Export fluxes of Th, POC, PON and bSi calcuated using sediment traps and thorium budget from samples collected on R/V Yellowfin cruises to the San Pedro Ocean Time-series (SPOT) in 2013 and 2014

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Data Type: Other Field Results
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Project
» Collaborative Research: Use of Triple Oxygen Isotopes and O2/Ar to constrain Net/Gross Oxygen Production during upwelling and non-upwelling periods in a Coastal Setting (UpRISEE O2 upwelling)

Contributors	Affiliation	Role
Haskell, William	University of California-Santa Barbara (UCSB-MSI)	Principal Investigator
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Coverage

Spatial Extent: **Lat**:33.55 **Lon**:-118.4
Temporal Extent: 2013-01-16 - 2014-06-19

Dataset Description

Export fluxes of Th, POC, PON and bSi calcuated using sediment traps and thorium budget. Measurements were made at the San Pedro Ocean Time-series (SPOT) station (33 33'N, 118 24'W). Data are also published in Table 4 in the following publication:
Haskell, W. Z., et al. 2016. An organic carbon budget for coastal Southern California determined by estimates of vertical nutrient flux, net community production and export. Deep-Sea Research I, 116, 49-76. doi:10.1016/j.dsr.2016.07.003

Methods & Sampling

See complete methodology in Haskell et al. (2016). In summary:
This study is part of an effort aimed at characterizing the biological response to upwelling at SPOT on 21 cruises between January 2013 and June 2014; the Upwelling Regime In-Situ Ecosystem Efficiency (Up.R.I.S.E.E.) study.

Sediment traps: During 13 of the 22 cruises, one string of surface-tethered drifting sediment traps containing two Particle-Interceptor-Traps (PITs) was deployed at 100 m and 200 m. A 50 m section of 1-inch thick bungee cord was inserted to dampen the movement caused by waves. A series of five surface buoys were attached to the line and to a mast buoy, which held a strobe light, radio transmitter, radar reflector and Pacific Gyre GPS satellite transmitter. Each trap had a total surface area of 0.0851 m2. All traps had 12 collection tubes with an aspect ratio of 6.4 and had 1 cm x 1 cm baffles fitted into the top opening of the tubes. Funnels with centrifuge tubes were attached into the base of each trap tube. The centrifuge tube (50 ML) contained a brine solution of NaCl (in excess of sea water by 5 ppt) prepared from filtered seawater that was poisoned with 3% formaldehyde and buffered with disodium tetraborate. Deployments averaged 25 h, and were typically deployed near noon. After recovery, each trap was covered and allowed to settle for at least 1 h before the water overlying the centrifuge tubes was siphoned off and the tubes removed from the bottom of each trap tube and capped. For all trap deployments, material from each trap were then filtered onto Whatman Nuclepore polycarbonate membrane (0.4 um) filters and left to dry at room temperature for 2 days. Each filter was folded and put in a counting tube, and placed in a gamma detector (same as Th analysis) to measure thorium and beryllium activities. After counting, the filters were removed from the tubes, the trap material scraped off and homogenized into powder with a mortar and pestle, then divided into three splits. One split was placed in silver foil, acidified with HCl fumes to drive off the inorganic C, and then pelletized. One split was placed in tin foil without acidification. Both splits were sent to the UC Davis Stable Isotope Facility (SIF) for C and N elemental analysis via an isotope ratio mass spectrometer. A third split was transferred to a centrifuge tube for digestion in Na2CO3 to measure biogenic silica (SiO2) using colorimetric analysis at USC. The results of each analysis were then scaled up by weight percent to the initial mass weight of the entire trap catch. Uncertainty in surface-tethered sediment trap fluxes are reported here as +/- 50%.

Sediment trap-based export production: Rates of carbon and nitrogen export in sinking particles from the
surface ocean were calculated during 13 surface-tethered sediment trap deployments. Biogenic Si (bSi) was measured in trap material during 9 of the 13 trap deployments.

