SKrillExII Cruise Report

California Current Ecosystem LTER Program and UC Ship Funds
SP1510, Student Cruise
R/V Robert Gordon Sproul, 11 June – 17 June 2015
Compiled and Submitted by Catherine Nickels
Scripps Institution of Oceanography, Univ. of California, San Diego

Cruise ID: SP1510, aka SKrillExII
Depart: 11 June at 0800 (PDT)
Return: 17 June at 0800
Vessel: R/V Robert Gordon Sproul
Operator: Scripps Institution of Oceanography, Univ. of California, San Diego
Master: Captain Christopher Welton
Chief Scientist: Catherine Nickels
Marine Technicians: Josh Manger, Keith Shadle

Contents

Cruise Science Personnel

Catherine Nickels	cnickels@ucsd.edu	Chief Scientist, Graduate Student
Jennifer Brandon	jbrando@ucsd.edu	Graduate Student
Jeff Ellen	jellen@cs.ucsd.edu	Graduate Student
Natalya Gallo	ndgallo@ucsd.edu	Graduate Student
Lillian McCormick	lrmccorm@ucsd.edu	Graduate Student
Kirk Sato	knsato@ucsd.edu	Graduate Student
Brandon Stephens	bmstephe@ucsd.edu	Graduate Student
Benjamin Whitmore	bmwhitmo@ucsd.edu	Graduate Student
Mark Ohman	mohman@ucsd.edu	Faculty Member
Jackson Powell	jpowell3@calstatela.edu	Undergraduate Student

Science Objectives

The California Current Ecosystem (CCE) experienced an anomalously warm oceanic event beginning in summer 2014 (**Fig. 1a**). Though the predicted El Niño (ENSO), as determined by conventional indices, had yet to manifest, either local heating and/or an intrusion of warm seawater into the CCE affected the local ecosystem in summer 2014. For example, chlorophyll-*a* concentrations were anomalously low throughout much of the CCE (**Fig. 1b**). Additionally, biological indicator species of warm water intrusion into the CCE, such as pelagic red crabs (*Pleuroncodes planipes*), salps, and By-the-Wind Sailors (*Velella velella*) were observed in the summer of 2014 in the California Current.

Last July, with support from the CCE LTER program, we sampled the pelagic and benthic environments in the CCE around Nine Mile Bank (NMB) on the R/V *New Horizon*. Consistent with satellite sea surface temperature anomalies, density profiles from both the R/V *New Horizon* cruise (SKrillExI) and a subsequent cruise aboard R/V *Melville* (P1408) in August 2014 demonstrate enhanced stratification caused by elevated temperature in the surface layer (cf., magenta and green lines in **Fig. 2**) in summer 2014, as compared to other recent cruises in the region. While this warm water, positive stratification condition cannot be taken as diagnostic of El Niño, it nonetheless represents a significant perturbation to the pelagic ecosystem. It is hypothesized that with a warming climate, increased stratification due to higher surface temperatures will reduce the input of inorganic nutrients into the euphotic zone and depress primary productivity in the California Current, which could impact the entire CCE food web. Other physical considerations, such as increased wind stress, and a switching of nutrient source pools, can possibly negate and override stratification effects. The current multivariate ENSO index (MEI) still shows no El Niño event, though conditions are favorable for its development in the coming months. Also, the positive sea surface temperature anomaly is still present in the CCE region, and is likely to continue. Therefore, a synthesis of the anomalously hot summer of 2014 and a subsequent survey in 2015 would allow for a data-driven quantification of the stratification effect in the CCE.

On this cruise, we built upon our initial work by returning to the NMB in July 2015. We assessed alterations to the pelagic and benthic environments since the previous summer's warm water intrusion in the CCE.

