Oc1507b Cruise Report

California Current Ecosystem LTER Program

oc1507b, Student Cruise

R/V Oceanus, 28 July – August 2nd 2015

Compiled and Submitted by Brandon M. Stephens and Angel Ruacho

Scripps Institution of Oceanography, Univ. of California, San Diego

Cruise ID: oc1507b, aka CCE1507
Depart: 28 July at 0800 (PDT)
Return: 2 August at 0845
Vessel: R/V Oceanus
Operator: Oregon State University
Master: Captain Jeff Crews
Chief Scientists: Brandon M Stephens, Angel Ruacho
Marine Technicians: Eric Arneson, Sonia Brugger

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Additional Proposal Participants not on the cruise: Kylee Chang, Fanny Chenillat, Julie Dinasquet and Robert Letscher.

Science Objectives

The objectives originally proposed were two-fold: (1) to describe biogeochemical conditions surrounding surface organic matter and (2) to identify regions of enhanced benthic boundary exchange of the trace metal iron. To carry out these objectives we covered regions extending from Points Arguello and Conception to the CCE-2 Mooring (near CalCOFI Station 08.0 055.0), southward around the Channel Islands and eastward into the Santa Barbara basin (see map of locations in Appendix 1). Over 40 CTD casts were launched to collect surface water from surface euphotic zone depths and to identify the benthic boundary layer by beam transmittance. Additional work was set out to measure surface *p*CO2 concentrations by pumping flow-through water into a system developed by Kylee Chang (Martz lab), and two transects surrounding the CCE-2 Mooring provided context to the stationary time series. Further, several incubations were conducted on board to quantify zooplankton grazing, describe the chemical characteristics of fecal pellets produced by zooplankton, and to quantify the microbial degradation of surface organic matter as a function of micro- (iron) and macro-nutrient (nitrate) limitation. Finally, benthic organisms were collected via otter trawl to assess the relative biological impacts of varying dissolved oxygen concentrations; however, unfortunately, the trawl was lost during its second deployment thereby removing further opportunities to collect benthic organisms.

Overview of the Science Plan

Our study region primarily focused on the coastal regions surrounding Points Conception and Arguello as well as the benthic region surrounding the Channel Islands. The reason we selected these locations primarily stemmed from its relatively high levels of primary production associated with coastal upwelling, where we hypothesized that the benthic region is likely a significant source of the micronutrient iron to the surface ocean here. Further, we hypothesized that this region serves as a laterally transportable source of nutrients and accumulating organic matter.

We began the cruise by transiting from the 10th Ave. Terminal in San Diego to Point Conception, a transit requiring 22 hours. The following 24 hours comprised of a near- to offshore transect, covering four stations from Point Conception to the CCE2 Mooring. Twelve-hour shifts were then alternated over the following cruise three days between benthic boundary trace metal work during the day (Barbeau Lab) and surface organic matter, zooplankton experiments and hydrographic assessment during the night (Aluwihare, Mitchell and Landry Labs). With the extra free time due to the loss of the otter trawl, the study area and number of CTD casts increased for both the benthic boundary layer and surface biogeochemical work (see Appendix 1 for map of CTDs and pages 9-11 for a list of Daily Activities).

Group Reports

Surface Organic Matter and Nutrient Cycling – Aluwihare Group (B Stephens, N Arakawa, S Rivera, M White, W Mendoza)

Hydrography: A 12-bottle CTD rosette was deployed at night in order to provide hydrographic context for biogeochemical sampling. The CTD package had sensors for temperature, conductivity, photosynthetically active radiation (PAR), oxygen, chlorophyll fluorescence, beam attenuation by particles, and nitrate (ISUS). Samples were collected from Niskin bottles from four-to-five depths surrounding the chlorophyll maximum. Evidence of lower salinity for Cast003 (Table 1) and available ROMS model (Fig. 1) suggest that our offshore stations entered into the less saline southerly California Current waters, offering a contrasting source waters to nearshore environments likely influenced by northward flowing countercurrent waters.