Thorium-234: Vertical profiles from the surface to 200 m were collected for thorium via Niskin/CTD on every cruise. Ten liters were collected at eight depths, chosen based on the fluorescence profile observed during the CTD's descent. A 229Th spike of known activity was added to the samples as they were being transferred from Niskins into 10 L or 20 L polycarbonate carboys (to an activity ~0.9 dpm/L) and allowed to equilibrate for at least 24 h. The recovery yield of 229Th in each sample was used in all calculations of 234Th to correct for methodological efficiency. The samples were coprecipitated with MnO2 using the technique originally developed by Rutgers van der Loeff and Moore (1999) and detailed in Haskell et al. (2013). Samples were filtered onto a 0.45 um Pall Supor Membrane filter (142 mm). The filters were dried at room temperature, placed in a plastic test tube, and placed in an Ortec low background gamma detector (intrinsic germanium, well-type, 150cc active volume).

234Th/238U disequilibrium: In order to constrain particle export, we calculated 234Th export from the upper 100 m, by integrating the 234Th/238U disequilibrium. The disequilibrium at each station was calculated using trapezoidal integration of the difference between 238U activity and 234Th activity from the surface to the depth at which the sediment traps were deployed. We use the approach outlined in Haskell et al. (2015b) when calculating the particle export of 234Th (PTh), assuming steady-state. The export flux of particulate organic carbon (POC) out of the zone of 234Th deficiency can be estimated from PTh if the ratio of POC:234Th in sinking particles is established. In this study, POC and 234Th were measured on material caught in sediment traps set at 100 m and 200 m. This ratio is then used in the following equation to estimate POC export:

POCflux = PTh * (POC: 234Th)

For 7 of the 20 sampling periods, there were not any accompanying sediment traps to measure the ratio. For these, we used the most recent ratio measured in the calculation of POC flux, except for the first cruise (SP42) where we used the seasonal average since it occurred a month prior to the most recent trap deployment.

Thorium-based export: The 234Th: 238U disequilibrium approach for estimating POC export was used for every cruise except Up-14 and Up-16, providing insight into particle export fluxes between sediment trap deployments. Generally, export estimates calculated using this approach agreed well with those calculated using the sediment trap approach, although in most cases, they were larger in magnitude.

Data Processing Description

BCO-DMO Processing:

-modified parameter names to conform with BCO-DMO naming conventions;
-formatted dates to yyyy-mm-dd;
-replaced "-" and blanks (missing data) with "nd";
-added site name, lat, and lon from information on metadata form.

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Data Files

File
export_fluxes.csv (Comma Separated Values (.csv), 7.28 KB) MD5:94edb06535f195c2680b2b281af71a0c Primary data file for dataset ID 684872

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Parameters

Parameter	Description	Units
site	Name of the site	unitless
lat	Latitude of the site	decimal degrees
lon	Longitude of the site	decimal degrees
cruise_id	Cruise identifier	unitless
date	Date of sampling formatted as yyyy-mm-dd	unitless
year	4-digit year	unitless
month	2-digit month	unitless
day	2-digit day	unitless
yrday	Year day (sequential day of year, eg. Jan 1 = 1)	unitless
depth	Sample depth	meters (m)
mass_flux_sed	Sediment trap-based mass flux	milligrams per square meter per day (mg m-2 d-1)
Corg_to_Th_sed	Ratio of organic carbon to thorium (sediment trap-based)	micromoles per disintegrations per minute (umol dpm-1)
Be_to_Th_sed	Ratio of beryllium to thorium (sediment trap-based)	unitless
Corg_to_N_sed	Ratio of organic carbon to nitrogen (sediment trap-based)	unitless
bSi_to_Th_sed	Ratio of biogenic silica to thorium (sediment trap-based)	micromoles per disintegrations per minute (umol dpm-1)
Th_flux_sed	Sediment trap-based thorium flux	disintegrations per minute per square meter per day (dpm m-2 d-1)
Th_flux_sed_sd	Standard deviation of sediment trap-based thorium flux. Uncertainty is reported as 50% for all sediment trap deployments.	disintegrations per minute per square meter per day (dpm m-2 d-1)

