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Advance phone interviews with the authors are available. The Nature paper in full is available for preview at <http://dl.dropbox.com/u/3960397/BB%20proof.pdf>; high-resolution photos at www.toppmedia.org (user ID: topp; password: media); b-roll at ftp.greatmarlinrace.org, FTP server port 21, SFTP server port 22, username: topp@greatmarlinrace.org, password: media; and additional figures at <http://dl.dropbox.com/u/3960397/SupplementaryInformationFinal.pdf>

Pacific's California Current Likened to Africa's Serengeti Plain - Teeming with Animal Hotspots, Well-defined Highways, Annual Homecomings

Decade of electronic tagging, tracking of 23 top Pacific Ocean predators reveals remarkable homing by marine animals

Fish, sharks, mammals, seabirds, turtles yield secrets of vast savannas of the sea

Like the vast African plains, two huge expanses of the North Pacific Ocean are major corridors of life, attracting an array of marine predators in predictable seasonal patterns, according to final results from the Census of Marine Life [Tagging of Pacific Predators](#) (TOPP) project published today in the journal *Nature*.

The paper culminates the TOPP program's decade-long effort to track top marine predator movements in the Pacific Ocean. It presents for the first time the results for all 23 tagged species and reveals how migrations and habitat preferences overlap -- a remarkable picture of critical marine life pathways and habitats.

The study found that major hot spots for large marine predators are the California Current, which flows south along the US west coast, and a trans-oceanic migration highway called the North Pacific Transition Zone, which connects the western and eastern Pacific on the boundary between cold sub-arctic water and warmer subtropical water -- about halfway between Hawaii and Alaska.

"These are the oceanic areas where food is most abundant, and it's driven by high primary productivity at the base of the food chain -- these areas are the savanna grasslands of the sea," say co-authors and project originators **Barbara Block** of Stanford University's Hopkins Marine Station and **Daniel Costa**, professor of ecology and evolutionary biology at the University of California, Santa Cruz.

"Knowing where and when species overlap is valuable information for efforts to manage and protect critical species and ecosystems."

Drs. Costa and Block were joined by **Steven Bograd** of the NOAA Southwest Fisheries Science Center, **Randy Kochevar** of Stanford University and others to launch the project in 2000 as part of the Census of Marine Life, a 10-year research initiative that investigated the diversity, distribution, and abundance of marine life in the global ocean. TOPP became the world's largest-ever biologging study, eventually involving more than 75 biologists, oceanographers, engineers and computer scientists across five countries.

Says Dr. Block: "It's been a bit like looking down on the African savanna and trying to figure out: Where are the watering holes that a zebra and a cheetah might use? Where are the fertile valleys? Where are the deserts that animals avoid, and the migratory corridors that animals such as wildebeest use to travel from place to place? We've come to a vast oceanic realm in the Pacific and answered these questions for animals as diverse as bluefin tuna, blue whales and leatherback sea turtles."

"This is the first publication that pulls all of the pieces together in one place," says Dr. Costa, who oversaw the tracking of marine mammals, birds, and turtles. "We brought

together a large team of investigators to study diverse species and look at how these organisms use the ocean. It is an unprecedented examination of so many species over such a large scale."

The scientists used a variety of technologies to track the locations of different species as well as environmental variables such as water temperature, salinity, and depth. Altogether, the project deployed 4,306 electronic tags on the 23 species, yielding a huge amount of data for analysis.

Working with Census scientists at Dalhousie University in Halifax, Canada and its Future of Marine Animal Populations project (FMAP), the scientists spent two years synthesizing data sets with advanced statistical techniques and discerned intersecting hotspots and highways of ocean life and how marine conditions influenced where animals hang out.

"One of the challenges for this study was to take distinctly different types of location data – some very precise from ARGOS satellites and others far less precise from ambient light level readings and bring them together using a powerful statistical framework that enabled identification of high use areas" says Dalhousie's **Dr. Ian Jonsen**.

The results suggest water temperature is key to the seasonal migrations of many species. This was particularly evident in the large marine ecosystem defined by the California Current, where cool, nutrient-rich water moves south along the US west coast.

The study reveals the Current as a vast marine savanna to and within which a large number of whales, sharks, seals, seabirds, turtles and tunas migrate loyally every year.

It shows many highly migratory marine species return to the same ocean regions, homing with astonishing fidelity to the places they were first tagged, following a predictable seasonal pattern.

Says Dr. Block: “For me, the homing capacity of species which routinely return to the California Current or shelf waters of North America has been the biggest surprise.”

Adds Dr. Costa: “It is akin to a student from London studying in far-off Rome and returning home each summer at the same moment -- but doing it all in the dark, without a map or compass, using only their internal sense of position and direction.”