Table 1. Average surface isopycnal (σ_θ<25.5 kg m^{-3}) hydrographic values from select casts.

Cast	Salinity (psu)	Temp (°C)	Oxygen (µM)	Fluorescence (µg L^{-1})	Nitrate (µM)
Cast001	*33.2*	*13.6*	*221.4*	*1.1*	*6.9*
Cast003	*32.5*	*14.2*	*224.7*	*1.3*	*7.0*
Cast031	*33.1*	*14.8*	*234.3*	*2.0*	*6.2*
Cast043	*33.3*	*14.1*	*227.6*	*1.8*	*9.9*

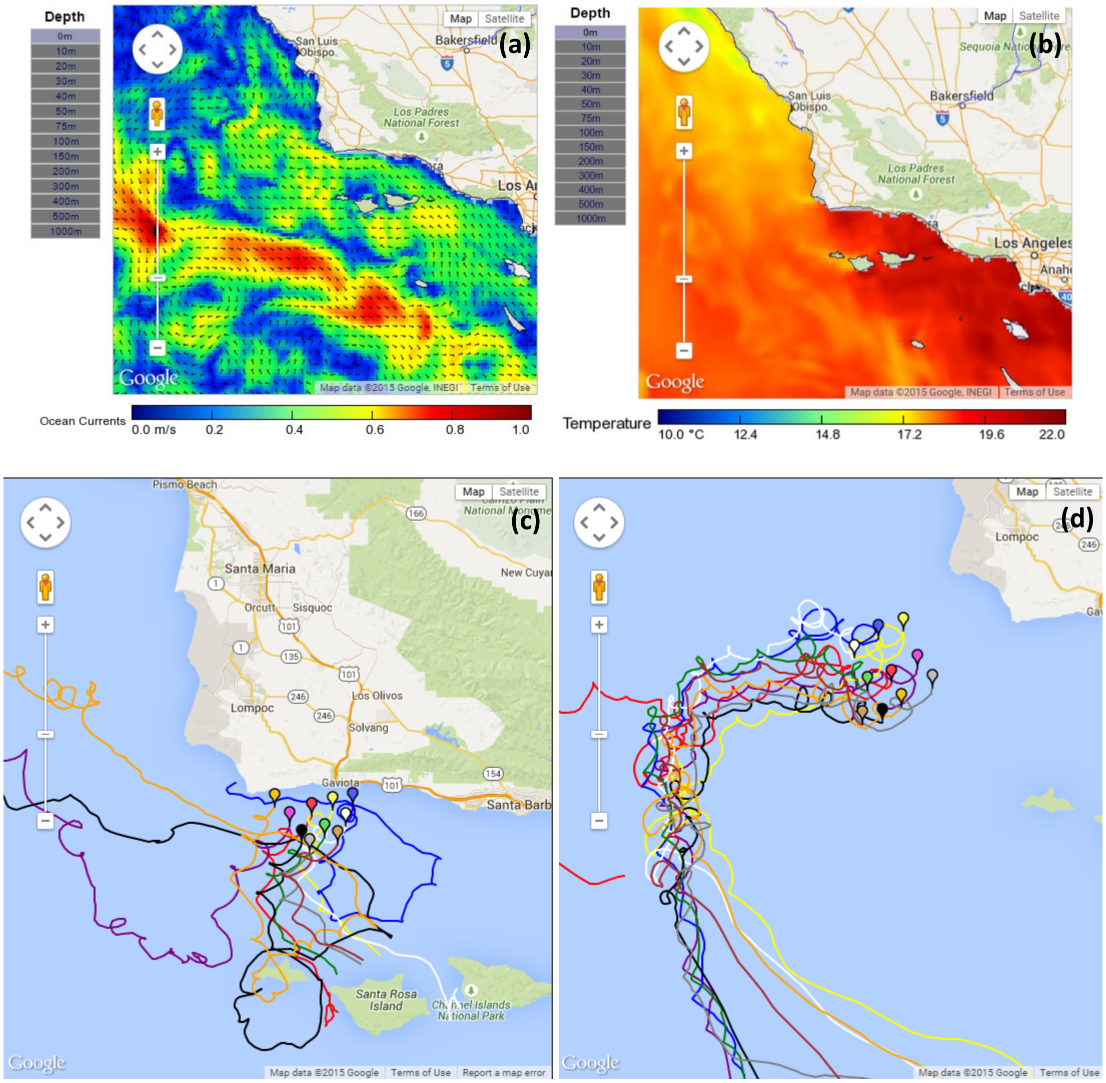

Fig. 1. Regional Ocean Model-based estimates of surface velocity and temperature (a and b) and surface water tracers run forward for four days starting from July 24th, 2015 (c and d). Data obtained from http://www.sccoos.org/.

Use of the California Current Ecosystem-owned nitrate sensor allowed for bottle depth selection of slight increases in nitrate concentrations. Such depths have been associated with the primary nitrite maximum, a feature associated with biological and chemical processes surrounding nitrogen cycling in the California Current (e.g., Santoro et al., 2013). An example profile below demonstrates usage of Niskin bottle selection for sampling the mixed layer depth, Chlorophyll maximum, nitricline and subeuphotic zone (Fig. 2).

