Cruise Report C3O/DBO 2015-07

Pacific Region Vessel CCGS *Sir Wilfrid Laurier*

DATE: **FROM:** 3 July 2015 **TO:** 23 July 2015

SCIENCE CRUISE NUMBER: 2015-07 **SHIP'S PATROL NUMBER:**

CHIEF SCIENTIST: Svein Vagle

INTRODUCTION/PROGRAM BACKGROUND:

This research cruise is part of the Distributed Biological Observatory (DBO) effort, which is an international effort to make repeat oceanographic observations at chosen stations the Bering, and Southern Chukchi Seas and in Barrow Canyon. It is also a continuation of the Canada Three Oceans project "C3O" which was part of Canada's contribution to the International Polar Year research effort. The focus of this collaboration between DFO-IOS and University of Maryland, Center for Environmental Science, Clark University and NOAA in the US, and the Universities of Victoria and British Columbia in Canada is to study impacts of climate variability on the sub-arctic and Arctic water circulation and on the associated ecosystems. This year the ship transect across the NE Pacific followed a more southern route between southern Vancouver Island and Unimak Pass in the Aleutians in order to deploy 12 Argo floats in locations where floats were missing.

CRUISE OBJECTIVES:

During this cruise aboard the CCGS Sir Wilfrid Laurier data were collected on the physical, biological and geochemical properties of ocean waters across the North Pacific Ocean, and the shelf regions of the Bering and Chukchi Seas as well as across Barrow Canyon. Data were also collected on the benthic ecosystems in these locations. Marine mammal observations were done between Victoria and Barrow, while bird observations were done from Dutch Harbor in the Aleutians to Barrow.
The shipboard data collection included physical, biological, geochemical and benthic sampling:

- Profiles of water temperature and salinity were obtained with a Seabird Conductivity, Temperature and Depth (CTD) system, and using an Oceanscience Underway CTD system (UCTD). In addition eight expendable CTD probes (XCTD) were deployed from the ship across the NE Pacific.
- Additional sensors on the Seabird CTD profiler collected *in-situ* data on phyto-plankton concentrations (fluorometer), optical clarity (transmissometer), dissolved oxygen and photoactive radiation (PAR).
- A rosette bottle sampler was used with the CTD to obtain water samples from discrete depths for a broad suite of biological and geochemical parameters, some for onboard analysis, others to be stored for later analysis in shore-based laboratories following the return of the ship to Victoria in the autumn.
- Benthic sampling using Van Veen grabs.
- Depth-varying current information were collected using a RDI Longranger 150 kHz Acoustic Doppler Current Profiler (ADCP) This instrument was mounted in a stainless steel frame and deployed over the port side of the ship at most of the science stations.

- Zooplankton samples were obtained in vertical hauls by Bongo-nets lowered to 100 m or from bottom depth minus 10 m in waters shallower than 110 m.
- Continuous underway sampling of near-surface seawater temperature, salinity, fluorescence, oxygen and nitrogen.
- Onboard laboratory primary productivity experiments were performed in incubators located on the helicopter deck.
- Extensive onboard chlorophyll sampling and filtering were done for comparisons with satellite ocean observations.
- Bird and marine mammal observations (Marine mammal observations all the way from Victoria and designated bird observations from Dutch Harbor onwards).
- Cesium-137 sampling along the ship track from Victoria to Dutch Harbor to look for Fukoshima Nuclear disaster water.
- Methane and C13 gas sampling from a selection of Rosette bottles.
- Measurements of the apparent optical properties of the upper ocean (C-OPS).

DAYS ALLOCATED: 22 **DAYS OF OPERATION:** 22

SCIENTIFIC PERSONNEL: In Victoria (VIC), 6 scientists embarked July 3rd and stayed onboard until Barrow Alaska (Bar) (Disembarked July 23th). Another 9 scientists embarked in Dutch Harbor (DH) July 11th and disembarked in Barrow July 23th.

Name	Tasks	Affiliation	from	To
Svein Vagle	ADCP/Underway surface water analysis/UCTD/XCTD/CTD	DFO-IOS	VIC	Bar
Laura McKay	Isotope analysis/water sampling	UVIC	VIC	Bar
Jennifer Long	Phyto-plankton	UVIC	VIC	Bar
Curtis Martin	Phyto-plankton	UVIC	VIC	Bar
Bruce Patterson	Marine Mammal Observer	DFO	VIC	Bar
Lindsay Fenwick	Gas measurements	UBC	VIC	Bar
Jackie Grebmeier	Benthic/water sampling	U.Maryland	DH	Bar
Lee Cooper	Benthic/water sampling	U.Maryland	DH	Bar
Monika Kedra	Benthic/water sampling	U.Maryland	DH	Bar
Christina Goethel	Benthic/water sampling	U.Maryland	DH	Bar
Samuel Berman	Optics/Water analysis	Clark University	DH	Bar
Kristen Shake	Optics/Water analysis	Clark University	DH	Bar
Janine Beckett	Zoo-plankton	Stantec	DH	Bar
Katherine Kuletz	Bird Observer	US Fish and Wildlife Service	DH	Bar

