonaire WebCams, a series of cameras that transmit video from various locations on the Caribbean island of Bonaire. One of these cameras is the so-called Bonaire ReefCam, located in shallow water inside the Bonaire National Marine Park. The ReefCam is operated privately by a resort and dive operator under permit from the park, and was installed by Caribbean Webcams (http://www.caribbeanwebcams.com).

Below, *MPA News* talks with Daniel Senie, Chief Technology Officer of Caribbean Webcams, about the usefulness and limitations of underwater webcams.

MPA News: You have said that setting up and operating underwater webcams involves a significant investment in equipment, expertise, and time. On average, what would you estimate the set-up and annual operating costs to be for a single underwater webcam?

Daniel Senie: Costs are highly variable and depend on many factors. Pricing could range from US$6000 to $15,000 or beyond, depending on connectivity available, methodology for linking the camera to shore, power availability, and so forth. [Editor's note: Some of the technologically advanced webcam systems described in the preceding article, including for offshore sites, can range into tens of thousands of dollars or more to install, and require a full-time technician to operate.]

MPA News: What are the main challenges involved in setting up and maintaining an underwater webcam?

Senie: Saltwater destroys equipment. Although inexpensive gear will provide great images the first week, and maybe even the first few months, there will be serious trouble in the future. Also, maintenance requires divers on a very frequent basis — at least a few times a week. Sea life will otherwise overgrow the camera, lens port and all.

MPA News: What are the ideal ecological conditions for operating an underwater webcam?

Senie: More than any other factor, closeness to shore — with the ability to run a protected cable out to the camera — makes for the ideal setting. Complexity arises when cameras cannot be powered from shore, and data signals thus have to travel over wireless connections. There are solutions to all such problems, but the more complexity present, the more things there are to go wrong. When equipment is in remote locations, things "going wrong" become that much more difficult to manage.

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MPA Perspective A Practical Rule of Thumb for Spacing in MPA Networks

By Jeffrey M. Leis

[Note: A full list of the literature cited in the following essay is available at http://depts.washington.edu/mpanews/Leis-cited.htm.]

MPA networks are a series of reserves that individually may be too small to be self-seeding, but that are close enough together so that one reserve can seed another (Palumbi 2002). A major unknown in planning MPA networks is how far apart the individual components of the network should be separated. Most connectivity between the populations of demersal organisms protected within the individual network components is by dispersal of larvae, so the geographic scale over which larval dispersal takes place in the ocean has become a major concern. It is increasingly obvious that it is inappropriate to assume larvae of fishes and decapod crustaceans (if not other taxa) are passive particles whose dispersal can be understood as a purely physical process applied over the pelagic larval duration (PLD). Dispersal is a much more biological process than was thought only a few years ago: it is now clear that larvae *behave* (Sponaugle et al. 2002; Leis 2006), and this can greatly influence dispersal outcomes.

However, hard data on how far larvae actually disperse are rare. In addition, dispersal of relevance for genetic connectivity (i.e., evolutionary connectivity) is likely to be over much greater distances than for demographic connectivity (i.e., ecological connectivity) (Leis 2002; Leis 2006). Further, dispersal distance will differ among:

- Species because of species-specific behaviors and PLDs;
- Locations because of site-specific differences in hydrography and the interaction of behavior of larvae with hydrography over both small and large scales; and
- Seasons, years, and other time periods, due to (a) differences in hydrography among seasons and years as well as long-term oceanographic variations and trends, and (b) temperature-dependant rates of development and physiology in the cold-blooded organisms that dominate marine communities.

As a result, it is clear that no single inter-reserve spacing will be suitable for all MPA networks, and one that is suitable from an ecological point of view will probably differ from one suitable from an evolutionary point of view. A fixed inter-component spacing in MPA networks that is suitable for a sponge is unlikely to be suitable for a fish. This lack of clarity on ideal inter-component spacing in MPA networks causes headaches for planners and managers, and can delay the planning and consultation process.

A solution that provides a rule of thumb for inter-component spacing in MPA networks has been hinted at in the literature, but I have not seen it clearly and simply stated. It is this:

> All distances between all components of an MPA network (not just adjacent components) should be scaled so that there is an approximately equal number in each distance category (e.g., very short, short, medium, large, very large), and there should not be large size gaps between distance categories.

Put more formally, the frequency distribution of all inter-component distances should be "flat", or even. Smaller distances might be able to be accommodated within individual components of the MPA network, whereas moderate and large distances would be among the different components of the network. Extremely long dispersal distances, if they are thought to exist, might be accommodated by taking into account more distant MPA networks. The distances must be within water (e.g., not cutting across islands or peninsulas.)

This rule of thumb assumes that the frequency distribution of dispersal distances for all the individual species that the MPA network is supposed to protect, integrated over time and over the space occupied by the network, will be approximately flat, and that MPAs are designed to provide both ecological and evolutionary protection. We will not be able to adequately test the first part of the assumption for some time, but based on current knowledge, it seems to be the best-informed guess we will be able to make within the near future. The advantage of this rule of thumb is that it can be applied now.