For each of the primary depths highlighted in Fig 2 triplicate Niskin bottles were triggered for the collection of stable isotopes for size-fractionated particulate organic matter, size-fractionated chlorophyll, nutrients, total organic carbon, fluorescent dissolved organic matter, primary amine, ^{15}N of nitrate, 16s and 18s, bacteria counts and epifluorescence. Bottle samples were occasionally collected for salinity to verify that bottles were tripped at the appropriate depths. The combined measurements described above will contribute to theses dissertations for graduate students and research publications for post-doctoral researchers.

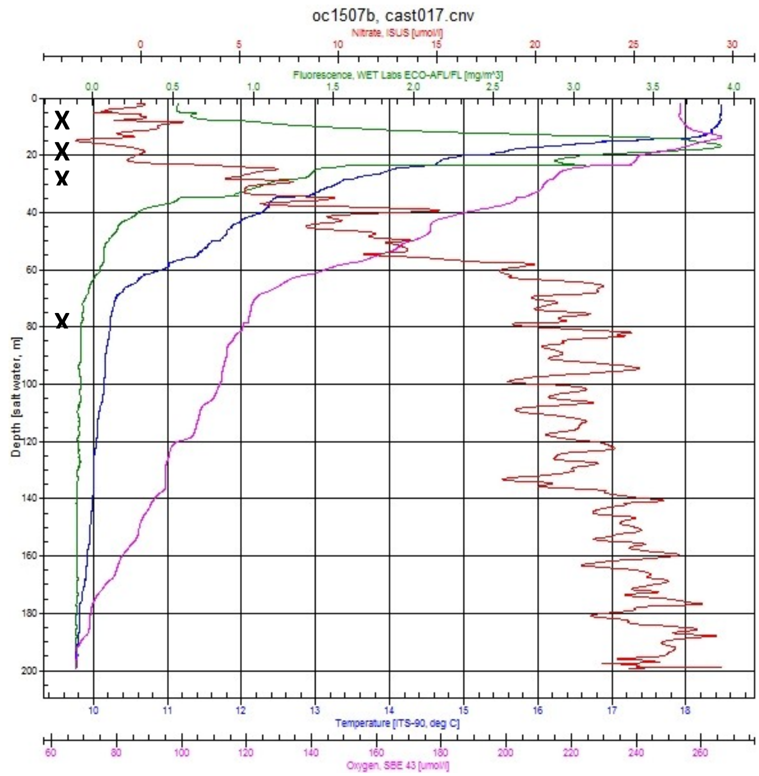

Fig. 2. CTD Cast017 profile of nitrate, fluorescence, oxygen and temperature. x's indicate typical profile features for which Niskin bottles were triggered.