SUMMARY of RESULTS:

Underway data collection included:

- Without slowing down the ship 24 UCTD profiles (one every 6 hours) to a depth of 400 m were collected across the NE Pacific from the west coast of Vancouver Island and shortly before arrival in Dutch Harbor.
- Daily XCTD was deployed (total number=7) to a depth of 1100 m while crossing the NE Pacific, also without slowing down the ship.
- Taking a slightly southern route across the Pacific, 12 Argo floats were deployed at pre-defined locations.
- Continuous monitoring of surface water properties with electronic sensors from the seawater loop in the main laboratory (temperature, salinity, chlorophyll, oxygen, and nitrogen),
- Bird (Dutch Harbor to Barrow) and marine mammal (Victoria to Barrow) observations.
- Across the NE Pacific, 18 water samples from the seawater loop were collected for Cesium-137 analysis.
- Meteorological and ship position data from ship sensors.

At the 54 science stations in the Bering and Chukchi Seas and across the Barrow Canyon, the following science tasks were completed

- 41Rosette casts,
- 54 CTD casts,
- 41 150 kHz ADCP and AZFP deployments,
- 41 Bongo plankton net hauls,
- 40 Benthic sampling stations with up to 5 van Veen mudgrabs per station.
- 20 stations where water was collected for methane and C13 analysis.
- 4 stations that were sampled for primary productivity incubation experiments.
- 12 stations were sampled for apparent optical properties (C-OPS).

AREAS OF OPERATION:

North Pacific, Bering Sea, Chukchi Sea, Barrow Canyon.

The maps below (Figures 1 and 2) show the science stations and underway CTD (UCTD) drops occupied along the route. A list of these science station locations, dates and activities is included in appendix 1. There were no stops during the ship's transect across the Pacific; except for a few minutes at 12 locations to deploy Argo floats over the side (Figure 1). The ship left Victoria 16:30 PDT July 3rd and arrived in Dutch Harbor 08:30 PDT July 11th. The ship left Dutch Harbor 18:30 PDT July 11th. Arrived Barrow 08:00 PDT July 21st. The science party departed the ship in the morning of July 23rd. Science party flew from Barrow on July 24th.

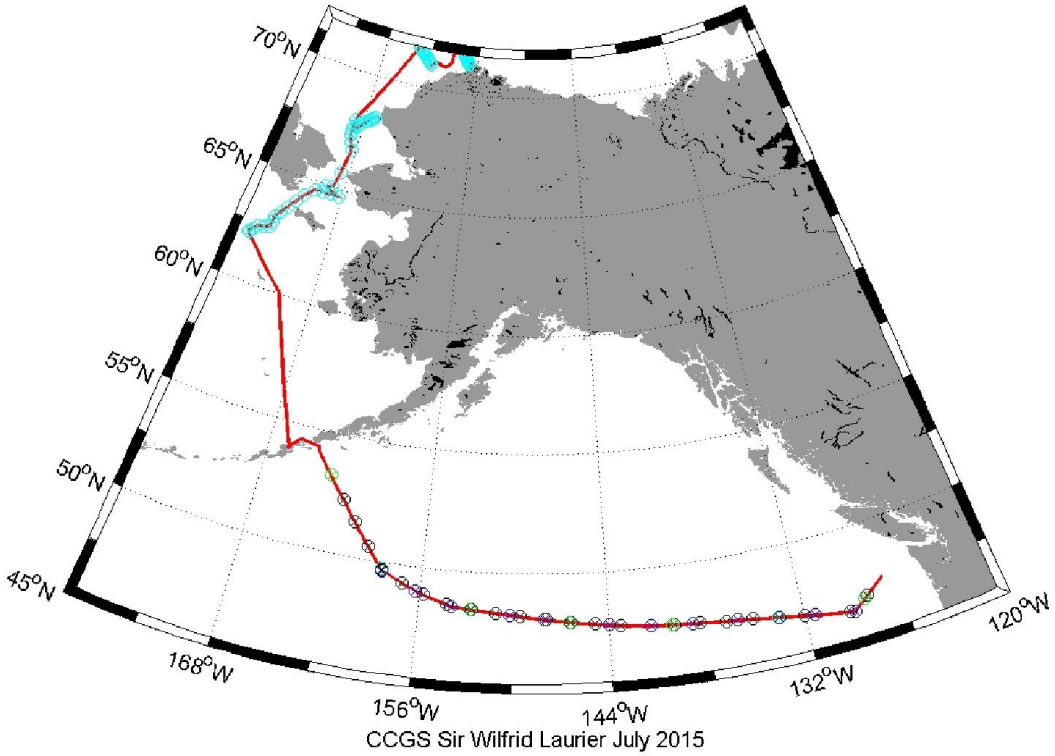

Figure 1. Map showing SWL ship track (red line) across the NE Pacific and Bering and Chukchi Seas. Locations of UCTD profiles (black crossed circles), XCTD profiles (green crossed circles), Argo float deployments (blue crossed circles) and science stations (cyan crossed circles) are also shown.