The motivating research questions we plan to investigate were:

1. **Were the warm water conditions of 2014 a short term anomaly, or a transition to a new state in the CCE with lasting effects on the local biological communities?**
2. **Can persistent ecosystem alterations be detected one year after an anomalously warm water year in the CCE?**
3. **If the warm conditions persist through summer 2015, in which environment (pelagic and/or benthic) and in which assemblage of organisms (phytoplankton, zooplankton, benthic epifauna) are such effects most pronounced?**

We hypothesized that the full-term effects of the warm water intrusion from last year would only become apparent after a year, since we were there in the onset of the event the previous July. We detected some immediate effects of the warm water in the pelagic, but it is unclear whether we measured the full extent of the effects in the benthic environment. The benthos typically respond with a time lag, and so we expected this cruise to show some unique signs of the warm water intrusion not measured on SKrillExI. Thus, it was essential that this area be remeasured to see the full effects of the warm water intrusion from 2014. Because the warming event had not subsided by July 2015 we captured two timepoints in the physical and biological response to the ongoing warming.

A. B.

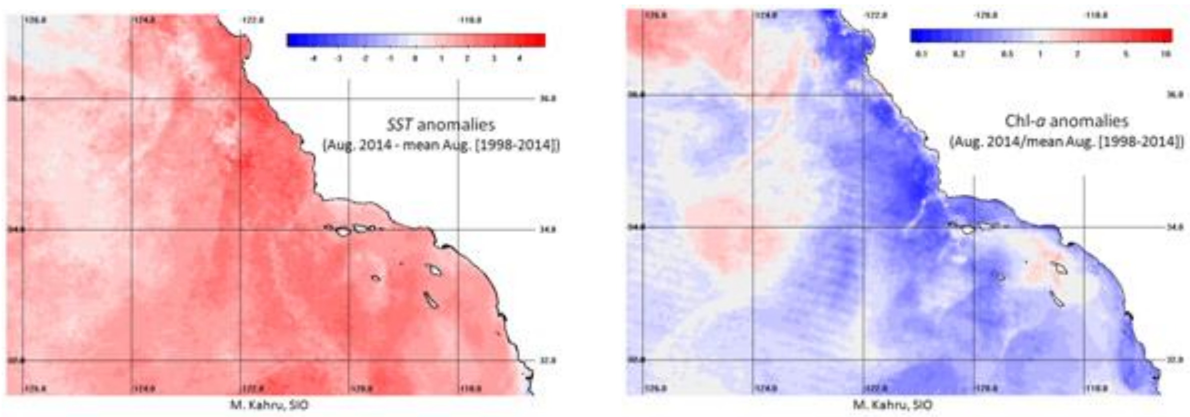


Fig. 1. A. Sea surface temperature anomalies for August 2014. Colors represent temperature values of the August 2014 SST minus the 17-year mean SST (blue shadings are negative anomalies; red shadings are positive anomalies). B. Chlorophyll-*a* anomalies for August 2014. Colors represent the ratio of August 2014 chl-*a* to the 17-year mean chl-*a* in August (Blue shadings indicate an anomalously lower chl-*a* in 2014; red indicates higher chl-*a*). Data Courtesy: M. Kahru (SIO)

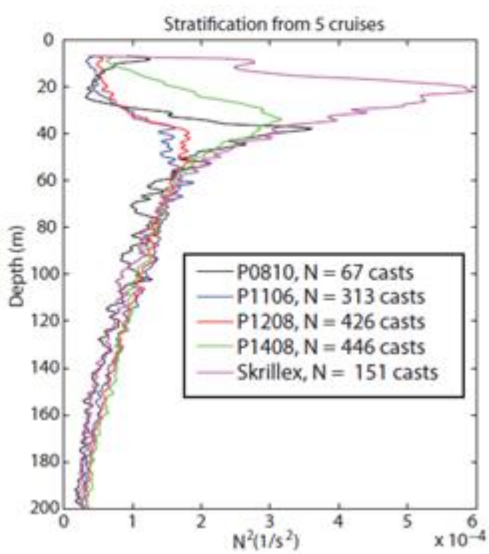


Fig. 2. Stratification profile (as the buoyancy frequency squared, N^2) from SKrillExI (magenta) and P1408 (green) compared to previous cruises in the CCE.

