Workshop report: The ecological role of squid in pelagic ecosystems University of Hawaii, Honolulu, 16-17 November 2006

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CLIOTOP Working Group 3 (Trophic Pathways in Open Ocean Ecosystems) organised a workshop to examine the ecological role of squid in pelagic ecosystems. The workshop was designed to bring current and past workers in the field together to discuss the state of knowledge and to prioritise research objectives, particularly those relevant to understanding the effects of climate change on the distribution and ecology of squid populations. The workshop was held at the University of Hawaii on 16 and 17 November 2006, and was sponsored by GLOBEC and the Pelagic Fisheries Research Program (University of Hawaii).

Background

The central aim of CLIOTOP is to identify, characterise, and model the key processes involved in the dynamics of oceanic pelagic ecosystems leading to top predators such as the tunas and billfishes. To do this we need to develop an understanding of the components of the pelagic ecosystem that lead to these top predators, and how changes in the pelagic environment will affect what we consider to be the status quo. The traditional pelagic food web model on which much of our understanding of ecosystem interactions is based is a conceptual pyramid with large pelagic fishes at the top preying on increasingly complex groups of organisms and supported by primary production at the base. In the middle of this web lies the squid community, itself composed of a vast array of species that inhabit all water masses from the surface to the deep water.

Several factors, including the ability of squid to avoid capture, their complex taxonomy and the lack of fisheries for them, have limited our understanding of their role in the pelagic ecosystem. We do know, however, that they are a central component of many pelagic ecosystems and can act as both prey and predator. Their short life spans (usually no more than a year), voracious appetites and rapid growth rates and their ability to withstand a range of environmental conditions suggest that they could play a role as indicators of ecosystem change in the world's oceans. For example, the recent rapid expansion of the Humboldt squid, *Dosidicus gigas*, off South and Central America may be an indicator of changed conditions in the eastern Pacific Ocean. Whether the expansion of this species is the result of climate forcing remains to be identified. However, understanding the ecology of this and other important squid species will be invaluable in understanding wider changes in the pelagic environment.

The increased awareness of the role of squid in pelagic ecosystems has facilitated a number of studies in the world's oceans that specifically address the ecological role of squid in pelagic systems. These studies have been greatly facilitated by new technologies such as archival tagging, analytical methods such as stable-isotope and fatty-acid analyses and developments in ecosystem modelling techniques. It seemed timely therefore to stock takee on what is known and where the future directions in research lie for this diverse group.

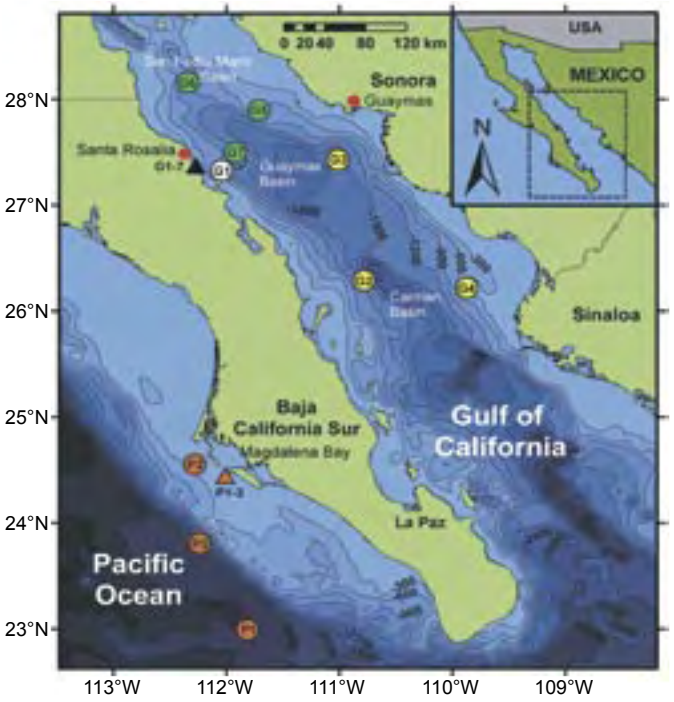

Figure 1. Satellite archival track of Dosidicus gigas. (Black triangle off Santa Rosalia marks deployment site for PSAT's G1-G7 (Wildlife Computer PAT 3.0); pop-up locations are given by yellow (October 2004) and green (November 2005) circles. Other tags deployed off Magdalena Bay in June 2005 (P1-P3) are denoted by a red triangle and individual red circles). Figure courtesy of William Gilly and drafted by Ashley Booth.

The workshop

Oral presentations (and five posters) were given by twenty one squid researchers from ten countries, who attended with financial and logistical support from GLOBEC-CLIOTOP and the Pelagic Fisheries Research Program (University of Hawaii).

The focus of the workshop was:

- to consider the role of squid in pelagic ecosystems that support tunas and other upper-level predators;
- to consider how climate change might impact squid populations and the ecosystem;
- to consider the recent range expansions of *Dosidicus gigas* in the Pacific Ocean, especially in terms of its effects on the ecosystems; and
- to identify research needs for large pelagic squid to meet the goals of GLOBEC CLIOTOP and to identify potential research proposals.

The workshop was divided into four themes - biology and ecology, trophic links, climate impacts, and modelling. A final session led by the moderators from each theme reviewed the outcomes from each theme and highlighted potential future research objectives. A summary of these themes will be published electronically in the March 2007 PFRP newsletter and a brief account is given below.

