Time-at-depth data (to generate histograms) from tagged jumbo squid from R/V R4107, R/V Pacific Storm, Chartered Vessels, R/V cruises in the Monterey Bay vicinity and Gulf of California from 2004-2009

Website: https://www.bco-dmo.org/dataset/471977
Data Type: Other Field Results
Version: 1
Version Date: 2013-11-22

Project
» Hypoxia and the ecology, behavior and physiology of jumbo squid, Dosidicus gigas (Jumbo Squid Physiology)
» Physiological limits to vertical migrations of the pelagic, jumbo squid, Dosidicus gigas in the Gulf of California
(Jumbo Squid Vertical Migration)

Contributors	Affiliation	Role
Gilly, William	Stanford University	Principal Investigator
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Abstract
Time-at-depth data (to generate histograms) from tagged jumbo squid from R/V R4107, R/V Pacific Storm, Chartered Vessels, R/V cruises in the Monterey Bay vicinity and Gulf of California from 2004-2009

Table of Contents

Coverage

Spatial Extent: **N**:37.91 **E**:-111.22 **S**:27.34 **W**:-123.48
Temporal Extent: 2008-10-12 - 2008-11-28

Dataset Description

Humboldt squid (*Dosidicus gigas*) were tagged from 2004-2009 in the California Current System (CCS) and Gulf of California (GOC). Data include the amount of time spent per depth bin from each tagged squid. Daily histograms can be produced by adding up the counts per day for each depth bin. Each count in the count_night and count_day columns represents 75 seconds of time.

Methods & Sampling

All data were collected with Mk10-PAT tags (Wildlife Computers, Redmond, WA) attached to living Humboldt squid (*Dosidicus gigas*) as described elsewhere (Gilly et al. 2006). Tags were programmed to sample at 0.5 Hz or 1 Hz. Tags deployed in Monterey Bay (CCS-1through CCS-6; deployed during OCE-0850839) were programmed to transmit time series data (75 s intervals = 0.01333 Hz) for depth, temperature and light to the

Argos satellite system. Tags deployed in the Gulf of California (GOC-1 through GOC-6; deployed during OCE-0526640) were physically recovered, and the data were subsampled to match the 75 s interval of the CCS tags. This procedure was also carried out for tag CCS-6 that was recovered but never reported to Argos.

Mk10 PAT tags measure depth from 0 to 2000 m with a resolution of 0.5 m and temperature from 0 to +40 degrees C with a resolution of 0.05 degree C. The tags were used as supplied by the manufacturer without additional calibration.

References:
Gilly, W.F., Zeidberg, L.D., Booth, J.A.T, Stewart, J.S., Marshall, G., Abernathy, K., and Bell, L.E. 2012. Locomotion and behavior of Humboldt squid, *Dosidicus gigas*, in relation to natural hypoxia in the Gulf of California, Mexico. The Journal of Experimental Biology, 215, 3175-3190. doi: 10.1242/jeb.072538.
Gilly, W.F., Markaida, U., Baxter, C.H., Block, B.A., Boustany, A., Zeidberg, L., Reisenbichler, K., Robinson, B., Bazzino, G., and Salinas, C. 2006. Vertical and horizontal migrations by the jumbo squid *Dosidicus gigas* revealed by electronic tagging. Marine Ecology Press Series, 324, 1-17. doi: 10.3354/meps324001.
Stewart, J.S., Field, J.C., Markaida, U., and Gilly, W.F. 2013. Behavioral ecology of jumbo squid (*Dosidicus gigas*) in relation to oxygen minimum zones. Deep Sea Research Part II: Topical Studies in Oceanography, 95, 197-208. doi: 10.1016/j.dsr2.2012.06.005.

Data Processing Description

Counts of presence in each 50 m depth bin were made from the 75 s time-series data using Matlab scripts. Each count represents a 75 s interval. Daytime and nighttime were defined by times of local sunrise and sunset (http://aa.usno.navy.mil/data/docs/RS_OneYear.php). Time-at-depth histograms were computed from these data and reported as counts (75 s intervals) in 50 m depth bins for individual day and night periods. Note: Day 1 of deployment and the final day are not 24 hour days, because tag activation and pop-off occurred at arbitrary times.

[table of contents | back to top]

Data Files

File
time_at_depth.csv (Comma Separated Values (.csv), 208.72 KB) MD5:0e9cf189b8f5fbfd9582d39eca65525b
Primary data file for dataset ID 471977

[table of contents | back to top]

