Autonomous Behaving Lagrangian Explorer (ABLE) output for 5 taxonomic groups examined from the R/V Cape Horn in the upwelling region of the west coast of California, USA in August 2015

Website: https://www.bco-dmo.org/dataset/681042
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Project
» Collaborative Research: Field test of larval behavior on transport and connectivity in an upwelling regime (ABLE)

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Abstract
Autonomous Behaving Lagrangian Explorer (ABLE) output for 5 taxonomic groups (Cyprid, Melibe, Pluteus, Pteropod, and Velella) from the R/V Cape Horn in the upwelling region of the west coast of California, USA in August 2015.

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Coverage

Spatial Extent: **N**:38.309512 **E**:-122.963942 **S**:38.218773 **W**:-123.08404
Temporal Extent: 2015-08-19 - 2015-08-21

Dataset Description

Autonomous Behaving Lagrangian Explorer (ABLE) output for 5 taxonomic groups (Cyprid, Melibe, Pluteus, Pteropod, and Velella).

Methods & Sampling

Sampling:
ABLE 6218 (aka Velella) – constant depth of 3m
ABLE 6155 (aka Cyprid) – diel vertical migration 3-15m, 2.0 cm/s, up 3:00/down 13:00
ABLE 6157 (aka Pteropod) – diel vertical migration 3-15m, 2.0 cm/s, up 3:00/down 13:00
ABLE 5996 (aka Pluteus) – constant depth 15m
ABLE 6031 (aka Melibe) – constant depth 15m

We simulated documented behaviors using the Autonomous Behaving Lagrangian Explorer (ABLE). ABLE, designed by Tom Wolcott, is a biomimetic robotic drifter that senses in situ environmental stimuli (e.g., variations in PAR, pressure, salinity, or temperature). It can be programmed to maintain depth or vertically migrate in response to *in-situ* variables, like the larvae under study. It can reveal quasi-Lagrangian transport of vertically migrating plankters that swim between water parcels at different depths. ABLE weighs 3 kg and is 36 cm tall, topped by a 15 cm antenna mast. It necessarily integrates water motions at and below its own scale. Consequently, it cannot mimic transport of individual plankters, nor diffusive processes at scales smaller than its own. ABLE best simulates the transport of the centroid of a cloud of plankters that is large relative to its own dimensions.

ABLE dynamically calculates its target depth from measurements of its immediate microenvironment and a behavioral model for the organism being simulated. It moves toward the new target depth at a biologically realistic velocity, permitting it to show transport consequences of adaptive behaviors in response to actual (not average) conditions and actual (not modeled) water movements. Because behavioral patterns are under the experimenter's control, ABLE can reveal effects of either known or hypothetical behavior patterns. ABLE has no structures outside the parcel of water in which it is embedded, hence no extraneous drag that would cause drift errors. Use of ABLE (unlike modeling) requires no a priori characterization of the system before the first data can be collected; immediately upon deployment it begins yielding information on how water and organisms in the system move.

Although ABLE has no extraneous drag, hence no drift errors, while embedded in the tracked water parcel, it must periodically leave that parcel and make excursions to the surface to obtain and transmit GPS fixes. A drift error is created by velocity differences (relative to the target parcel) at other depths multiplied by the time ABLE spends transiting each during a pop-up, which cannot be simply estimated in heterogeneous systems. A rule of thumb analogous to that for suspended-drogue drifters would be that ABLE must spend <1/40 of the time making excursions to the surface. As target (operating) depth increases, transit time to the surface increases, and hence allowable fix frequency decreases.

To facilitate tracking, it has an ultrasonic beacon that provides bearings and telemeters depth during operation at depth; when at the surface it obtains fixes from its GPS receiver and transmits the fix data by VHF radio (short range) and satellite modem (global range). The GPS fix obtained at each surface interval is logged in ABLE's data memory, even if it is not received by the Globalstar satellite system. To facilitate recovery at the sea surface, it transmits updated fixes continuously by VHF and periodically via satellite while blinking high-brightness LED beacons for visual fixes. We also command ABLE to surface for recovery by decoding ultrasonic signals while rejecting noise from surf and biota. It senses the bottom and swims up a programmed distance above the substrate.

When deployed, it uses measurements of *in-situ* variables (depth, T, S, PAR, time of day, vertical speed relative to water). It subtly adjusts buoyancy (by < 1g) to "swim" toward that target depth, maintaining a rate realistic for the organism being simulated (0 to >10 cm/s). It periodically pops to the surface to obtain a GPS fix and transmit it by VHF, ultrasonic pinger and satellite (or cell phone) modem. Along its entire trajectory, it logs *in-situ* measurements; the suite of variables and frequency of logging are user-selectable. On the bench, ABLE communicates by wireless Bluetooth with a host computer or smart phone and presents a menu for downloading logged data, testing and calibrating sensors, altering data logging parameters, or even rewriting the entire program. Endurance during deployments is about 2 wk with 7 NiMH "D" cells, depending on frequency of excursions to the surface and pumping of ballast to hoist antennas.

ABLEs were deployed by boat at pre-defined locations and retrieved a pre-defined number of days later.

Data Processing Description

Data has been manually reformatted to accommodate columns and rows.