Overview of Science Plan

The cruise was carried out in the vicinity of Nine Mile Bank (also known as the Coronado Escarpment), a frequent blue whale feeding area. The activities on the cruise were designed to characterize the prey field and surrounding environment. Three transects were completed overnight from near to offshore across the bank feature. Each transect consisted of six stations (except for transect one in which only four stations were completed) which included a CTD cast on the station and a bongo net towed in the direction of the next station. Bucket samples for microplastic collection were performed at alternating stations. They prey field was characterized vertically by two pairs of day and night MOCNESS tows, performed northward along the bank. The MOCNESS was equipped with a strobe light to mitigate net avoidance by euphausiids, particularly during the daytime tows. A third day and night pair of MOCNESS tows was performed as a test of the efficacy of the strobe light in limiting avoidance. Three surveys were also performed with a Moving Vessel Profiler (MVP) to characterize the spatial gradients in the area. The fourth component of the cruise took advantage of the daylight hours by casting deeper into the ocean with an Otter Trawl. Eight otter trawls were conducted to investigate the composition of the benthic community across multiple environmental gradients. Multifrequency active acoustic data were collected continuously throughout the cruise.

Group Reports

Chemistry-Brandon Stephens

The primary purpose for B Stephens was primarily (1) to test out sample collection procedures that would be carried out during an upcoming CCE-supported student cruise (oc1507b). Profiles of high-volume (+20L) samples were collected from two stations and profiles of small volume (4L) samples were collected from five stations during CTD-transects. A separate objective (2) was carried out by BM Stephens to collect bulk zooplankton samples via bongo nets and while the nets were deployed collect high volume (+300L) surface water. These samples were obtained from three stations.

Microplastics– Jennifer Brandon

As part of her thesis research, Jenni Brandon collected surface water from metal bucket samples along the three sampling transects. The water was filtered in an all-glass filtering system to prevent contamination. The water was filtered onto glass fiber filters and polycarbonate filters to filter for nanoplastic particles. Then water was also pre-filtered through 202 µm steel mesh to remove larger particulates before being filtered onto the same type of filters. These filters will be run under Raman laser spectroscopy for nanoplastic identification. One pint of water was also removed from each bucket and preserved with formalin for future analysis if needed. Jenni also sampled for microplastics and microplastic-consuming neustonic organisms with a manta net. The samples collected from the 505 µm mesh manta net were collected and preserved in formalin for future analysis. They are stored in glass jars with metal lids so there is no plastic contamination.

Euphausiids– Catherine Nickels

Bongo tows were performed with a 202µm mesh bongo net for determination of cross-bank gradients in euphausiid distribution. Fifteen oblique, nighttime tows were performed to approximately 200 m where depth allowed. Both net samples from each tow were preserved in 5% buffered Formalin for later analysis.

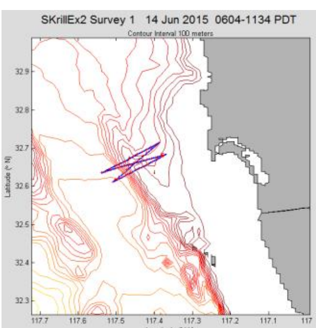
Vertically stratified samples were collected with a MOCNESS for determination of vertical gradients in euphausiid distribution. A strobe-light equipped $1m^2$ MOCNESS with 202 µm mesh was used. Two day and two night tows were completed and all samples were preserved in 5% buffered Formalin for later analysis. In addition, one pair of day and night strobe light tests was conducted to determine the effect of the strobe lights on catch efficiency of euphausiids and pelagic red crabs. The strobe lights were turned on, the net lowered to an acoustically detected krill aggregation, and several nets were triggered. The net was then recovered, and strobe lights turned off, and the net redeployed to the euphausiid aggregation to sample with the remaining nets. This operation was performed as the ship moved in a circle to remain within the same euphausiid patch.

