Long-term monitoring of pelagic biodiversity in the NE-Pacific: a new program based on vertical ROV video surveys during NEPTUNE observatory maintenance expeditions.

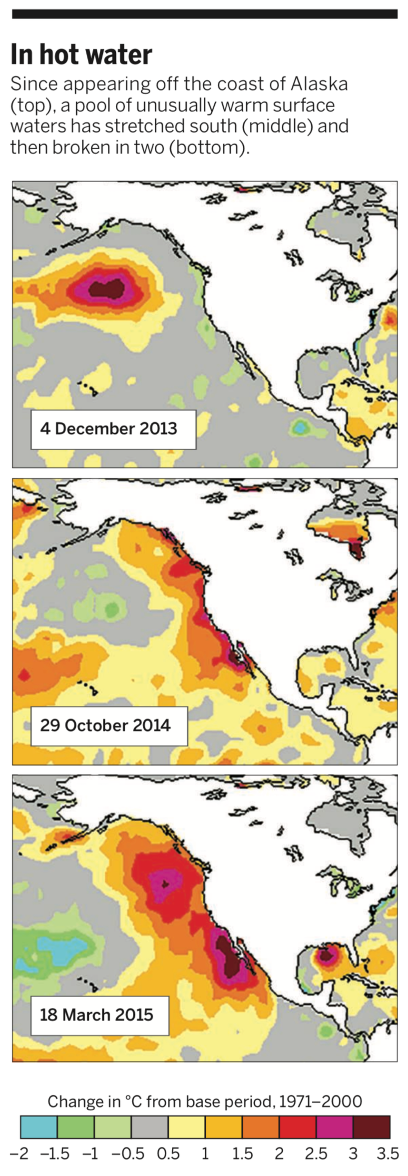
Fabio C. De Leo[1,2] (fdeleo@uvic.ca) , Marco Francescangeli[3], Lu Guan[1], Jacopo Aguzzi[4], Emanuela Fanelli[3], Mistuko Umetsu[5], Dhugal Lindsay[5]

[1]Ocean Networks Canada, University of Victoria, Canada, [2]Department of Biology, University of Victoria, [3]Polytechnic University of Marche, Ancona, Italy; [4]Instituto de Ciencias del Mar (ICM-CSIC), Barcelona, Spain; [5]Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan

Summary

Ocean Networks Canada (ONC) operates large seafloor cabled observatory networks in the Arctic and NE Pacific, with some of its long-term observations nearly approaching 15 years of archived data. The seafloor network of 850+ km of backbone cables connects > 50 instrumented sites (>400 oceanographic instruments, >5,000 sensors), in habitats ranging from temperate coastal fjords and rocky subtidal reefs, ice-covered Arctic bays, to deep-sea canyons, cold seeps, abyssal plains and hydrothermal vents. Since 2015 ONC initiated a new long-term monitoring program with the overall goal of adding pelagic biodiversity monitoring to an otherwise benthic-focused observatory infrastructure. Remotely Operated Vehicle (ROV) dives conducted yearly to maintain the regional offshore NEPTUNE observatory have been collecting high-definition video to assess the vertical distribution of gelatinous plankton and nekton in **Barkley Canyon (1000 m), Clayoquot Slope (1200 m), Cascadia Abyssal Plain (2600 m) and Endeavour Hydrothermal Vent (2300 m)**. Here we present preliminary results based on 4 years of observations, of abundance and diversity linked to oceanographic drivers of community structure such as temperature and dissolved oxygen. This new time-series overlapped with the onset and demise of a strong positive temperature anomaly in the upper NE Pacific Ocean ('Warm Blob'), which brought major ecosystem reorganization that ranged from reduced offshore primary productivity to the appearance of non-indigenous species, most notably the dominance by picoplanktonic *Prochlorococcus*, and a massive bloom of pelagic tunicates, *Pyrosoma atlaticum*. We also discuss the challenges and new collaboration opportunities for this new long-term monitoring program of pelagic biodiversity in an otherwise poorly studied area of the Pacific Ocean.