Flag descriptions:
0 – no QC,
1 – good,
2 – unreliable,
3 – bad,
4 – changed,
5 – no data.

BCO-DMO Processing:
-modified parameter names to conform with BCO-DMO naming conventions;
-formatted dates to yyyy-mm-dd and times to HH:MM:SS;
-replaced blanks (missing data) with 'nd';
-added ISO_DateTime_UTC field using original date and time columns.

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Data Files

File
ABLE.csv (Comma Separated Values (.csv), 9.83 MB) MD5:d7263d0c425f80240184ad99bfb07165 Primary data file for dataset ID 681042

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Parameters

Parameter	Description	Units
taxon	Taxonomic group examined using ABLE	unitless
cumulative_secs	Cumulative seconds	seconds
date_utc	Date (UTC) formatted as yyyy-mm-dd	unitless
time_utc	Time (UTC) formatted as HH:MM:SS	unitless
Z	Current depth	meters (m)
Z_flag	Quality flag for current depth: 0 – no QC, 1 – good, 2 – unreliable, 3 – bad, 4 – changed, 5 – no data.	unitless
target_Z	Target depth in meters	meters (m)
Z_bot	Assumed bottom depth	meters (m)
temp	Temperature	degrees Centigrade (C)
temp_flag	Quality flag for temperature: 0 – no QC, 1 – good, 2 – unreliable, 3 – bad, 4 – changed, 5 – no data	unitless
PAR	Photosynthetically active radiation (PAR)	moles per square meter per second (mol m-2 s-1)
PAR_flag	Quality flag for PAR: 0 – no QC, 1 – good, 2 – unreliable, 3 – bad, 4 – changed, 5 – no data	unitless
sal	Salinity	practical salinity scale (PSU)
sal_flag	Quality flag for salinity: 0 – no QC, 1 – good, 2 – unreliable, 3 – bad, 4 – changed, 5 – no data	unitless
ang_vel_X	Angular velocity in x direction	unitless (raw counts from the gyro)
ang_vel_Y	Angular velocity in y direction	unitless (raw counts from the gyro)
ang_vel_Z	Angular velocity in z direction	unitless (raw counts from the gyro)
pump_down	Number of pump strokes in a downward direction	unitless
pump_up	Number of pump strokes in an upward direction	unitless
lat	Latitude	decimal degrees
lon	Longitude	decimal degrees
DOP	Dilution of precision for GPS quality	unitless
batt_V	Battery voltage	volts
ISO_DateTime_UTC	Date and time (UTC) formatted ISO 8601 standard: yyyy-mm-ddTHH:MM:SS.xxZ (where T indicates the start of the time string and Z indicates UTC)	unitless

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Instruments

Dataset-specific Instrument Name	ABLE
Generic Instrument Name	Autonomous Behaving Lagrangian Explorer
Generic Instrument Description	The Autonomous Behaving Lagrangian Explorer (ABLE), designed by Tom Wolcott, is a biomimetic robotic drifter that senses in situ environmental stimuli (e.g., variations in PAR, pressure, salinity, or temperature) and can be programmed to respond to these cues with vertical migration behavior like that of the planktonic organism of interest.

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Deployments

20150821_CapeHorn

Website	https://www.bco-dmo.org/deployment/681036
Platform	R/V Cape Horn
Start Date	2015-08-19
End Date	2015-08-21

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Project Information

Collaborative Research: Field test of larval behavior on transport and connectivity in an upwelling regime (ABLE)

Coverage: Upwelling region, West coast of USA, Northern California

Description from NSF award abstract:
The majority of larvae of coastal marine species are planktonic and generally weak swimmers. Thus, they are thought to be dispersed widely by coastal currents. However, there is accumulating evidence that their behavior can strongly influence their transport: some remain within estuaries, while others make true migrations between adult and larval habitats, even out to the edge of the continental shelf and back. Rates and directions of larval transport are thought to be determined largely by the timing, duration, and amplitude of vertical migrations and the mean depth that larvae occupy in stratified flows. The PIs propose to provide one of the first direct tests of how behavior affects across-shelf and alongshore transport using biomimetic drifters. The study will be conducted in a region of persistent upwelling, where strong currents are widely believed to overwhelm larval swimming and limit recruitment to adult populations.

Knowledge of underlying mechanisms regulating larval transport is central to understanding ecology and evolution in the sea and anticipating the impacts of climate change on marine populations and communities. The proposed research will provide the first experimental field-test of how larval behavior affects the rates, directions and distances of transport and population connectivity in an upwelling regime. The PIs will test three hypotheses:

1. Residence below the wind-driven surface layer and vertical migrations below that layer keep larvae closer to shore compared to residence in the surface layer or larvae without depth preferences and vertical migration.

2. Residence at depth enhances northward transport near shore, and vertical migration leads to decreased alongshore mean displacement but increased variance for a group.

3. Depth preferences and vertical migrations have pronounced effects on retention and transport of plankton in upwelling regions.

The study will compare direct measurements from mimetic drifters with observed and modeled cross-shelf larval distributions, and with modeled alongshore transport. Results will be broadly applicable to upwelling regimes along the western margins of continents, and the approach can be applied to non-upwelling systems throughout the world.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1334448
NSF Division of Ocean Sciences (NSF OCE)	OCE-1334553

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