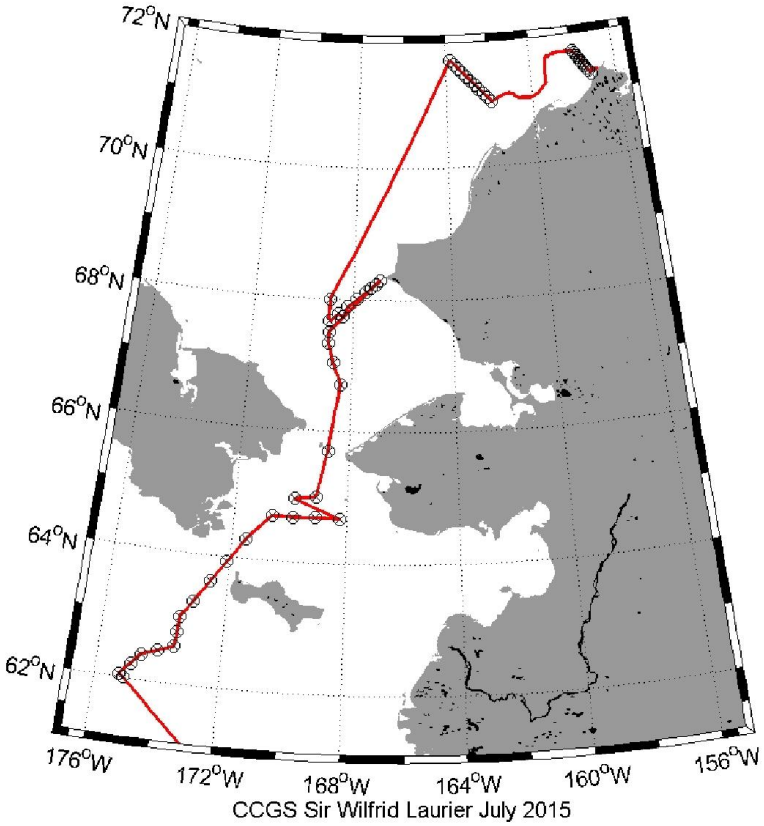

Figure 2. More detailed map of science stations (black crossed circles) in Bering and Chukchi Seas.

The total distance travelled from Victoria to Barrow was about 3600 nautical miles, and the estimated incremental time required for the extra steaming and all science stations was under 6 days.

FIELDWORK:

Science activities aboard the CCGS Sir Wilfrid Laurier for the July leg of the program covered two distinct segments:

1. Across the North Pacific from Victoria, BC to Bering Shelf:
   - Continuous measurements of near-surface water properties from the salt-water loop in the main laboratory.
   - Underway CTD-probe deployed to a depth of 400 m behind the ship every 6 hours without any interruption to ship speed and routines (Figure 3).
   - XCTD probe deployments to a depth of 1100 m every 24 hours.
   - Sampling of water for Cesium-137 analysis.

2. During the Bering/Chukchi Seas and across Barrow Canyon segment from the Aleutian Islands to Barrow, Alaska, 54 repeat stations was occupied as outlined in the table in the appendix. At these locations some or all of the following science tasks were accomplished:
   - CTD with or without Rosette (Figure 4) casts were done to get samples from the overlying water column for the physics, biology and geochemistry groups;
   - A Bongo plankton net haul was done at most stations (Figure 5),
   - ADCP 150 kHz backscatter data and current profiles were collected from an instrument deployed first and recovered last at all full Rosette stations (Figure 6). (During CTD only stations the time on station is too short (~15 minutes) to warrant ADCP deployments.)
   - Van Veen mudgrabs (between 2 and 5 grabs per station) were collected at most stations (Figure 7).
   - Water was collected and filtered at a number of depths at most stations (Figure 8).
   - Primary productivity incubation experiments where conducted using water from a subgroup of stations (Figure 9).
   - An Optical instrument package (C-OPS) was lowered over the side during daylight hours to measure the apparent optical properties of the upper ocean (Figure 10).

This year we also deployed 12 Argo floats along a more southern track than usual (Figure 11).

Figure 3. Underway system used to deploy Conductivity, Temperature, Depth probe to 400 m every 6 hours while crossing NE Pacific.

Figure 4. CTD/Rosette system with 24, 10 liter Niskin bottles deployed over the side of the ship 54 times during the trip.