Corg_flux_sed	Sediment trap-based organic carbon flux	millimoles per square meter per day (mmol m-2 d-1)
Corg_flux_sed_sd	Standard deviation of sediment trap-based organic carbon flux. Uncertainty is reported as 50% for all sediment trap deployments.	millimoles per square meter per day (mmol m-2 d-1)
N_flux_sed	Sediment trap-based nitrogen flux	millimoles per square meter per day (mmol m-2 d-1)
N_flux_sed_sd	Standard deviation of sediment trap-based nitrogen flux. Uncertainty is reported as 50% for all sediment trap deployments.	millimoles per square meter per day (mmol m-2 d-1)
bSi_flux_sed	Sediment trap-based biogenic silica flux	millimoles per square meter per day (mmol m-2 d-1)
bSi_flux_sed_sd	Standard deviation of sediment trap-based biogenic silica flux. Uncertainty is reported as 50% for all sediment trap deployments.	millimoles per square meter per day (mmol m-2 d-1)
Th_flux_Th	Thorium flux, using the thorium-based approach	disintegrations per minute per square meter per day (dpm m-2 d-1)
Th_flux_Th_sd	Standard deviation of thorium flux, using the thorium-based approach. Uncertainty in Th-based approach calculated by propagating uncertainty in upwelling velocity and Th deficiency.	disintegrations per minute per square meter per day (dpm m-2 d-1)
Corg_flux_Th	Organic carbon flux, using the thorium-based approach	millimoles per square meter per day (mmol m-2 d-1)
Corg_flux_Th_sd	Standard deviation of organic carbon flux, using the thorium-based approach. Uncertainty in Th-based approach calculated by propagating uncertainty in upwelling velocity and Th deficiency.	millimoles per square meter per day (mmol m-2 d-1)
N_flux_Th	Nitrogen flux, using the thorium-based approach	millimoles per square meter per day (mmol m-2 d-1)
N_flux_Th_sd	Standard deviation of nitrogen flux, using the thorium-based apporach. Uncertainty in Th-based approach calculated by propagating uncertainty in upwelling velocity and Th deficiency.	millimoles per square meter per day (mmol m-2 d-1)
bSi_flux_Th	Biogenic silica flux, using the thorium-based approach	millimoles per square meter per day (mmol m-2 d-1)
bSi_flux_Th_sd	Standard deviation of biogenic silica flux, using the thorium-based approach. Uncertainty in Th-based approach calculated by propagating uncertainty in upwelling velocity and Th deficiency.	millimoles per square meter per day (mmol m-2 d-1)
Mean_Corg_flux	Mean organic carbon flux	millimoles per square meter per day (mmol m-2 d-1)
Mean_Corg_flux_sd	Standard deviation of mean organic carbon flux. Uncertainty is reported as the same as in Th-based approach.	millimoles per square meter per day (mmol m-2 d-1)

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Instruments

Dataset-specific Instrument Name	Seabird CTD
Generic Instrument Name	CTD Sea-Bird
Dataset-specific Description	Vertical profiles from the surface to 200 m were collected for thorium via Niskin/CTD on every cruise.
Generic Instrument Description	Conductivity, Temperature, Depth (CTD) sensor package from SeaBird Electronics, no specific unit identified. This instrument designation is used when specific make and model are not known. See also other SeaBird instruments listed under CTD. More information from Sea-Bird Electronics.

Dataset-specific Instrument Name	Isotope-ratio mass spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Splits were sent to the UC Davis Stable Isotope Facility (SIF) for C and N elemental analysis via an isotope ratio mass spectrometer.
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Vertical profiles from the surface to 200 m were collected for thorium via Niskin/CTD on every cruise.
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

Dataset-specific Instrument Name	surface-tethered drifting sediment traps
Generic Instrument Name	Sediment Trap
Dataset-specific Description	During 13 of the 22 cruises, one string of surface-tethered drifting sediment traps containing two Particle-Interceptor-Traps (PITs) was deployed at 100 m and 200 m.
Generic Instrument Description	Sediment traps are specially designed containers deployed in the water column for periods of time to collect particles from the water column falling toward the sea floor. In general a sediment trap has a jar at the bottom to collect the sample and a broad funnel-shaped opening at the top with baffles to keep out very large objects and help prevent the funnel from clogging. This designation is used when the specific type of sediment trap was not specified by the contributing investigator.