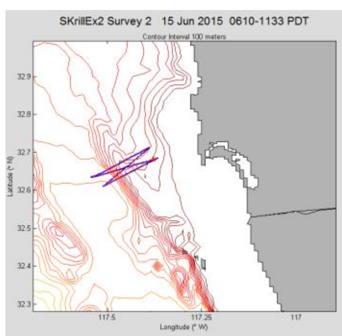
Multifrequency acoustic data (38, 70, 120, and 200 kHz) were collected throughout the cruise with a pole-mounted Simrad EK-60. The pole was inspected every three hours and the data were backed up daily. The data will be used in association with the net tow data for biomass and distribution estimates.

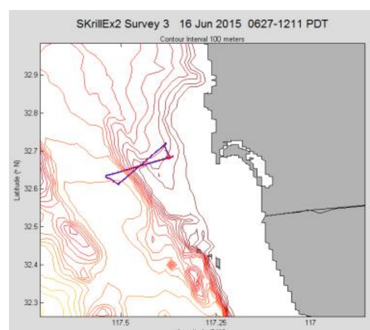
Moving Vessel Profiler (MVP) – Mark Ohman

A free-fall Moving Vessel Profiler was used to characterize spatial gradients across 9 Mile Bank. The properties measured were temperature, salinity, and pressure (AML Micro CTD), Chl-*a* fluorescence (Wetlabs FLRT fluorometer), and suspended particles and size distributions (ODIM Rolls Royce Laser Optical Particle Counter, LOPC). An Acousonde probe (Acoustimetrics, model B003A) was also attached to the MVP fish, to record marine mammal vocalizations. Three daytime surveys were completed, including 4, 4, and 2 trans-bank crossings, respectively. For Surveys 1 and 2, vertical casts extended to a depth of 200 m (bottom depth permitting), at a ship's speed of ~7 knots (13 km hr^{-1}). For Survey 3 the cast depth was extended to 350 m and the ship slowed to ~ 5 kts (9 km hr^{-1}), in order to sample euphausiid layers between 200-300 m depth with the MVP-mounted LOPC.

Survey	Date	Time (PDT)	Ship's speed	No. of casts	Nominal depth
1	14 June 2015	0604-1134	7 kts	53	200 m
2	15 June 2015	0610-1133	7 kts	54	200 m
3	16 June 2015	0627-1211	5 kts	34	350 m







Benthic– Natasha Gallo, Kirk Sato, Lillian McCormack

Sampling of the benthic and demersal community was conducted using otter trawls and paired with CTD casts to look at how multiple environmental gradients, including oxygen, temperature, pressure, pH and pCO2, influence benthic community composition. Replicate quantitative trawl samples were undertaken at ~200 m above or at the upper boundary of the oxygen limiting zone and at ~700 m within the oxygen minimum zone core. Bottle samples from nearby CTD casts were collected and will be analyzed for dissolved inorganic carbon and total alkalinity. Quantitative trawl samples obtained during SKrillEx 2 allow for a comparison of how the benthic community responds following a 1-year long warm water anomaly. Additionally, quantitative trawl samples were taken within the oxygen limiting zone at 340 m and the data contributed to a benthic time-series at this site, contributing to our understanding of seasonal and interannual variability of deep-sea benthic communities. A total of 8 trawls were conducted. The data collected will contribute significantly to two PhD student theses and better our understanding of how benthic communities are influenced by multiple environmental gradients on the continental margin, and how the hydrochemical environment and the benthic community respond following a one-year warm water anomaly. This dataset collected also generates a baseline to compare future ecosystem responses that may follow the strong El Nino.