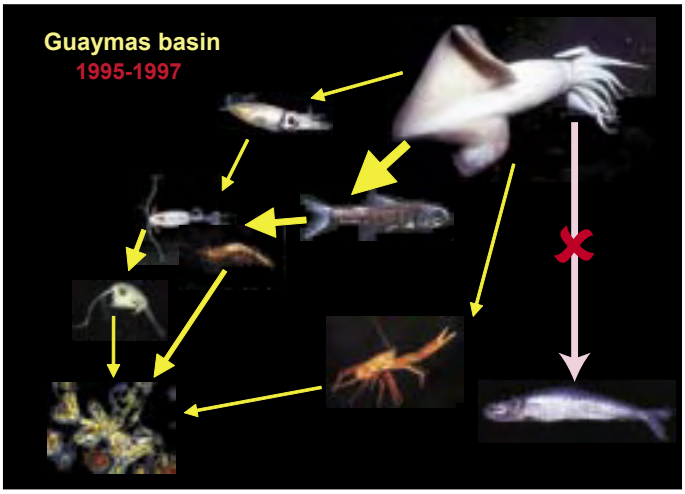

Figure 2. Prey of Dosidicus gigas in the Gulf of California. Figure courtesy of Unai Markaida.

The first theme concentrated on the biology and ecology of the Humboldt squid, which as previously mentioned, has become a dominant component of the eastern Pacific pelagic food web. The species is now the target of the world's largest cephalopod fishery. Discussion centred on the potential reasons for the apparent range expansion, including its tolerance to low oxygen environments, and its tolerance to wide temperature and salinity ranges. To understand the reasons for this seemingly rapid change several studies employing state of the art technologies have begun. For example, satellite archival tagging has shown that this squid migrates over a wide geographic range (Fig. 1). The vertical distribution data collected as part of these studies showed that this species migrates to depths below 400 m, well below the oxygen minimum, possibly out of the range of a number of its predators. The second session, climate impacts, presented fishery and limited fishery-independent surveys, which showed links between the distribution and abundance of *Dosidicus gigas* and other ommastrephid species and *El Niño/La Niña* oscillations. One longer-term study in the northern Pacific Ocean showed a link between the northward extension of less productive tropical water and weaker cohorts of *Ommastrephes bartramii*, a common oceanic species.

The meeting brought a body of international squid biologists together with vertebrate-focused biologists, fisheries scientists and conservationists. A large part of the discussion focused on one species of squid in particular, Dosidicus gigas, the Humboldt or jumbo squid. Furthering our understanding of this species and its interaction with the pelagic and mesopelagic ecosystems in the eastern Pacific Ocean was deemed to be of critical importance. An informal consensus was reached that an international research effort was immediately needed to advance our knowledge of this species and its impacts on the highly productive ecosystems within its range, including the California and Peru Currents and the Costa Rica Dome.

In conjunction with discussions with several participants after the meeting, I agreed to investigate mechanisms of support and to begin organising an international group of potential participants. I propose to approach the problem by dividing the range of Dosidicus gigas into six biogeographic regions, each with a responsible co-ordinating investigator and other participants.

William Gilly (GLOBEC-funded participant)

I am thankful to GLOBEC for providing me with the opportunity to attend the workshop on the role of squid in pelagic marine ecosystems at Hawaii in November 2006. I had a great time participating in the joint workshop in which scientists from both squid and non-squid disciplines took part. I found the discussion on various topics related to the role of squid in pelagic marine ecosystem very interesting. I also learnt about the gap between the contributions presently being made by the squid scientists to GLOBEC-CLIOTOP objectives and the expectations of the non-squid scientists working towards the same objectives. I believe the joint workshop helped the scientists from both groups to understand the each others perspectives and will help to identify research subjects to narrow this gap in near future.

I also realised the importance of international collaborations for the holistic understanding of the pelagic ecosystem. For example, my institute has been collecting hundreds of stomach content samples annually from southern bluefin tuna, whose main food is pelagic squid, but those precious samples have only been used for preliminary analysis and then been abandoned due to lack of expertise in Japan. We should devise collaboration mechanisms between international groups for effective use of such samples.

Taro Ichii (GLOBEC-funded participant)

The second day began with the trophic links theme, which again emphasised the central position of squid in a number of pelagic food webs in the Pacific and Atlantic Oceans. However, it soon became obvious that relatively few trophic studies were available on squid from the high seas, particularly in the Indian Ocean. Another limitation identified was the lack of time series studies from which evidence of climate change could be deduced. There was a recurring theme on the importance of detailed taxonomy of prey species to understand potentially subtle shifts in understanding these food webs. For example, data were presented for *D. gigas* from the Gulf of California showing the importance of lanternfishes in their diet, and not sardines as previously thought (Fig. 2). Fatty acid analyses were presented as a useful tool in efforts to separate potential prey items in the mostly digested remains with which squid trophic ecologists are usually presented. The final session dealt with models examining the role of squid in oceanic and coastal ecosystems. One study estimated that up to 30% of the fishery landings and market values from large marine ecosystems in the world's oceans pass through the cephalopod biomass pool (i.e. species that prey on cephalopods or cephalopods themselves).

The workshop ended with perspectives from contributors on a number of research areas. Linking tagging studies with the Census of Marine Life initiative, development of biochemical techniques to elucidate trophic structure, and laboratory studies to anticipate the effects of potential changes in the physics and chemistry of the world's oceans were some of the topics discussed. Gaps in knowledge included the lack of time series data and the lack of studies generally in the Indian Ocean. A full report of the workshop with extended abstracts will appear in a separate volume of the GLOBEC Report Series.