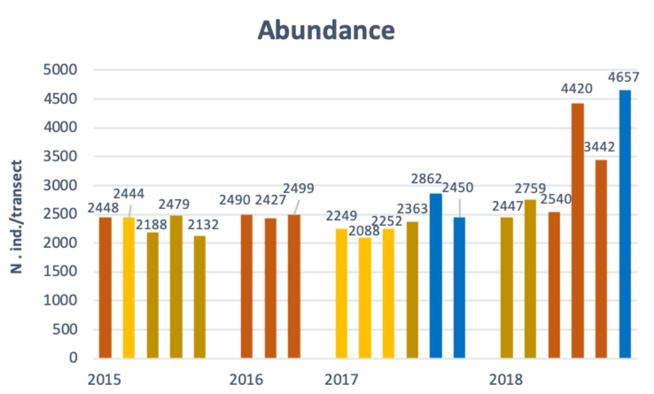
2013-2016 NE Pacific Sea-Surface Warm Temperature Anomaly

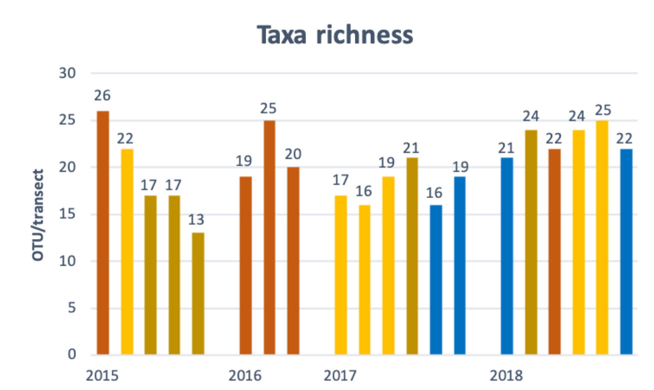


Kintisch 2017, Science 348, 17-18

- Initiated in Oct. 2013 in the Gulf of Alaska, triggered by a highly anomalous weather pattern, with anomalously high Sea-Level Pressure (SLP);
- High SLP in the region impacted the wind-forced currents and wind-generated mixing and upwelling;
- Sea-surface temperatures (SST) in upper 100 m exceeded 3 standard deviations (up to 3°C) and were the greatest observed in this region for the month of February since at least the 1980s and possibly as early as 1900 (Bond et al 2015. Geophys. Res. Lett., 42, 3414-3420);
- The 'Blob' persisted until late 2016 and promoted large coastal and offshore marine ecosystem restructuring, including:
- Change in phytoplankton assemblages, from a diatom-based to picoplankton dominated (Peña et al 2019, Limnol. Ocean. 64 515-525);
- Widespread and multiple harmful algal bloom (HAB) events coastwide from Southern California up to Vancouver Island (McCabe et al 2016, Geophys. Res. Lett., 43, 10,366–10,376);
- Many examples of species 'invasions', with taxa only common in warmer subtropical waters appearing as northward as in the Gulf of Alaska (e.g., pyrosomes);
- Massive seabird die-offs of zooplanktivorous seabirds from California to British Columbia (e.g., Cassin's auklets, Jones et al 2018, Geophys. Res. Lett., 45, 3193–3202);
- Cod fisheries collapse (Cornwell 2019, Science 263(2426) 442-445);
- Large number of marine mammal stranding (due to starvation and toxins during HAB events).