Data collected from CTD casts for the benthic component of the cruises was also used to look at how environmental gradients, including light, influence the distribution of cephalopod (squid and octopus) juveniles and paralavae in the water column. Abundance of cephalopod young was determined using Bongo net tows to depths of 100-300m (depending on time of day) and comparing it to CTD casts. Counts from one side of the Bongo net collections over 9 Mile Bank during the planned night operations were used, in addition to six separate Bongo net tows conducted specifically for this project. The results from SKrillEx 1 and 2 will be analyzed and compared to determine the effects of changes in temperature, oxygen, and light in the distribution of highly visual organisms. Microrespiration experiments were performed on live specimens from the tows to determine oxygen consumption of juvenile/paralarval cephalopods. A total of 9 successful respiration experiments on juvenile squid, juvenile octopus, and octopus paralarvae were conducted in the ship lab, which will help define the physiological limits of these organisms and be compared to the abundance results to examine distribution in a changing ecosystem.

Daily Activities Schedule

Time	Operation	Latitude	Longitude	Duration	Depth
June 11	Thursday				
0900	Leave Dock				
0900	Transit to otter trawl 1			6 hrs	
1500	700m CTD	32° 50.699'N	117° 28.929'W	1.5 hrs	700m
1730	Otter trawl 1	32° 50.699'N	117° 28.929'W	3 hrs	700 m
2200	Begin Transect 1	32° 42.838'N	117° 23.169'W	8 hrs	
2200	Transect 1: Station 1, Bucket and CTD on coordinates, bongo to next station	32° 42.838'N	117° 23.169'W	1 hr	Bongo: 200m CTD: 200m Bucket: Surface
June 12	Friday				
0000	Transect 1: Station 2	32° 42.277'N	117° 24.232'W	1 hr	Bongo: 200m CTD: 80m
0200	Transect 1: Station 3	32° 40.585'N	117° 27.575'W	1 hr	Bongo: 200m CTD: 80m Bucket: Surface
0330	Transect 1: Station 4	32° 38.622'N	117° 31.236'W	1 hr	Bongo: 200m CTD: 80m Bucket: Surface
	Transit to otter trawl site	32° 40.038'N	117° 21.099'W	2 hrs	
0700	200 m CTD	32° 40.038'N	117° 21.099'W	1 hr	200 m
0830	Otter Trawl 2	32° 40.038'N	117° 21.099'W	2 hrs	200 m
1100	Otter trawl 3	32° 43.516'N	117° 21.227'W	2 hrs	200 m
1400	Otter trawl 4	32° 49.133'N	117° 22.234'W	2 hrs	200 m
1700	Otter trawl 5	32° 52.830'N	117° 28.726'W	3 hrs	700m
2100	Begin Transect 2	32° 41.989'N	117° 22.771'W	8 hrs	
2100	Transect 2: Station 1, Bucket and CTD on coordinates, bongo to next station	32° 41.989'N	117° 22.771'W	1.3 hr	Bongo: 200m CTD: 300m Bucket: Surface
2220	Transect 2: Station 2	32° 41.448'N	117° 23.793'W	1.3 hr	Bongo: 200m CTD: 100m Bucket: Surface
2340	Transect 2: Station 3	32° 39.812'N	117° 26.987'W	1.3 hr	Bongo: 200m CTD: 100m Bucket: Surface
June 13	Saturday				
0100	Transect 2: Station 4	32° 39.244'N	117° 28.067'W	1.3 hr	Bongo: 200m CTD: 100m