Parameters

Parameter	Description	Units
squid_id	Unique squid identifier.	dimensionless
tag_id	Unique tag identifier.	dimensionless
descrip	Description of sampling location and time of year. CCS = California Current System; GOC = Gulf of California.	dimensionless
dorsal_mantle_len	Dorsal mantle length (DML).	centimeters (cm)
date_start	Year, month, and day when the tag was deployed on the squid in YYYYmmdd format.	unitless
lat_start	Latitude at the time of deployment. Positive values = North.	decimal degrees
lon_start	Longitude at the time of deployment. Negative values = West.	decimal degrees
date_end	Year, month, and day when the tag detached from the squid in YYYYmmdd format.	unitless
lat_end	Latitude at the time the tag detached. Positive values = North.	decimal degrees
lon_end	Longitude at the time the tag detached. Negative values = West.	decimal degrees
sampling_time	Total number of sampling days.	number of days
max_depth	Maximum depth achieved by squid.	meters (m)
recovered	Indicates if the tag was physically recovered.	yes/no
deploy_day	Day of total tag deployment starting on Day 1.	dimensionless
depth_m	Depth.	meters (m)
count_night	Number of counts spent in given temperature bin during nighttime (sunset to sunrise). Each count represents 75 seconds.	Number of counts (1 count = 75 seconds)
count_day	Number of counts spent in given temperature bin during daytime (sunrise to sunset). Each count represents 75 seconds.	Number of counts (1 count = 75 seconds)

Instruments

Dataset-specific Instrument Name	MK10 PAT
Generic Instrument Name	Wildlife Computers Mk10 Pop-up Archival Tag (PAT)
Dataset-specific Description	Mk10-PAT tags (Wildlife Computers, Redmond, WA) were programmed to sample at 0.5 Hz or 1 Hz. Tags deployed in Monterey Bay (CCS-1through CCS-6) were programmed to transmit time series data (75 s intervals = 0.01333 Hz) to the Argos satellite system. Tags deployed in the Gulf of California (GOC-1 through GOC-6) were physically recovered. Mk10 PAT tags measure depth from 0 to 2000 m with a resolution of 0.5 m and temperature from 0 to +40 degrees C with a resolution of 0.05 degree C. The tags were used as supplied by the manufacturer without additional calibration.
Generic Instrument Description	The Pop-up Archival Transmitting (Mk10-PAT) tag, manufactured by Wildlife Computers, is a combination of archival and Argos satellite technology. It is designed to track the large-scale movements and behavior of fish and other animals which do not spend enough time at the surface to allow the use of real-time Argos satellite tags. The PAT can be configured to transmit time-at-depth and time-at-temperature histograms, depth-temperature profiles, and/or light-level curves. The histogram duration (1 to 24 hours) and bin ranges can also be configured. PAT archives depth, temperature, and light-level data while being towed by the animal. At a user-specified date and time, the PAT actively corrodes the pin to which the tether is attached, thus releasing the PAT from the animal. The PAT then floats to the surface and transmits summarized information via the Argos system. Argos also uses the transmitted messages to provide the position of the tag at the time of release.

Deployments

Gilly_Squid_CCS1

Website	https://www.bco-dmo.org/deployment/471957
Platform	R/V R4107
Start Date	2009-11-04
End Date	2009-11-05

Gilly_Squid_GOC1

Website	https://www.bco-dmo.org/deployment/472157
Platform	R/V Pacific Storm
Start Date	2007-03-13
End Date	2007-03-13

Gilly_Squid_GOC2

Website	https://www.bco-dmo.org/deployment/472155
Platform	Chartered Vessel
Start Date	2004-10-25
End Date	2008-11-16
Description	Multiple deployments during 2004 and 2008 in the California Current System (CCS) and Gulf of California (GOC) for the purpos of squid tagging. Various vessels were used, including the following: October 2004 -- small, privately owned vessel May 2008 -- Pez Sapo, Baja Expeditions, La Paz, BCS, Mexico (http://bajaex.com/)

Gilly_Squid_GOC3

Website	https://www.bco-dmo.org/deployment/472193
Platform	R/V BIP XII
Start Date	2008-11-16
End Date	2008-11-16

Project Information

Hypoxia and the ecology, behavior and physiology of jumbo squid, Dosidicus gigas (Jumbo Squid Physiology)

Coverage: Guaymas Basin, Gulf of California, Mexico (27 N 112 W) and Monterey Bay, CA (36 N 123 W)

This project concerns the ecological physiology of *Dosidicus gigas*, a large squid endemic to the eastern Pacific where it inhabits both open ocean and continental shelf environments. Questions to be addressed include:
1) How does utilization of the OML by *D. gigas* vary on both a daily and seasonal basis, and how do the vertical distributions of the OML and its associated fauna vary?
2) What behaviors of squid are impaired by conditions found in the OML, and how are impairments compensated to minimize costs of utilizing this environment? and
3) What are the physiological and biochemical processes by which squid maintain swimming activity at such remarkable levels under low oxygen conditions?