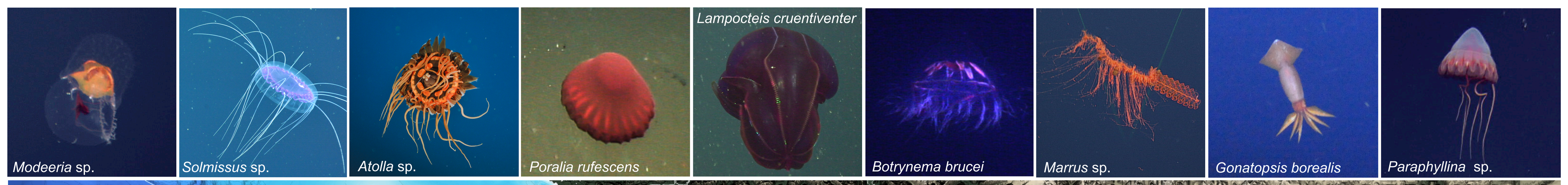
Total Abundance and Taxa Richness

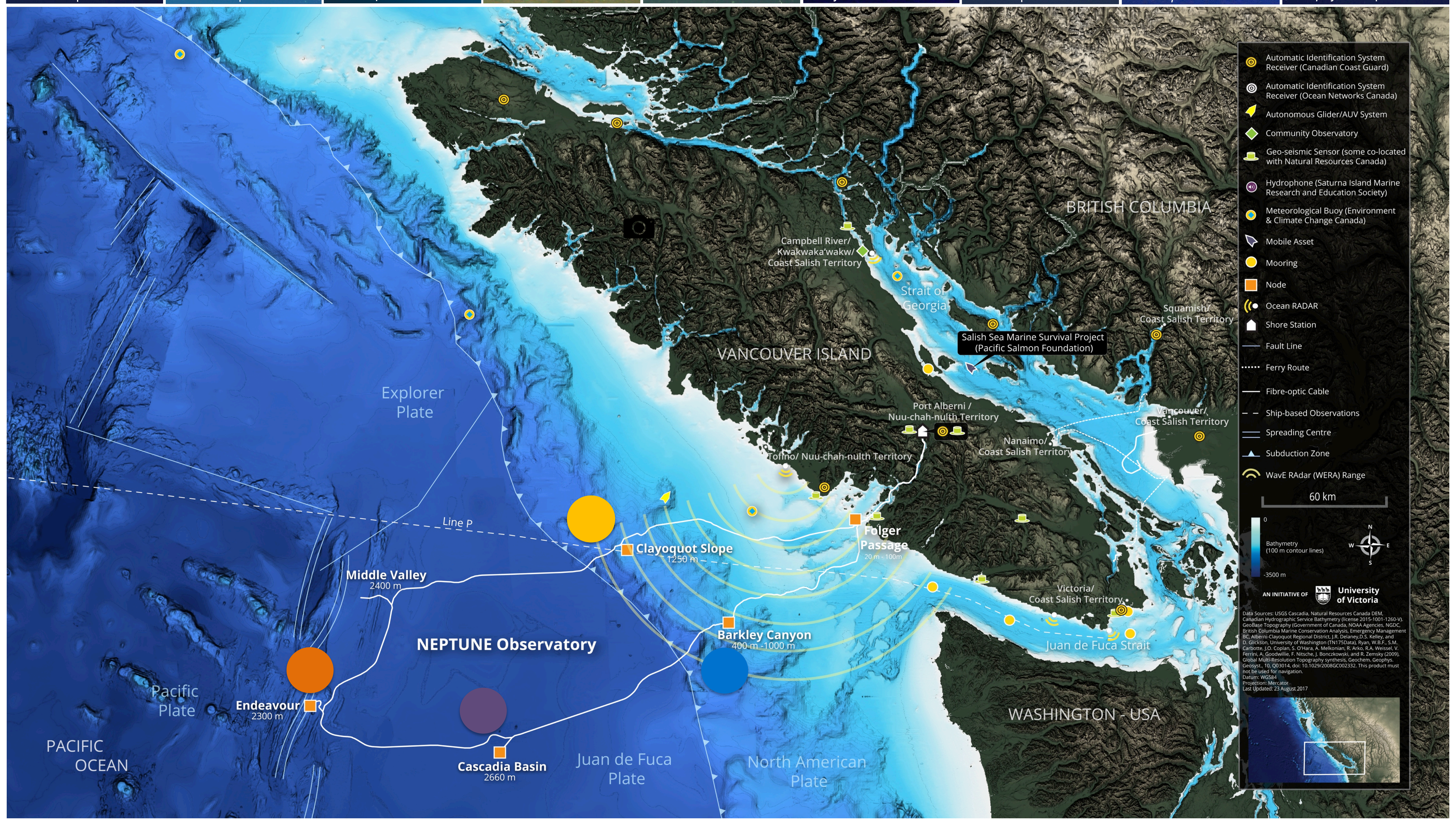




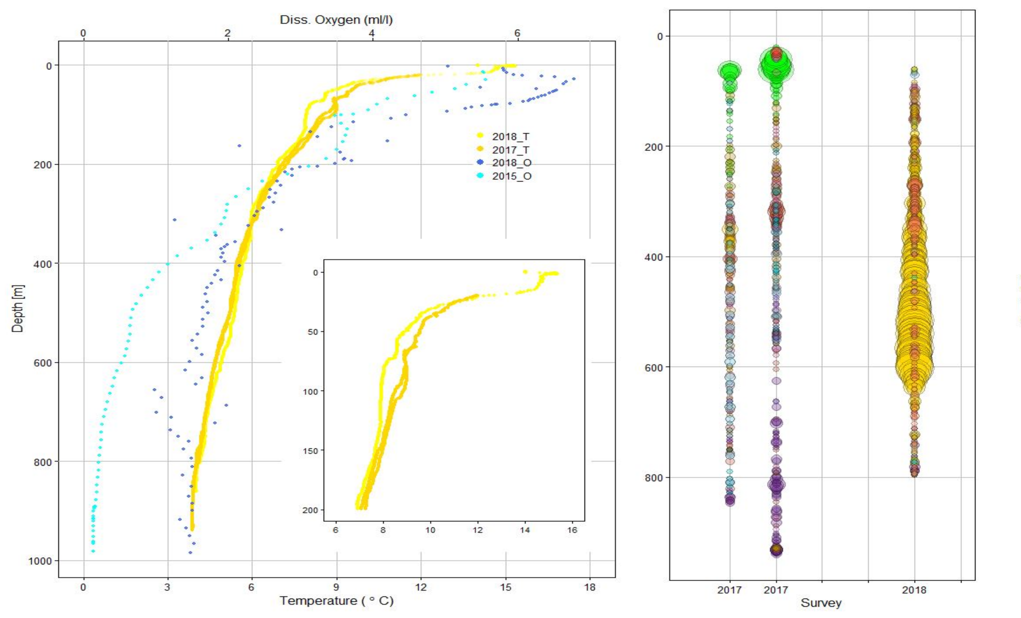
- Combined abundances of gelatinous plankton and nekton ranged from 2,088 to 4,657 indiv. per video transect;
- No significant spatial differences in faunal abundance were observed between all four NEPTUNE sampling stations;
- 2018 was the year with higher total pelagic abundances in particular due to the high myctophid abundances both in Barkley Canyon and at Clayoquot Slope;
- While the average in taxa richness was the lowest in 2015 (15 sp./transect), it reached its highest values in 2018 (23 sp./transect).

