An enigmatic problem in marine ecology uncovered

May 10 2011

A new research paper from an international and interdisciplinary team, published in the journal *Ecography*, has uncovered the mystery behind the relationship between the duration of the open water period and the geographic coverage of marine species.

Reef fishes and many other marine species live all their adulthood in one place but early in their lives, when they're eggs and larvae, spend a short period of time drifting and swimming in the open ocean. It seems intuitive that the duration of this open water period should determine the geographic extent over which species are found as species that spend longer drifting at sea are likely to reach greater distances. Interestingly enough, numerous studies have consistently failed to find any relationship between the duration of the open water period and the geographic coverage of marine species. A new research paper has uncovered this mystery.

"One of the most puzzling results in the study of reef fishes and other marine organisms that dwell sea-floor habitats as adults but drift in open water early in their lives is why their geographic coverage bears no relationship with the duration of the open water period," explains co-author Dr. Camilo Mora, post-doctoral fellow in the Department of Biological Science at Dalhousie University. "Since this idea was first proposed over 30 years ago, we've been scratching our heads trying to resolve this mystery by evaluating the relationship multiple times in different groups of species and regions. Yet we consistently we failed to find a noteworthy relationship."

In this new study, the team of researchers, which included marine ecologists, geneticists and ocean current modelers, first evaluated the possibility that the relationship between geographic extent and the duration of the open water period was compounded by the evolutionary age of species, whose effect has not been considered in previous studies. The rationale was that the age of a species should add to the geographic coverage of species as older species have had more time to expand geographically compared to younger species.

To evaluate this idea, the authors compiled the largest set of data yet assembled on evolutionary ages of reef fish species, and the duration of their open water periods and geographic extents. The analysis of this data showed, however, that even after taking evolutionary age into account there was still no relationship between geographic extent and the duration of the open water period.

"We expected that the effect of species ages could be the missing piece to resolve this puzzle," says co-author Dr. Denis Roy, post-doctoral associate in the Department of Biology/Marine Gene Probe Laboratory at Dalhousie University. "So we were a bit disappointed to find that neither the age of the species nor the duration of the open water period or both combined played an important role on the geographic extent of reef fishes."

"This result, about the limited effect of species ages, deepened our intrigue," says co-author Kate Crosby from Dalhousie University. "The only other thing we could think of was that perhaps reef habitats were so highly connected by ocean currents that species could reach all suitable habitats regardless of their open water period or time since they originated as new species."

To test this idea, the team took on the challenge of modeling the paths of fish larvae during the open water period over the world's tropical reefs.

The authors used state of the art models of ocean currents and compiled a worldwide set of data on marine habitats where reef fish dwell. Simulated larvae were released from all possible habitats and allowed to drift for times equal to the duration of their open water periods. The simulation required 600 computer processors running continuously for six months. The results revealed that the majority of reef habitats worldwide are so interconnected that species can quickly spread their geographic distribution pushed by ocean currents. This lack of constraints to the geographic expansion of species provides one of the first explanations for why geographic extent bears no relationship with the duration of the open water period.

"An underlying assumption of the expected relationship between geographic extent and the duration of the open water period is that reef habitats are positioned in a gradient of isolation, which species can bridge only depending on how long the spend drifting in the open ocean ," says co-author Dr. Eric Treml, post-doctoral fellow in the School of Biological Sciences at University of Queensland, Australia. "Our simulations of what happens during the open water period suggest that that assumption is just not valid. Given ocean currents, fish larvae can go almost anywhere."

"This is like having a 100 metre race between a car and a bike and giving them one hour to finish; the task is so easy that both vehicles will reach the finish line independent of their speeds," says co-author Jason Roberts at Duke University, U.S.A. "As for reef fishes, ocean currents provide such fast freeways that species can easily reach suitable reefs independent of the time they spend drifting in the open water."

"We've been able to provide new insight into why an intuitively important factor played no role in shaping the geographic extent of reef fish species," says co-author Derek Tittensor at Microsoft Research in Cambridge, U.K. "Given our results, however, a question that still needs

to be answered is why all reef fish species are not found everywhere."

Provided by Dalhousie University