Combined efforts from this CCE-funded student and post-doc cruise will contribute to surface ocean biogeochemical cycling of ecosystem-relevant carbon and nitrogen species. We have selected stations for our study that cover a range of primary production states and nutrient availability, where we expect the quantity and quality of surface ocean organic matter to reflect ecosystem condition (i.e., based on primary productivity). Our goal for this study will be to test the extent to which Points Conception and Arguello serve as sources of bioavailable material to the surrounding less productive regions.

Additionally, as part of a separate effort from the surface ocean work, several large-volume deep ocean water samples were collected to isolate sufficient dissolved organic matter (DOM) for high resolution chemical characterization. Recently developed methods from this lab have demonstrated the ability to isolate unique fractions of the DOM that could suggest differing origin and/or age. Therefore, we will attempt to obtain radiocarbon ages of these separate fractionations of the deep DOM.

Benthic Boundary Layer – Barbeau Group (A Ruacho, L Manck, K Forsch)

Many of the activities conducted during the cruise were planned activities with stations north of Pt. Conception replacing stations near Santa Barbara.

After departing San Diego and transiting to the study area we stopped near Santa Catalina Island to conduct a test cast with Go-Flo sampling bottles. Four bottles were successfully deployed and we continued the transit to the study region. A total of 9 Go-Flo casts (including the test cast) were conducted throughout the cruise. Samples collected are to be analyzed for total dissolved and dissolvable iron as well as iron-binding ligands. The focus of these samples is to study the influence of the benthic boundary layer (BBL) on the supply of iron to surface waters in the northern coastal region of the CCE-LTER study area. Along with Go-Flo deployments, 17 CTD survey casts were conducted to identify the regional extent of the BBL, via the transmissometer on the CTD package (Fig. 3). An extensive and well-defined BBL was identified and sampled in shelf waters around Pt. Conception and Pt. Arguello, and points north. In contrast, no BBL was detected in the majority of the CTD casts on the island platforms of the nearby San Miguel and Santa Rosa Channel Islands. To study the potential biological influence of iron in the BBL, a 3-day deckboard incubation grow out experiment was conducted by mixing BBL water with surface waters (CTD cast 7 station).