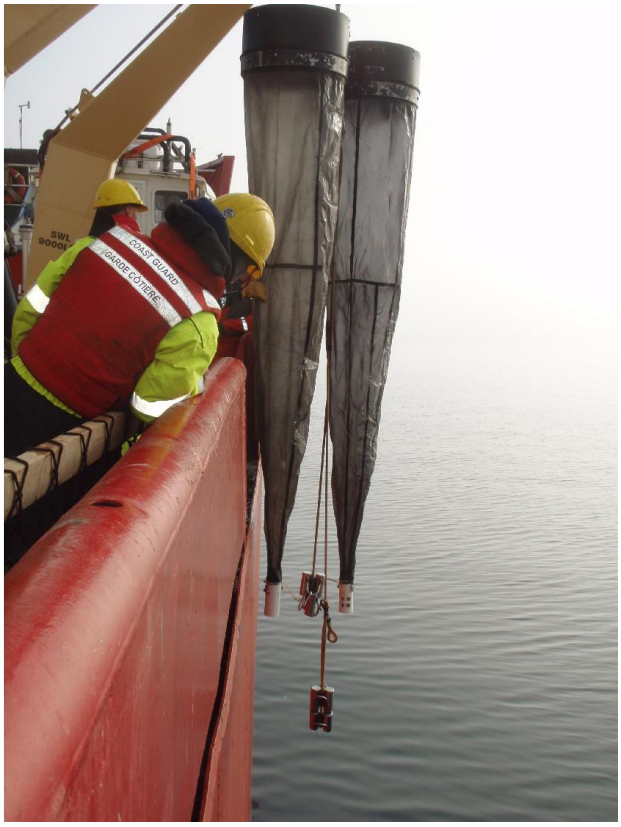

Figure 5. Vertical Bongo nets deployed over the side for collection of zooplankton.

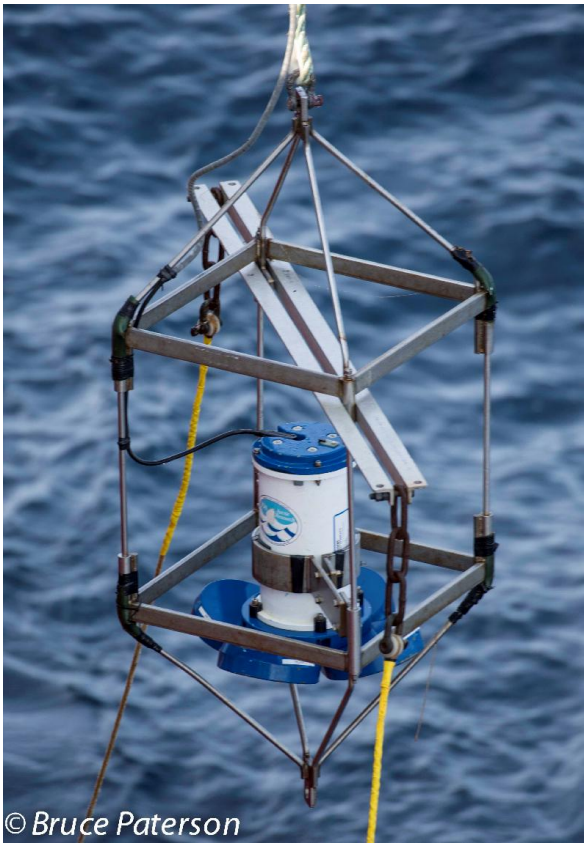

Figure 6. 150 kHz Acoustic Doppler Current Profiler (ADCP) deployed over the side at most CTD/Rosette stations for measurements of currents every 4 m from 5 m below the ship to the bottom.

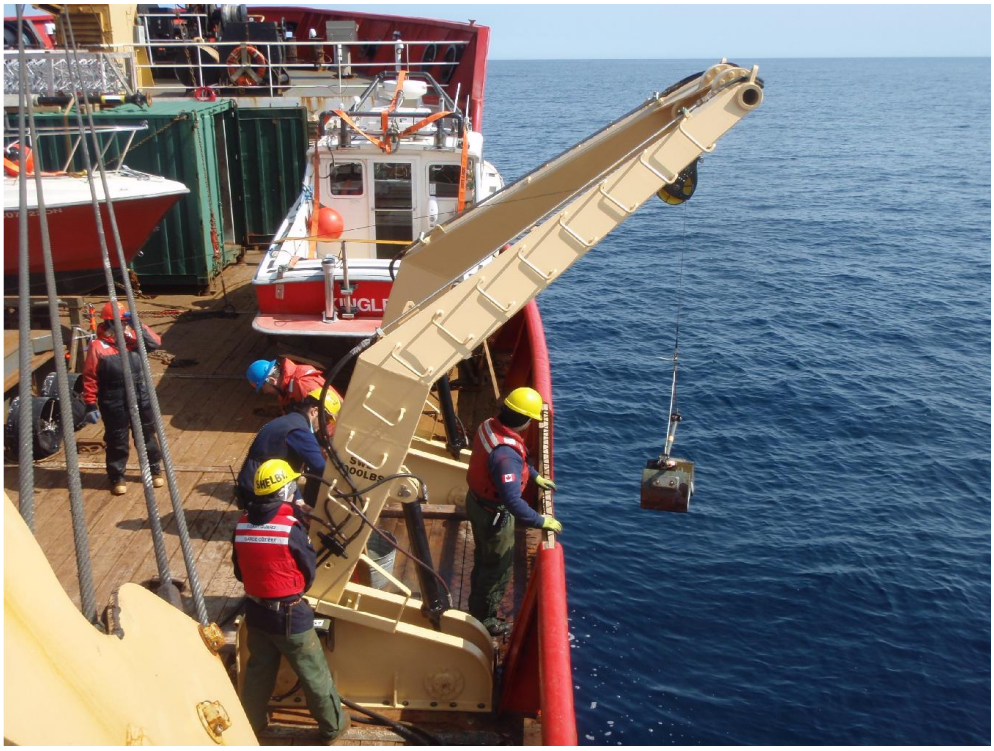

Figure 7. Van Veen grab going over the side to collect sediments and benthic fauna.