This rule of thumb was hinted at by several authors in the seminal *Ecological Applications* volume on MPAs (13[1] supplement 2003). For example, Roberts et al. (2003) state: "it will be safest to have a range of distances among reserves". But perhaps the clearest statement is in Steve Palumbi's report for the Pew Oceans Commission (Palumbi 2002): "Because the models show that these different types of species require reserves with different spacing, the simple conclusion is that reserve networks should have a variety of spacing — from quite low to high — in order to accommodate the whole community." The rule of thumb does not, however, seem to have reached a wide audience of MPA planners and managers. I have been raising it at conferences for a few years, yet it always seems to be greeted with surprise. This essay is an attempt to fully and clearly state the rule of thumb and introduce it to a wider audience.

My thanks to Bob Warner for pointing out important literature, Alan Jordan for comments, and Sue Bullock for editorial assistance.

Editor's note

Jeffrey Leis is principal research scientist for ichthyology at the Australian Museum. Our March 2003 edition (*MPA News* 4:9) featured his remarks on larval dispersal and marine reserves, accompanied by an extended online interview.

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Notes & News

New publications on coral bleaching and management

There are two new publications available on managing coral reefs in an era of climate change. *A Reef Manager's Guide to Coral Bleaching* — co-produced by the (US) National Oceanic and Atmospheric Administration, the Great Barrier Reef Marine Park Authority, and IUCN — provides managers with the latest scientific information on the causes of coral bleaching and new strategies for responding to this threat. These strategies include meaningful actions for before, during, and after bleaching events. The guide makes several references to protected areas, such as identifying the key role that MPA networks can play in helping reefs rebound from bleaching events via larval connectivity. Featuring advice and case studies from dozens of experts in coral bleaching and coral reef management, the report is available in PDF format at http://www.coralreef.noaa.gov.

The second report, *Coral Reef Resilience and Resistance to Bleaching*, published by IUCN and The Nature Conservancy (TNC), provides similar advice to reef managers. Co-author Rodney Salm of TNC says it is essential to anticipate climate change. "Rising temperatures and sea-level challenge reef managers to be flexible and adapt their approaches to make the reefs under their care more resilient to climate change as new science and understanding emerges," says Salm. The report is available in PDF format at http://www.iucn.org/dbtw-wpd/edocs/2006-042.pdf. (A sister publication on mangrove management — *Managing Mangroves for Resilience to Climate Change*, also published by IUCN and TNC — is available in PDF format at http://www.iucn.org/dbtw-wpd/edocs/2006-041.pdf.)

WWF-Canada proposes framework for MPA network planning

A new report from WWF-Canada offers guidance on planning regional MPA networks across Canada, with best practices and a proposed set of actions for national leadership. The target audience for the report is planners, decision-makers, and stakeholders playing a role in shaping Canada's approach to planning MPA networks. *A Policy and Planning Framework for Marine Protected Area Networks in Canada's Oceans* is available in PDF format at *http://www.wwf.ca/marinepriorityareas*.

Thirteen tons of derelict fishing gear removed from Hawaiian MPA

More than 13 tons of derelict fishing gear were removed from coral reefs of the Northwestern Hawaiian Islands Marine National Monument during a recent month-long, multi-agency removal effort coordinated by the (US) National Oceanic and Atmospheric Administration, or NOAA. The derelict gear was collected from an area totaling three square miles (7.8 km^2). NOAA has worked since 1996 to remove hazardous marine debris from the Northwestern Hawaiian Islands (NWHI), where it injures marine life, destroys coral reef habitat, and threatens safe navigation. The NOAA marine debris team has collected more than 580 tons of debris in the islands since the beginning of the program; the collected debris is then incinerated on land to provide electricity for Hawai`i residents. The NWHI archipelago is in the North Pacific Gyre, a swirling vortex of ocean currents that routes debris in a circle around the North Pacific. Annually more than 52 tons of marine debris accumulate in the 362,000-km^2 Northwestern Hawaiian Islands Marine National Monument. Information on NOAA's marine debris removal operations for NWHI is available at http://www.pifsc.noaa.gov/cred/mdr.php.

Experimental lobster reserves established in Norway

Norway's Department of Fisheries and Coastal Affairs has designated four small experimental reserves (0.5-1 km^2 in area) along the Skagerrak coast in southeastern Norway with the goal of establishing and studying baseline populations of lobster in the closures, including their movement patterns in relation to the size and shape of reserves. Fishing for lobster inside the reserves is now banned for 10 years; only hook-and-line fishing is allowed. The four areas — the first lobster reserves in the nation — were nominated by local fishing organizations following a series of consultations with public officials. Even Moland of the Institute of Marine Research (Flodevigen station), who is conducting the lobster population experiments, says the reserves will serve to raise local awareness of MPAs as a management tool, and could provide a basis for regional discussion of the concept of large-scale zoning of the coastline.

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Upcoming events

Newly added meetings on the *MPA News* conference list include:

January 5-9, 2007 — "4th Annual CoralWatch Focus on Corals Workshop". Heron Island Research Station, Australia. Instructing marine educators on using a simple technique for monitoring coral bleaching. http://www.coralwatch.org

April 2-5, 2007 — "MARXAN Best Practices Workshop". Vancouver, British Columbia, Canada. Clarifying the relationship of planning tools to decision-making on marine resource management, and drafting text for a best-practices handbook on MARXAN. http://www.pacmara.org

September 25-28, 2007 — "European Symposium on MPAs as a Tool for Fisheries Management & Ecosystem Conservation". Murcia, Spain. Discussing ecological, economic, and social aspects of MPA development, and emphasizing integration of fisheries and ecosystem management. http://www.mpasymposium2007.eu

For a complete calendar of MPA-related events in 2007, visit http://www.mpanews.org.