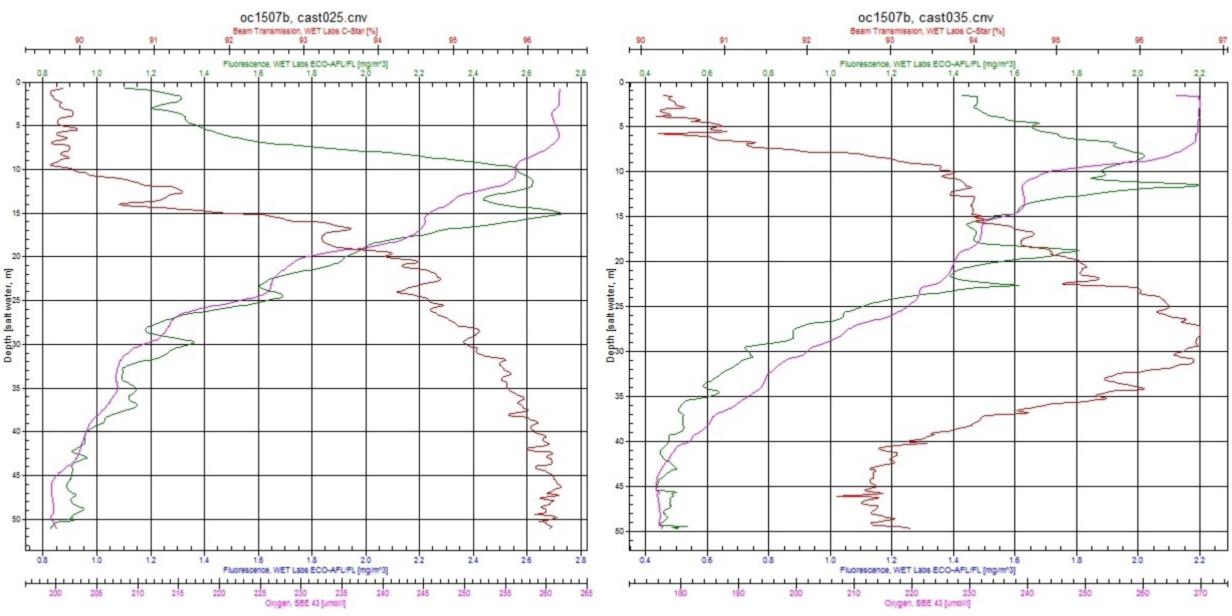

Fig. 3. An example of two CTD casts exhibiting differing benthic boundary layer beam transmittance levels. Cast 035 shows an increase in beam transmittance at 40-50m suggesting a source of suspended particles from the benthos.

Other trace metal experiments conducted during the cruise included a photochemical experiment exploring the effect of UV light on copper binding ligands (CTD cast 34 station), as well as an incubation experiment to evaluate the effect of iron limitation on the degradation of dissolved organic carbon by heterotrophic bacteria (set up at CTD cast 1 station and incubated for 4 days in the dark). Samples for total organic carbon, microscopy, transcriptomics, 16S tag sequencing as well as macronutrient concentrations, iron concentrations and speciation were collected from this incubation and will be processed in the lab.

Mesozooplankton Incubations – Landry Group (B Valencia)

Mesozooplankton samples were collected at four stations (3, 8, 12, and 16) using a ring net of 1 m of diameter, 200 µm mesh size, and provided with a General Oceanic flow meter. All samples were collected during the night and two tows were carried out at each station. The first tow was conducted with the objective of estimating mesozooplankton biomass. Thus, an oblique tow was performed to 200 m depth or above 20 m from the bottom in shallower stations. The tows typically lasted around 22 minutes and were held at an angle of 45° (± 5°) for most tows. Once on deck, the sample was poured into a bucket and carbonated water was added in order to anesthetize the zooplankton. The sample was then split in ¼ or ⅛, depending on the concentration of the sample and filtered through a 200 µm mesh filter placed at the bottom of jars of 4 oz. Due to time constraints, size fractionation of the samples were planned to be carried out at SIO.

The second ring net tow followed the first tow by roughly 90 minutes with the objective of evaluating the diet of the species of copepods representative of the CCE. Molecular analysis will be carried out on these samples in the future. Thus, this tow was shallower (~ 50 m), shorter (~ 6 min), and a non-filtering cod end was used. Once the net was on deck, the sample was poured into a bucket that contained filtered sea water (0.2 µm) to dilute the sample. Fractions of the sample were filtered through 200 µm mesh (47 mm) and preserved as quickly as possible in a -80°C freezer. Another fraction of the second tow was used to sort females of the copepod *Calanus pacificus* (~ 90 females), which were placed in FSW for around 10 hours. Next, the females were placed in water from the chlorophyll maximum collected from the same station as the tow for two hours, and then, they were placed again in FSW. Groups of approximately 15 females were then collected with a ladle at six time points (0, 10, 20, 40, 60 min) to evaluate DNA degradation in the gut of the copepods. In addition, in order to characterize the water column in terms of the potential prey available for the mesozooplankton, samples of water were collected for epifluorescence microscopy at two depths (mixed layer and chlorophyll maximum) from the CTD-rosette.

Otter Trawls – Levin Lab (K Sato, E Navarro, J Powell)

Students from the Levin Lab led the otter trawl and associated CTDs. We completed one successful trawl at 340 m and quantified the benthic megafauna community. These data may be compared with trawl data from similar depths, but different physicochemical environments in San Diego. We found 15 species of fish (higher than off San Diego), and similar species composition and diversity of invertebrates were found relative to San Diego trawls.