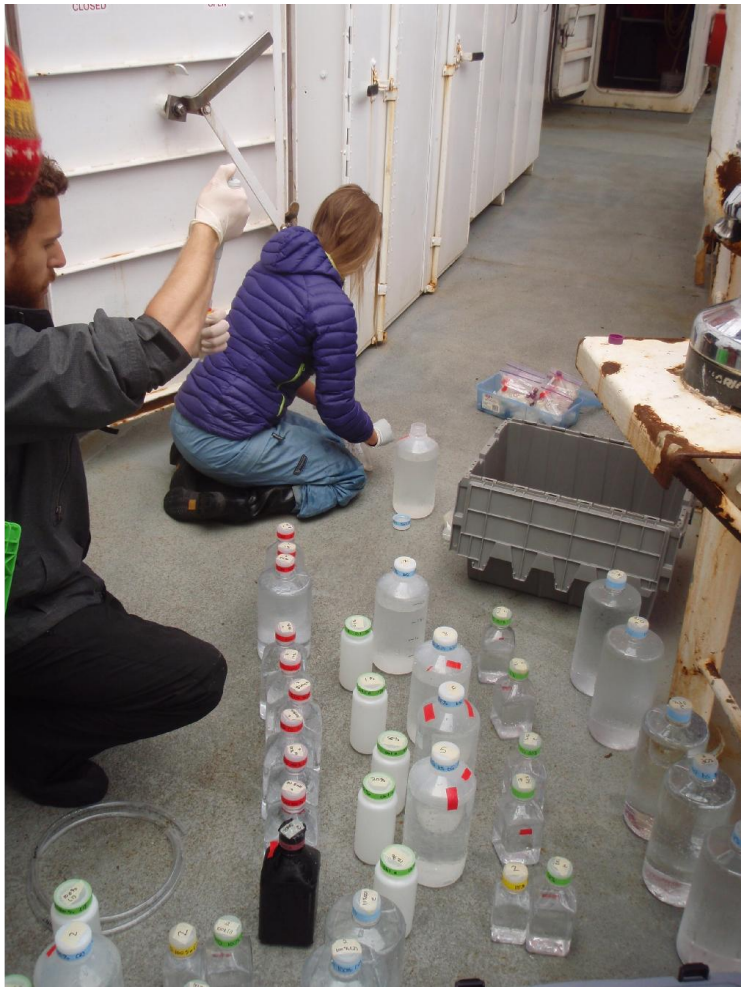

Figure 8. Water sampling from the Rosette Niskin bottles.

Figure 9. Phyto-plankton incubators on the helicopter deck.

Figure 10. Apparent optical property package (C-OPS) that was lowered over the side of the ship.

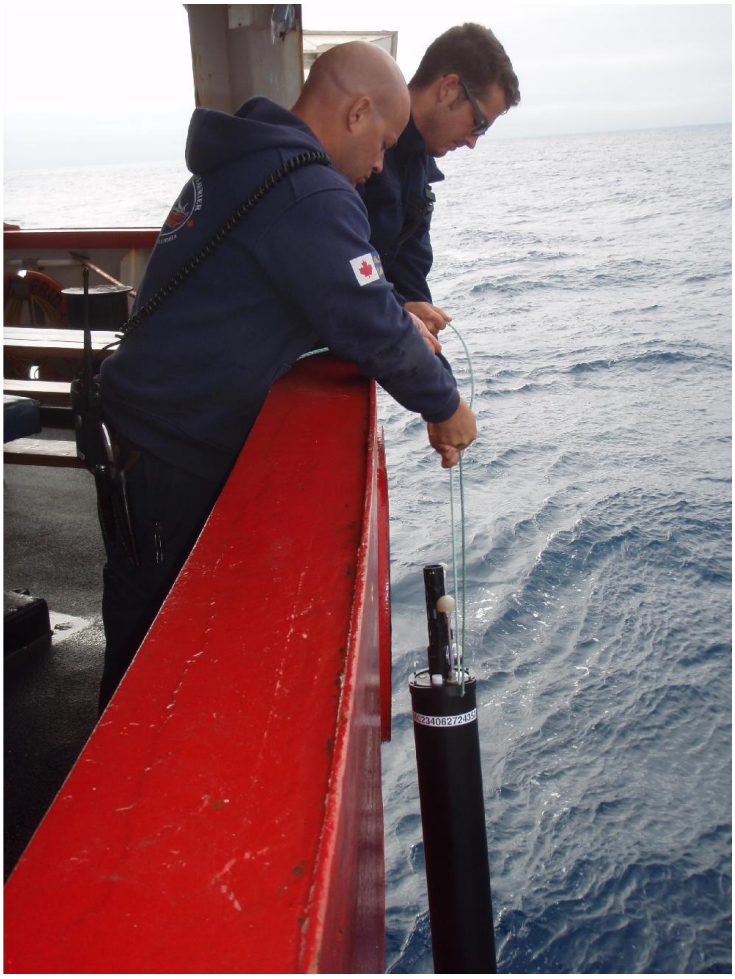

Figure 11. Argo float being deployed over the side. Twelve of these floats were deployed along the track shown in Figure 1.