The investigators will use an integrated approach involving oceanographic, acoustic, electronic tagging, physiological and biochemical methods. *D. gigas* provides a trophic connection between small, midwater organisms and top vertebrate predators, and daily vertical migrations between near-surface waters and a deep, low-oxygen environment (OML) characterize normal behavior of adult squid. Electronic tagging has shown that this squid can remain active for extended periods in the cold, hypoxic conditions of the upper OML. Laboratory studies have demonstrated suppression of aerobic metabolism during a cold, hypoxic challenge, but anaerobic metabolism does not appear to account for the level of activity maintained. Utilization of the OML in the wild may permit daytime foraging on midwater organisms. Foraging also occurs near the surface at night, and Dosidicus may thus be able to feed continuously. *D. gigas* is present in different regions of the Guaymas Basin on a predicable year-round basis, allowing changes in squid distribution to be related to changing oceanographic features on a variety time scales.

This research is of broad interest because *Dosidicus gigas* has substantially extended its range over the last decade, and foraging on commercially important finfish in invaded areas off California and Chile has been reported. In addition, the OML has expanded during the last several decades, mostly vertically by shoaling, including in the Gulf of Alaska, the Southern California Bight and several productive regions of tropical oceans, and a variety of ecological impacts will almost certainly accompany changes in the OML. Moreover, *D. gigas* currently supports the world's largest squid fishery, and this study will provide acoustic methods for reliable biomass estimates, with implications for fisheries management in Mexico and elsewhere.

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). This is a Collaborative Research project encompassing three NSF-OCE awards.

Background Publications:

Stewart, J.S., Field, J.C., Markaida, U., and Gilly, W.F. 2013. Behavioral ecology of jumbo squid (*Dosidicus gigas*) in relation to oxygen minimum zones. Deep Sea Research Part II: Topical Studies in Oceanography, 95, 197-208. doi:10.1016/j.dsr2.2012.06.005.

Gilly, W.F., Zeidberg, L.D., Booth, J.A.T, Stewart, J.S., Marshall, G., Abernathy, K., and Bell, L.E. 2012. Locomotion and behavior of Humboldt squid, *Dosidicus gigas*, in relation to natural hypoxia in the Gulf of California, Mexico. The Journal of Experimental Biology, 215, 3175-3190. doi: 10.1242/jeb.072538.

Related Project: Physiological limits to vertical migrations of the pelagic, jumbo squid, Dosidicus gigas in the Gulf of California

Physiological limits to vertical migrations of the pelagic, jumbo squid, Dosidicus gigas in the Gulf of California (Jumbo Squid Vertical Migration)

Coverage: Gulf of California

Description from NSF award abstract:
Inshore and open-ocean (pelagic) squid are the most athletic of all invertebrates. They are highly active, jet-propelled swimmers, have high metabolic rates and grow at a prodigious rate throughout their short life spans of one to two years. Such squid are abundant in all the world's oceans where they play important ecological roles as major predators. Adult squid serve as essential prey for many top predators, including sharks, tuna, billfish and marine mammals. In addition, squid are becoming increasingly important in commercial fisheries worldwide as they replace slow-growing fish, particularly where these stocks are being depleted. *Dosidicus gigas*, also known as the jumbo or Humboldt squid, is a true giant, reaching 2-3 m in overall length and over 50 kg in mass. It is widely distributed over the eastern Pacific, ranging from Chile to Canada and nearly to Hawaii at the equator. It forms the basis of a major commercial fishery, presently the third largest in Mexico. Despite the ecological and economic importance of *D. gigas*, little is known about its life history, behavior or physiology. Its large size and open-ocean habitat complicate traditional field and laboratory studies. This project focuses on integrative field and laboratory studies of *D. gigas* in the Gulf of California using recently developed techniques that facilitate such studies. Pilot tagging studies have revealed that *D. gigas* spends the daytime in cold, deep, oxygen-depleted water (~10 deg C at 300 meters) and migrates at night to shallow, aerated surface waters that can reach 30 deg C. Frequent rapid dives at night to daytime depths cover several hundred meters in minutes. It is a mystery how these large, metabolically active squid can tolerate the stress of chronic daytime hypoxia at depth. Conversely, warm surface waters also may present a stress that limits the time squid can spend in this zone. This proposal will employ electronic tagging to track vertical migrations of this pelagic predator and to monitor natural jetting and respiration at different depths. Oxygen consumption determined from these data, with calibrations provided by laboratory swim-tunnel experiments and biochemical indices of anaerobic metabolism, will provide a measure of the true energetic costs to the squid itself. Extreme low-light video methods will reveal natural behaviors over the range of a typical vertical migration, both day and night. Thus, this project will reveal what this remarkable squid is doing in its oceanic habitat, why it is doing it, and what physiological and biochemical adaptations permit these behaviors at some depths and preclude them at others.

This study will greatly advance our understanding of the biology of *D. gigas* and provide a model for an integrated approach to studying the ecological physiology of other pelagic predators. It will also establish a life-history framework that will ultimately be necessary to manage this fishery at the ecosystem level in Mexico and elsewhere.

Related Project: Hypoxia and the ecology, behavior and physiology of jumbo squid, *Dosidicus gigas*

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0850839
California Sea Grant (CASG)	R/OPCFISH-06
NSF Division of Ocean Sciences (NSF OCE)	OCE-0526640