We unfortunately lost our only trawl net (no backup was available, damaged in a previous deep water trawl) during our second trawl after it snagged on a large, immovable object on the seafloor near Pt. Conception. This loss opened up several hours of ship time to address other interesting questions with available CTD. We carried out a deep CTD cast to compare the structure of the Oxygen Minimum Zone off Pt. Arguello to that of the San Diego Trough. We collected and preserved bottle samples for seawater carbonate chemistry at depths deeper than those sampled by CalCOFI. These bottle samples are important to understand how the carbonate chemistry changes with depth as oxygen begins to increase below the OMZ core.

We found that the O_2 concentrations in the OMZ core were not significantly different between Pt. Arguello and San Diego Trough, but were different at shallower depths. This suggests that perhaps differences in the chemical environment may contribute to differences observed in the benthic community structure, however data collection and analyses are still ongoing

After losing the otter trawl, our team contributed to other science teams by volunteering to help out with deck operations, especially for newly chosen Benthic Boundary Layer (BBL) stations.

We were also in charge of regularly checking Kylee Chang's underway *p*CO2 system set up in the wet lab. We collected bottle samples every day from this system for calibration purposes and we made sure the flow rate was correctly functioning.

Daily Activities Schedule

Time	Operation	Latitude	Longitude	Duration	Depth/Distance
July28	DAY 1				
0800	Transit to SD Coastal Station			1 Hr	10 km
0900	Go-Flo Test Cast			1 Hr	50-75m
1000	Transit to CTD001			22 Hr	400 km
July 29	DAY 2				
0800	CTD001	34.3591	-120.7100	1 Hr	200m
0900	Go-Flo#1- Incubation			1 Hr	200m
1000	Transit to CTD002	34.4017	-120.6500	0.5 Hr	5 km
1030	Buffer Time			0.5 Hr	
1100	CTD002	34.400	-120.640	1 Hr	340m
1200	Otter Trawl #1	34.400	-120.640	3 Hr	340m
1500	Transit to CTD003			2 Hr	18 km
1700	Deep DOM CTD003	34.3084	-120.7958	1 Hr	800m
1800	Deep DOM CTD004	34.3083	-120.7966	1.5 Hr	800m
1930	Transects – pCO2			2 Hr	10 km/ea
2130	CTD005	34.3077	-120.7965	1 Hr	200m
2230	Ring Net #1	34.3077	-120.7965	1 Hr	100m
2330	Ring Net #2	34.3077	-120.7965	1.5 Hr	Surface
July 30	DAY 3				
0100	Transit to CTD006			2.5 Hr	25 km
0330	CTD006	34.4416	-120.5437	1 Hr	100m
0430	Transit to CTD007			0.5 Hr	5 km
0500	Buffer Time			1 Hr	
0600	CTD007	34.4298	-120.4822	1 Hr	50m
0700	BBL GoFlo #2	34.4298	-120.4822	2 Hr	50m
0900	Otter Trawl #2	34.4298	-120.4822	2.5 Hr	100m
1130	Transit to CTD008			1 Hr	10 km
1230	CTD008	34.3905	-120.4528	0.5 Hr	100m
1300	BBL GoFlo #3	34.3905	-120.4528	0.5 Hr	100m
1330	Transit to CTD009			0.5 Hr	9 km
1400	Buffer Time			0.5 Hr	
1430	CTD009	34.4250	-120.2803	1 Hr	175m
1530	BBL GoFlo #4	34.4250	-120.2803	1.5 Hr	175m
1600	Transit to CTD010			0.5 Hr	5 km
1630	CTD010	34.4365	-120.4804	0.5 Hr	60m
1700	Transit to CTD011			0.25 Hr	5 km
1715	CTD011	34.4104	-120.4856	0.5 Hr	100m
1745	CTD012	34.3920	-120.4890	0.5 Hr	150m
1815	Transit to CTD013			0.25 Hr	5 km
1830	CTD013	34.3901	-120.4482	0.5 Hr	100m
1900	CTD014	34.4060	-120.4481	0.5 Hr	90m
1930	CTD015	34.4223	-120.4470	0.5 Hr	75m
2000	CTD016	34.3522	-120.4488	1 Hr	280m
2100	Ring Net #3	34.3522	-120.4488	1 Hr	100m