Shipboard labs

Laboratory spaces on board were used to collect samples for nutrients and salts and electronic sensor data from the seawater loop and to filter rosette samples for chlorophyll. Isotope analysis associated with phytoplankton incubation experiments were also conducted in the main laboratory. Zooplankton samples from Bongo casts were prepared and stored for subsequent analysis back at IOS.

Deck space was used by science for launch and retrieval of equipment and instrumentation, including CTD/rosette for profiling & water sampling and for the launching and recovery of the underway CTD (UCTD) system. The breezeway on the port side of the ship was also used to deploy and recover the 150 kHz ADCP package for acoustic current and zooplankton measurements. The zooplankton Bongo nets and the van Veen grabs were deployed and recovered using the A-frame on the starboard side of the well deck.

To facilitate the science, two container labs were installed and used during leg 1. The 20-ft. green container on the well deck was used for sample preparations following Bongo net hauls and for storage of equipment used for benthic sampling. The 20-ft aluminium container on the boat deck was only used for short-term storage during this leg.

The container labs are well suited for lab duties, outfitted with counter space, shelving, simple sink, heat and power for instruments. Both are hooked up to electrical power for lights and heat, and had phone, ship's intercom and network connections.

CTD/rosette system

A Seabird SBE-9 profiling CTD was used with a custom built compact 24-bottle rosette water sampler. The CTD was equipped with the standard suite of pressure, temperature and conductivity sensors, and additional external sensors: a fluorometer to measure chlorophyll-a concentrations, a transmissometer to measure water clarity, a dissolved oxygen probe, and an acoustic altimeter to get accurate height above the bottom.

The 24-bottle rosette system (Figure 4) was equipped with a Seabird Carousel pylon to remotely trigger the 10-litre Niskin sample bottles. An SBE-11 deck unit was used with Seasave software to acquire real-time data from the CTD and to close the bottles at depths selected before and/or during the cast. The deck unit included a NMEA board to automatically add GPS position into the header of the data file. This system worked very well during the trip.

Plankton nets

Single Bongo plankton net hauls to a depth of water-depth minus 10 m were done at most stations, using the hydro winch and A-frame on the well-deck (Figure 5). These casts were done right after the CTD/rosette casts while water was being sampled from the rosette Niskin bottles or sometimes at the same time as the CTD/rosette casts.

Benthic sampling

Up to five 0.1 m^2 van Veen grab deployments were made at each science station for collections of surface sediment chlorophyll, organic carbon/nitrogen content, grain-size, and benthic marcrofaunal population structure (Figure 7).

ADCP/Backscatter sonar

A 150 kHz Teledyne RDI Acoustic Doppler Current Profiler (ADCP) was mounted in a stainless steel frame and lowered over the side when stopped at each science station (Figure 6). This package was the first to be deployed at each science station and the last to be recovered. Data from this instrument gives current profiles below the ship to a maximum depth of 500 m and a measure of plankton layers in the water column down to approximately 100 m.

Underway CTD system

During this cruise an underway CTD system was successfully used to collect temperature and conductivity (salinity) data from the surface and down to a maximum depth of 400 m while the ship was moving at cruising speed (Figure 3). The probe was dropped to 400 m. Across the Pacific the probe was deployed every 6 hours and the complete operation took less than 20 minutes per cast. This is an excellent method to collect high quality water property data from the ship without interfering with speed and ship operations. These data were augmented with expendable CTD probes dropped from the stern of the ship every 24 hours to extend the depth to 1100 m.

Cs-137 isotope collection

As part of the UVIC lead InFORM project, surface seawater was collected to characterize the distribution of Fukushima derived radionuclides 137-Cesium (137Cs half life ~30 years), and 134-Cesium (134Cs half life ~2 years). This information will help to determine how well model predictions of the activities and progression of ocean borne contamination across the Pacific Ocean match with observations. This provides important information on the impact of this contamination on the health of the Pacific ecosystem and the North American public that rely on the ocean for their food, livelihood and recreation. The evolution of the contaminant plume in time and space also helps the scientific community to better understand ocean mixing which is a key parameter toward understanding the oceans role in mitigating atmospheric greenhouse gas increases and climate change. These data will be combined with other data collected along the coast of western North America.

Gases and 13C-CH4 sampling

Nitrous oxide (N_2O) and methane (CH_4) are greenhouse gases that are many times more potent than CO_2 in the atmosphere. As the temperature of the atmosphere increases due to climate change, the concentrations of both of these gases in seawater are expected to grow. The Arctic is a particularly interesting location to study this due to its vulnerability to climate change and status as a global "bell weather".
Water samples were collected for later analysis for N_2O, CH_4, and 13C-CH_4. Depth profiles were taken at stations throughout the Bering and Chukchi Seas using the standard depths of 5, 15, 25, 35, 50, 75, 100, and bottom minus 5 meters. Approximately every other station on each line was sampled.