According to the authors, the mechanisms and cues that allow species to home with such fidelity to seasonal pathways are not yet fully understood, “but may represent a capacity to discriminate among areas of seasonal significance for foraging or reproduction.”

Some predators, such as California sea lions, spend their whole lives within the California Current, but others migrate vast distances across the Pacific Ocean to reach its abundant prey such as krill, sardines, anchovies, and squid.

“How or why a young bluefin tuna less than two years of age wakes up in the light of the Japan sea and decides to swim to Baja remains completely unknown,” says Dr. Block. “Once they get here, tagging data indicate they reside for years, taking advantage of the rich forage off North American coastlines. These tunas become vulnerable to oceanic fisheries across the Pacific during both this highly migratory period and this retentive period lunching on our coast.”

The project found several species, including leatherback sea turtles, black-footed albatrosses, sooty shearwaters, bluefin tunas and salmon sharks) migrate more than 2,000 km from the western, central or south Pacific basin to reach the California Current’s rich food resources -- a commute equal to that between Seattle and San Diego.

Species making seasonal north–south migrations included bluefin tunas and yellowfin tunas; mako, white and salmon sharks; blue whales; male elephant seals; and leatherback sea turtles.

Other species moved between near-shore and offshore waters, residing within the California Current or the Gulf of Alaska for a while, then migrating to points that ranged into the North Pacific transition zone (female elephant seals, salmon sharks and Laysan albatrosses), the subtropical gyre and north equatorial current (blue and mako sharks and leatherback sea turtles), or the ‘café’ regions of the eastern Pacific and the Hawaiian Islands (where species like white sharks, albacore tunas, and black-footed albatrosses meet).

Says Dr. Bograd of NOAA: “In the California Current we see a great deal of coastal upwelling, especially during the late spring and summer. This is when cold, nutrient-rich water rises to the ocean surface, causing phytoplankton blooms and creating a rich food source for a variety of ocean animals.”

The researchers found that the ocean productivity from upwelling was also associated with the north/south migratory patterns exhibited by several species. For the first time the TOPP team has been able to link the movements of tunas, sharks and blue whales north and south along the southwestern US coastline with seasonal changes in temperature and chlorophyll concentrations.

“Using satellite observations of temperature and chlorophyll concentrations alone, we can now predict when and where individual species are likely to be in a given ocean region and begin to understand factors that control their movements. This is fundamental to the concept of ecosystem-based management,” says Dr. Costa.

The researchers also used distinctly different types of tracking data to examine the partitioning of habitats by closely related species. Different tuna species, for example, prefer particular water temperatures, and these preferences correlate with physiological differences between the species.

In addition to developing new tracking technologies and techniques, the researchers had to manage large datasets and synthesize different kinds of data for the final analyses.

In addition to Drs. Block, Costa, Bograd and Jonsen, the paper was co-authored by

- * **Arliss Winship**, and **Greg Breed** of Dalhousie University;
- * **Salvador Jorgensen**, **George Shillinger**, **James Ganong**, **Alan Swithenbank**, and **Mike Castleton** of Stanford University;
- * **Scott Shaffer** of San Jose State University;
- * **Elliott Hazen**, **Dave Foley**, **Heidi Dewar**, and **Scott Benson** of the NOAA Southwest Fisheries Science Center;
- * **Autumn-Lynn Harrison**, **Michael Weise**, and **Bill Henry** of University of California Santa Cruz;
- * **Bruce Mate** of Oregon State University; and
- * **Kurt Schaefer** of the Inter-American Tropical Tuna Commission.

Says Dr. Block: “We clearly have an amazing African-like game park in our waters off the west coast. It will take enormous vision to protect this wild place. I hope our study stimulates the discussion of how best to do this.”

“Without effective management of open ocean realms, the bluefin tuna, leatherback sea turtles, blue whales and white sharks seen in the central and eastern Pacific or off our North American shores in 2011 might not be there for future generations. This work has created an opportunity to protect this marine wilderness and keep North American waters teeming with predators.”