					Bucket: Surface
0120	Transect 2: Station 5	32° 37.932'N	117° 30.454'W	1.3 hr	Bongo: 200m CTD: 100m Bucket: Surface
0240	Transect 2: Station 6	32° 37.423'N	117° 31.421'W	1.3 hr	Bongo: 200m CTD: 100m Bucket: Surface
0500	SDT2 CTD	32° 41.327'N	117° 31.901'W	2 hrs	1000m
0700	Transit to otter trawl			1.5 hr	
0830	340 m CTD	32° 43.251'N	117° 22.421'W	1.5 hrs	325 m
1000	Otter Trawl 6	32° 43.251'N	117° 22.421'W	2 hrs	325 m
1200	Transit to otter trawl			1.5 hrs	
1330	Otter Trawl 7	32° 51.624'N	117° 29.481'W	3 hrs	700 m
1800	Schedule reserve			3 hrs	Possible MVP testing underway, 200m
2100	Begin Transect 3	32° 40.965'N	117° 22.272'W	8 hrs	
2100	Transect 3: Station 1, Bucket and CTD on coordinates, bongo to next station	32° 40.965'N	117° 22.272'W	1 hr	Bongo: 200 m CTD: 300 m Bucket: Surface
2220	Transect 3: Station 2	32° 40.427'N	117° 23.291'W	1 hr	Bongo: 200m CTD: 100m Bucket: Surface
2340	Transect 3: Station 3	32° 38.871'N	117° 26.292'W	1 hr	Bongo: 200m CTD: 100m Bucket: Surface
June 14	Sunday				
0100	Transect 3: Station 4	32° 38.349'N	117° 27.308'W	1 hr	Bongo: 200m CTD: 100m Bucket: Surface
0220	Transect 3: Station 5	32° 37.227'N	117° 29.625'W	1 hr	Bongo: 200m CTD: 100m Bucket: Surface
0340	Transect 3: Station 6	32° 36.711'N	117° 30.501'W	1 hr	Bongo: 200m CTD: 100m Bucket: Surface
0500	MVP 1	32° 40.965'N	117° 22.272'W	6 hrs	200 m
	MVP 1: start	32° 40.965'N	117° 22.272'W		200 m
	MVP 1: Waypoint 1	32° 38.103'N	117° 32.250'W		200 m
	MVP 1: Waypoint 2	32° 42.838'N	117° 23.169'W		200 m
	MVP 1: Waypoint 3	32° 36.711'N	117° 30.501'W		200 m
1100	MVP 1: End	32° 40.965'N	117° 22.272'W		200 m
1530	MOCNESS 1	32° 43.333'N	117° 25.673'W	3 hrs	300 m

	End MOCNESS 1	32° 39.213'N	117° 22.623'W		
1900	Manta tow			1 hr	surface
2200	MOCNESS 2	32° 43.333'N	117° 25.673'W	3 hrs	300 m
	End MOCNESS 2	32° 39.213'N	117° 22.623'W		
June 15	Monday				
0500	MVP 2	32° 40.965'N	117° 22.272'W	6 hrs	200 m
	MVP 2: start	32° 40.965'N	117° 22.272'W		200 m
	MVP 2: Waypoint 1	32° 38.103'N	117° 32.250'W		200 m
	MVP 2: Waypoint 2	32° 42.838'N	117° 23.169'W		200 m
	MVP 2: Waypoint 3	32° 36.711'N	117° 30.501'W		200 m
1100	MVP 2: End	32° 40.965'N	117° 22.272'W		200 m
1300	MOCNESS 3	32° 43.333'N	117° 25.673'W	3 hrs	300 m
	End MOCNESS 3	32° 39.213'N	117° 22.623'W		
1900	Manta tow			1 hr	surface
2200	MOCNESS 4	32° 43.333'N	117° 25.673'W	3 hrs	300 m
	End MOCNESS 4	32° 39.213'N	117° 22.623'W		
June 16	Tuesday				
0500	MVP 3	32° 40.965'N	117° 22.272'W	6 hrs	200 m
	MVP 3: start	32° 40.965'N	117° 22.272'W		200 m
	MVP 3: Waypoint 1	32° 38.103'N	117° 32.250'W		200 m
	MVP 3: Waypoint 2	32° 42.838'N	117° 23.169'W		200 m
	MVP 3: Waypoint 3	32° 36.711'N	117° 30.501'W		200 m
1100	MVP 3: End	32° 40.965'N	117° 22.272'W		200 m
1300	MOCNESS 5	32° 43.333'N	117° 25.673'W	3 hrs	300 m
	End MOCNESS 5	32° 39.213'N	117° 22.623'W		
1900	Manta tow			1 hr	surface
2200	MOCNESS 6	32° 43.333'N	117° 25.673'W	3 hrs	100 m
	End MOCNESS 6	32° 39.213'N	117° 22.623'W		
June 17	Wednesday				
	Return to port				

Map of Sampling Locations