Compact Optical Profiling System (C-OPS)

C-OPS is a radiometer system for determining apparent optical properties in the ocean. It consists of two radiometers: one measuring in-water upwelling radiance, and the other either downward irradiance or upward irradiance. Both radiometers are equipped with 19 wavebands covering wavelengths in the UV and PAR (250 – 800 nm) measuring at 15 Hz. The surface reference is mounted with a clear view of the sky in a location where shadow is non-existent. The C-OPS radiometer is always deployed towards the sun to avoid ship shadow.

JAMSTEC moorings

No JAMSTEC mooring work was done this year.

SUCCESSES AND PROBLEMS [SCIENTIFIC]:

The data collected will be used with data collected along the same ship track and at similar stations in earlier years to investigate interactions between the biological conditions and the physical parameters that govern their environment and to allow for studies of possible ecosystem changes due to climate change.

All of the science instrumentation provided scientifically valuable data, and will help to combine biological findings with measurements of the physical characteristics of the ocean. All the scientific equipment performed well throughout the trip. Very little ice was found this year and with excellent weather conditions, all science stations were completed as planned and well ahead of schedule.

PROBLEMS [SHIP'S EQUIPMENT/OPERATIONS/PLATFORM SUITABILITY]:

The ship is very well suited for this type of oceanographic work. No problems were reported during the cruise. A major reason for yet another successful mission is the wonderful support from and professionalism of the ship's officers and crew.
There were no issues with the sharing of the aft-lab this year. CHS had packed away all their gear in such a way that the lab was perfectly suited for our work.

SUCCESSES [SHIP]:

The support of officers and crew in getting our equipment onboard, up and running, and during all station operations and data collection is invaluable and greatly appreciated. The professionalism of the Canadian Coastguard became obvious to the whole science team during this trip. The science party had a wonderful time onboard the ship.

DAYS LOST DUE TO WEATHER:

No science lost due to weather.

DELAYS [OTHER THAN WEATHER]:

No delays.

SAFETY CONCERNS:

No safety concerns were reported.

SUMMARY/FINAL COMMENTS:

Again we want to express our gratitude for all the help and support we received from Commanding Officer Victor Gronmyr and his officers and crew onboard CCGS Sir Wilfrid Laurier (SWL), resulting in a successful trip and the collection of significant amount of interesting and valuable scientific data and samples. All national and international collaborators have commented on how great a platform SWL is for the type of science we are doing.

for additional information on this report contact
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Appendix Science Stations

-ADCP is the down-looking 150 kHz Acoustic Doppler Current Profiler.
-CTDR is the CTD/Rosette electronic profiling and water sampling instrumentation deployed to the seafloor minus 5 m at each science station.
-CTD is a CTD cast only.
-Mud indicates collection of benthic sediment samples using a Van Veen grab. Numbers indicate number of grabs at a given station.
-Bongo is the dual plankton net vertical haul from depths of 100 m or less at the shallower stations.
-C-OPS is the optics package deployed over the starboard side to measure light attenuation characteristics by the Clark University team.