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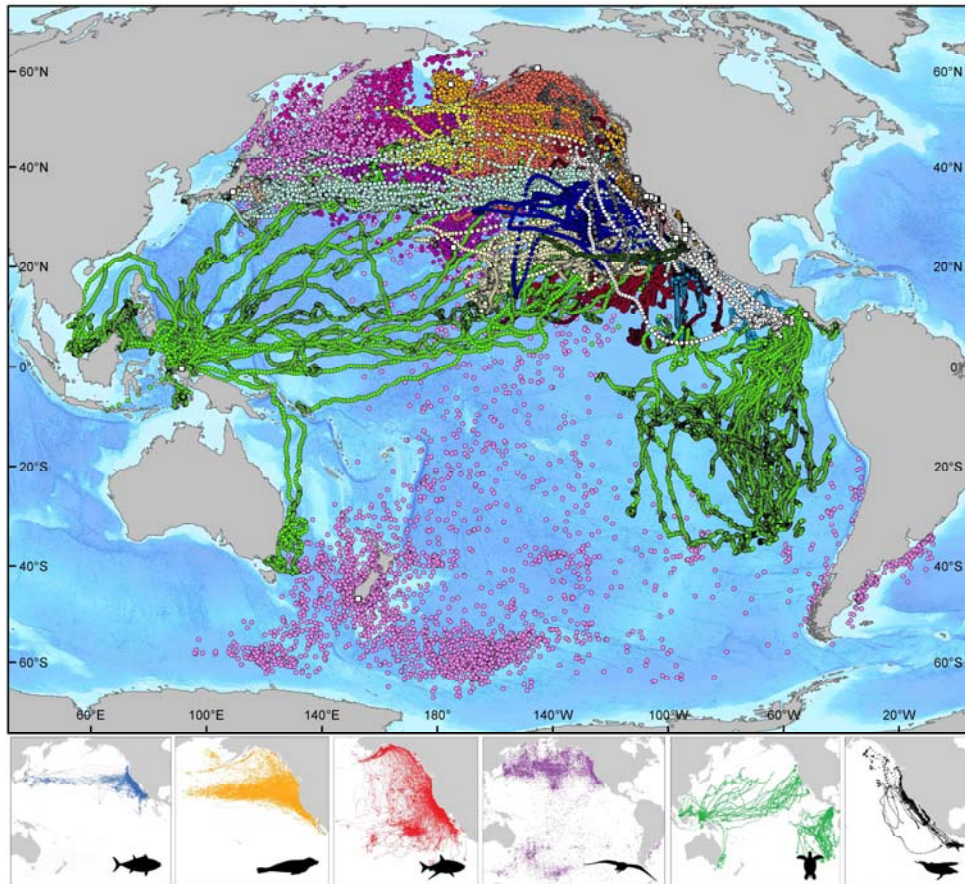
TOPP and FMAP were two of 17 projects of the [Census of Marine Life](#), which concluded last October -- an ambitious 10-year, 80-nation endeavor to assess and explain the diversity and abundance of life in the oceans. Funding for this study was provided as part of the synthesis activities of the Census of Marine Life.

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Funding for FMAP was provided by the Sloan Foundation.

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| ○ Humpback Whale | ○ Thresher Shark | ○ Pacific Bluefin Tuna |
| ● Fin Whale | ● Yellowfin Tuna | ● Leatherback Turtle |
| ● Sperm Whale | ● Albacore Tuna | ● Salmon Shark |
| ● Sooty Shearwater | ● Blue Shark | ● Laysan Albatross |
| ● California Sea Lion | ● Mako Shark | ● Black-footed Albatross |
| ● Northern Fur Seal | ● White Shark | ● Humboldt Squid |
| ○ Blue Whale | ● Loggerhead Turtle | |
| ● Northern Elephant Seal | ○ Mola mola | |

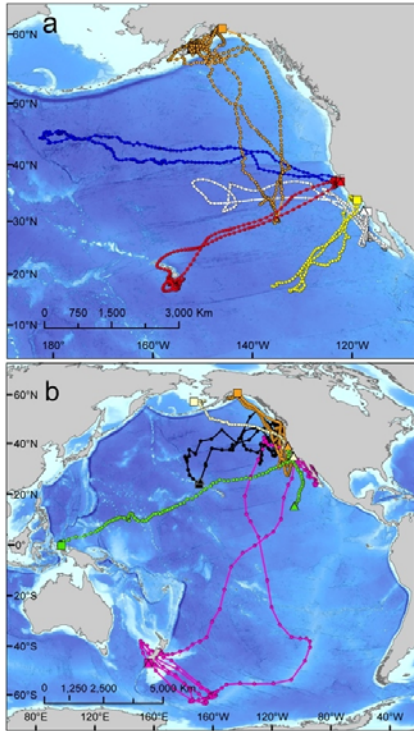


Figure 2 | Fidelity and attraction to the CCLME.

a, Examples of pelagic predators released and electronically tracked in the CCLME that show fidelity to deployment locations and the CCLME. We show the release locations (square), pop-up satellite end point locations (triangle) and daily mean positions (circles) of the following species: yellowfin tuna (yellow), bluefin tuna (white), white shark (red), elephant seal (blue) and salmon shark (orange). **b**, Individual tracks of pelagic animals released >2,000 km away from the CCLME that are indicative of cross-basin or ecosystem attraction to, and temporary residency within, the eastern North Pacific. Symbols are as in **a**, for leatherback sea turtles (green), sooty shearwaters (pink), fur seals (pale yellow), black-footed albatrosses (black) and salmon sharks (orange).