2200	Ring Net #4	34.3522	-120.4488	1 Hr	Surface
2300	Transit to CTD017			1.5 hr	15 km
Jul 31	Day 4				
0030	CTD017	34.2544	-120.3404	2 Hr	450m
0215	CTD018	34.2544	-120.3404	2 Hr	450m
0330	CTD019	34.2544	-120.3404	1 Hr	450m
0430	Transit to CTD020			1.5 Hr	15 km
0600	Buffer Time			1.5 Hr	
0730	CTD020	34.0743	-120.3430	0.75 Hr	50m
0815	CTD021	34.0849	-120.3905	0.5 Hr	50m
0845	CTD022	34.0933	-120.3811	0.5 Hr	50m
0915	CTD023	34.0983	-120.3731	0.5 Hr	50m
0945	Transit to CTD024			0.5 Hr	5 km
1015	CTD024	34.1148	-120.3729	0.75 Hr	100m
1100	Transit to CTD025			0.75 Hr	7 km
1145	CTD025	34.0137	-120.4063	0.5 Hr	50m
1215	CTD026	33.9965	-120.4071	0.5 Hr	100m
1245	CTD027	33.9790	-120.4072	0.5 Hr	100m
1315	Transit to CTD028			1.25 Hr	12 km
1430	CTD028	33.8779	-120.1335	0.5 Hr	100m
1500	BBL GoFlo#5	33.8779	-120.1335	1 Hr	100m
1600	CTD029	33.8603	-120.1357	0.5 Hr	150m
1630	CTD030	33.8425	-120.1368	1 Hr	365m
1730	Transit to CTD031			2.5 Hr	25 km
2000	CTD031	34.1872	-120.1128	1 Hr	560m
2100	Ring Net#5	34.1872	-120.1128	1.5 Hr	100m
2230	Ring Net#6	34.1872	-120.1128	0.5 Hr	Surface
2300	Transit to CTD032			0.5 Hr	5 km
2330	CTD032	34.2903	-120.1342	1 Hr	550m
Aug 1	Day 5				
0030	Transit to CTD033			1 Hr	10 km
0130	Buffer Time			0.5 Hr	
0200	CTD033	34.3882	-120.1364	1 Hr	270m
0300	Transit to CTD034			4.5 Hr	40 km
0730	CTD034	34.5316	-120.5607	0.5 Hr	30m
0800	BBL GoFlo#6	34.5316	-120.5607	1 Hr	30m
0900	Transit to CTD035			0.5 Hr	5 km
0930	CTD035	34.6948	-120.7107	0.5 Hr	50m
1000	BBL GoFlo #7	34.6948	-120.7107	1 Hr	50m
1100	CTD036	34.6947	-120.7511	0.5 Hr	80m
1130	CTD037	34.6946	-120.7915	0.5 Hr	100 m
1200	Transit to CTD038			1 Hr	10 km
1300	CTD038	34.6330	-120.9059	1 Hr	360m
1400	Transit to CTD039			0.5 Hr	5 km
1430	CTD039	34.5556	-121.1163	1 Hr	
1530	Transit to CTD040			1.5 Hr	15 km
1700	CTD040	34.5617	-120.7598	0.75 Hr	100m
1745	CTD041	34.5617	-120.7195	0.75 Hr	80m

1830	CTD042	34.5721	-120.7037	0.5 Hr	60m
1900	BBL GoFlo#8	34.5721	-120.7037	1 Hr	60m
2000	CTD043	34.5618	-120.7596	1.5 Hr	115m
2130	Ring Net#7	34.5618	-120.7596	1.5 Hr	100m
2300	Ring Net#8	34.5618	-120.7596	1 Hr	Surface
Aug 2	Day 6				
0000	Transit to Pt. Hueneme			8 Hr	80 km
0845	Arrive into Port				
0930	DeMob				