Station Name	Start (UTC)	Lat. North (deg)	Lat (min)	Long. West (deg)	Long (min)	Science Tasks
Victoria	Jul 3 23:30	48	25.215	123	23.343	Depart for Arctic
SLIP-1	Jul 14 14:18:29	62	0.6	175	3.6	ADCP, CTDR, Bongo, Mud*5
SLIP-2	Jul 14 17:07:04	62	2.99	175	12.59	ADCP, CTDR, Bongo, Mud*5, C-OPS
SLIP-2B	Jul 14 20:00:17	62	13.1	174	52.78	CTD
SLIP-3	Jul 14 21:38:27	62	23.4	174	34.21	ADCP, CTDR, Bongo, Mud*5, C-OPS
SLIP-3B	Jul 15 00:27:55	62	28.06	174	4.98	CTD
SLIP-5	Jul 15 02:16:47	62	33.62	173	33.1	ADCP, CTDR, Bongo, Mud*5
SLIP-5B	Jul 15 04:47:10	62	47.19	173	30.02	CTD
SLIP-4	Jul 15 06:27:29	63	1.77	173	27.64	ADCP, CTDR, Bongo, Mud*5
SLIP-4B	Jul 15 09:24:50	63	16.79	173	4.76	CTD
SLIP-4C	Jul 15 11:51:59	63	36.23	172	35.42	CTD
BCL-6A	Jul 15 14:07:11	63	55.19	172	6.01	ADCP, CTDR, Bongo
BCL-6B	Jul 15 16:56:11	64	17.51	171	29.86	CTD
BCL-6C	Jul 15 19:55:50	64	40.26	170	38.78	CTD
UTBS-5	Jul 15 21:53:58	64	40.33	169	55.39	ADCP, CTDR, Bongo, Mud*5, C-OPS
UTBS-2	Jul 16 01:13:53	64	40.94	169	6.33	ADCP, CTDR, Bongo, Mud*5
UTBS-2A	Jul 16 04:18:07	64	40.28	168	14.22	CTD
UTBS-4	Jul 16 08:52:41	64	57.66	169	53.26	ADCP, CTDR, Bongo, Mud*5
UTBS-1	Jul 16 11:44:56	64	59.48	169	8.44	ADCP, CTDR, Bongo, Mud*5
BRS-3	Jul 16 16:44:17	65	42.24	168	46.62	CTDR, Bongo
UTN-1	Jul 16 22:29:02	66	42.65	168	23.95	ADCP, CTDR, Bongo, Mud*5, C-OPS
UTN-2	Jul 17 01:23:40	67	2.99	168	43.67	ADCP, CTDR, Bongo, Mud*5, C-OPS
UTN-3	Jul 17 04:15:40	67	19.66	168	56.51	ADCP, CTDR, Bongo, Mud*5
UTN-4	Jul 17 06:16:44	67	29.99	168	56.53	ADCP, CTDR, Bongo, Mud*5
SEC-8	Jul 17 16:58:30	68	18.12	166	56.35	ADCP, CTDR, Bongo, Mud*2, C-OPS
SEC-7	Jul 17 19:05:29	68	14.5	167	7.32	ADCP, CTDR, Bongo, Mud*2
SEC-6	Jul 17 20:21:59	68	11.09	167	18.46	ADCP, CTDR, Bongo, Mud*2, C-OPS
SEC-5	Jul 17 21:48:14	68	7.63	167	29.72	ADCP, CTDR, Bongo, Mud*2
SEC-4	Jul 18 00:42:45	68	0.79	167	51.96	ADCP, CTDR, Bongo, Mud*5
SEC-3	Jul 18 03:00:36	67	53.87	168	14.02	ADCP, CTDR, Bongo, Mud*5
UTN-6	Jul 18 04:56:07	67	44.39	168	26.33	ADCP, CTDR, Bongo, Mud*5
SEC-2	Jul 18 06:21:03	67	46.97	168	36.11	ADCP, CTDR, Bongo, Mud*5
SEC-1	Jul 18 08:39:43	67	40.19	168	57.57	ADCP, CTDR, Bongo, Mud*5

UTN-7	Jul 18 12:31:28	68	0	168	56.64	ADCP, CTDR, Bongo, Mud*5
DBO4.6	Jul 19 15:57:50	71	37	163	47.37	ADCP, CTDR, Bongo, Mud*5, C-OPS
DBO4.5A	Jul 19 18:01:50	71	33.25	163	36.04	CTD
DBO4.5	Jul 19 19:02:32	71	29.41	163	24.65	ADCP, CTDR, Bongo, Mud*5, C-OPS
DBO4.4A	Jul 19 20:40:35	71	25.82	163	14.09	CTD
DBO4.4	Jul 19 21:33:52	71	21.69	163	1.85	ADCP, CTDR, Bongo, Mud*5, C-OPS
DBO4.3A	Jul 19 23:22:05	71	17.76	162	50.23	CTD
DBO4.3	Jul 20 00:38:11	71	13.97	162	39.05	ADCP, CTDR, Bongo, Mud*5
DBO4.2A	Jul 20 01:58:27	71	10.36	162	28.51	CTD
DBO4.2	Jul 20 02:47:37	71	6.24	162	16.46	ADCP, CTDR, Bongo, Mud*5
DBO4.1A	Jul 20 04:05:39	71	2.42	162	5.56	CTD
DBO4.1	Jul 20 04:56:07	70	58.42	161	53.7	ADCP, CTDR, Bongo, Mud*5
BarC-10	Jul 20 19:22:20	71	37.04	157	54.74	ADCP, CTDR, Bongo, Mud*2
BarC-9	Jul 20 20:21:39	71	34.69	157	49.94	ADCP, CTDR, Bongo, Mud*2
BarC-8	Jul 20 21:24:12	71	32.24	157	44.85	ADCP, CTDR, Bongo, Mud*2
BarC-7	Jul 20 22:38:47	71	30.01	157	40.29	ADCP, CTDR, Bongo, Mud*2
BarC-6	Jul 21 00:39:43	71	27.33	157	34.74	ADCP, CTDR, Bongo, Mud*2, C-OPS
BarC-5	Jul 21 02:39:01	71	24.61	157	29.45	ADCP, CTDR, Bongo, Mud*5, C-OPS
BarC-4	Jul 21 04:52:27	71	22.34	157	24.81	ADCP, CTDR, Bongo, Mud*2
BarC-3	Jul 21 06:28:28	71	19.82	157	19.73	ADCP, CTDR, Bongo, Mud*2
BarC-2	Jul 21 08:01:33	71	17.29	157	14.72	ADCP, CTDR, Bongo, Mud*2
BarC-1	Jul 21 09:27:07	71	14.83	157	9.68	ADCP, CTDR, Bongo, Mud*2
Barrow						Science program ends