Dataset-specific Instrument Name	Particle-Interceptor-Traps (PITs)
Generic Instrument Name	Sediment Trap - Particle Interceptor
Dataset-specific Description	During 13 of the 22 cruises, one string of surface-tethered drifting sediment traps containing two Particle-Interceptor-Traps (PITs) was deployed at 100 m and 200 m.
Generic Instrument Description	A Particle Interceptor Trap is a prototype sediment trap designed in the mid 1990s to segregate 'swimmers' from sinking particulate material sampled from the water column. The prototype trap used 'segregation plates' to deflect and segregate 'swimmers' while a series of funnels collected sinking particles in a chamber (see Dennis A. Hansell and Jan A. Newton. September 1994. Design and Evaluation of a "Swimmer"-Segregating Particle Interceptor Trap, Limnology and Oceanography, Vol. 39, No. 6, pp. 1487-1495).

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Deployments

UpRISEE_SPOT_13-14

Website	https://www.bco-dmo.org/deployment/684011
Platform	R/V Yellowfin
Start Date	2013-01-16
End Date	2014-06-19
Description	A series of cruises were conducted from January 2013 to June 2014 to the San Pedro Ocean Time-Series (SPOT) station. These cruises were part of a study aimed at characterizing the biological response to upwelling at SPOT: the Upwelling Regime In-Situ Ecosystem Efficiency (Up.R.I.S.E.E.) study.

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Project Information

Collaborative Research: Use of Triple Oxygen Isotopes and O2/Ar to constrain Net/Gross Oxygen

Production during upwelling and non-upwelling periods in a Coastal Setting (UpRISEE O2 upwelling)

Coverage: Northeast Pacific Ocean

The marine biological pump is one of the primary pathways via which anthropogenic carbon dioxide may be sequestered from the atmosphere and exported to the deep ocean as organic carbon. While the link between nutrient supply and high primary productivity in upwelling regions is well established, factors controlling the organic carbon export efficiency of upwelling ecosystems are not well known. Scientists from the University of Southern California and Pomona College plan to determine the factors that control the rates and magnitudes of two components of biological production, Net Community Production (NCP) and Gross Primary Production (GPP), as well as particulate organic carbon export efficiency, at the San Pedro Ocean Time Series, a coastal site in the California Borderland during periods of minimal and high upwelling velocity over a 2-year span. At this site, past and ongoing observations of hydrography and carbon rain will provide an historical context for interpreting results and mechanisms at work.

Rates of NCP and GPP will be quantified at different upwelling intensity, using dissolved oxygen to argon (O2/Ar) ratios and the oxygen triple isotope composition of dissolved oxygen (O2). The export of organic carbon will be established using 234Th (thorium) profiles in the water column, coupled with floating sediment trap deployments, and the development of a carbon isotope balance for the water column. Upwelling will be characterized using non-steady state budgets for atmospheric 7Be (beryllium) input and its depth-integrated decay, as well as estimating rates based on remote measurements of wind stress curl and budgets for dissolved inorganic carbon and silicon. Application of the O2/Ar ratio and the oxygen triple isotope approach will require depth-integrated profiles of these tracers to evaluate the impact of upwelling on mixed layer inputs and use of non-steady state models during seasonal transitions in upwelling. The comprehensive data set to be obtained should provide insights into the organic carbon export efficiency under variable upwelling regimes and help to relate the satellite-based measurements of chlorophyll to the organic carbon export of these highly productive ecosystems.

Broader Impacts: One graduate and one undergraduate student from the University of Southern California and two undergraduate students from Pomona College would be supported and trained as part of this project.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1260296
NSF Division of Ocean Sciences (NSF OCE)	OCE-1260692

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