APPENDIX 1

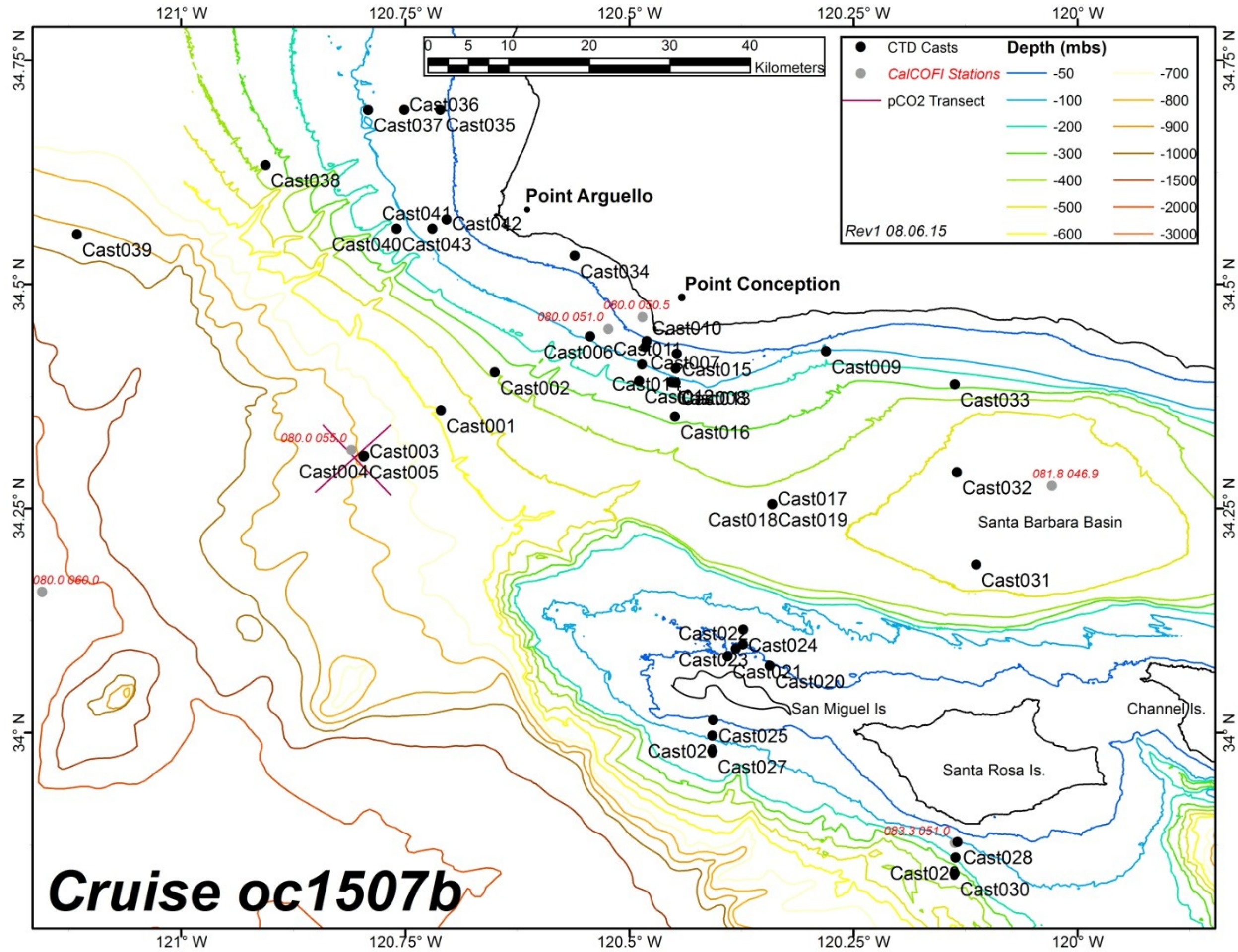

Fig. 4. Map of CTD cast locations.