A range of species found at the 4 NEPTUNE observatory locations



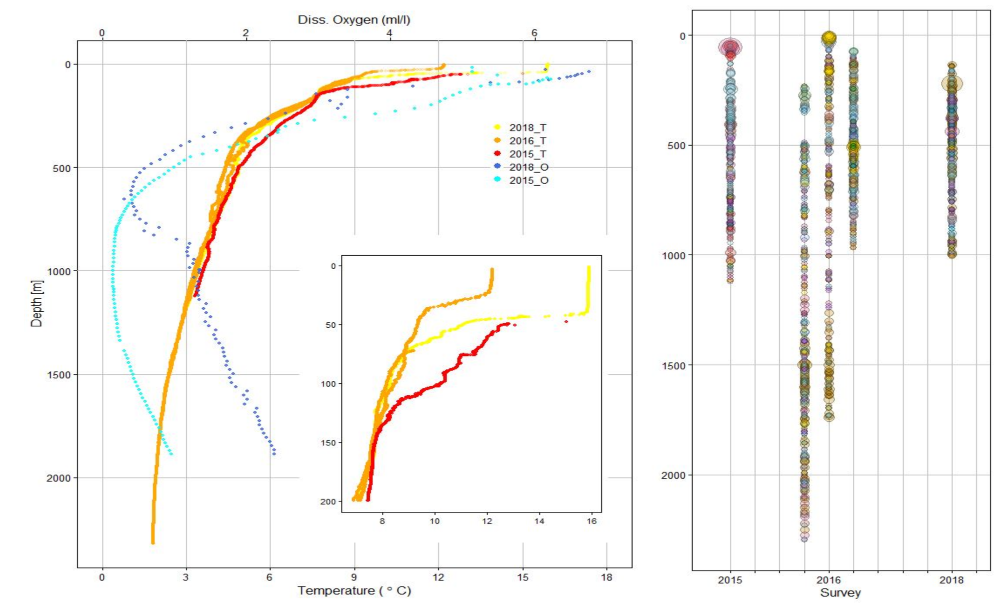


Barkley Canyon



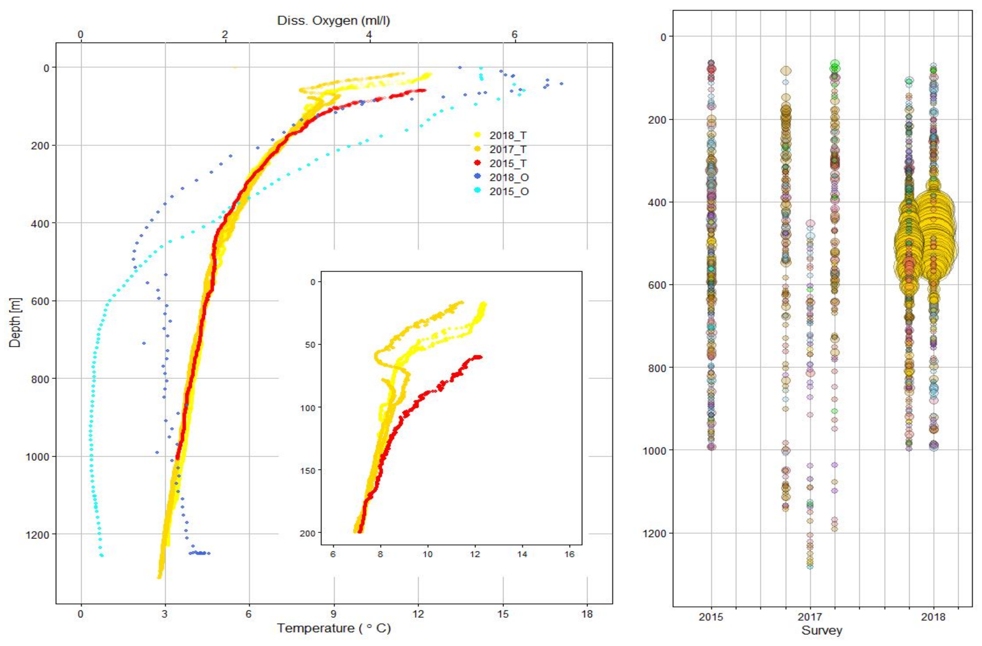
- 34 taxa identified from 2 years of observations in Barkley Canyon;
- Pyrosomes dominated the upper 100 m of the water column in 2017;
- *Poralia rufescens* distinctly dominated from 700-900 m in 2017;
- In 2018, a dense layer of myctophids is visible between 400 and 650 m;

Endeavour Vent Field



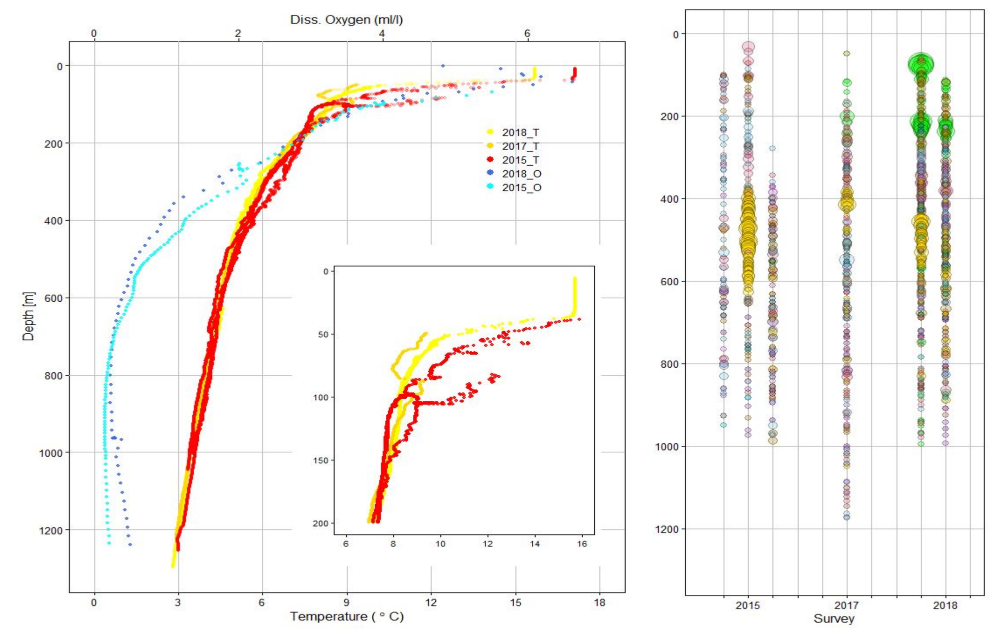
- 47 taxa identified from 3 years of observations at Endeavour;
- The Blood-belly ctenophore *Lampocteis cruentiventer* and jelly *Poralia rufescens* dominated the gelatinous plankton, each with 24% of the total abundance (3 years combined);
- An unidentified shrimp species accounted for 17% of the total abundance; an unidentified squid for 14%, chaetognaths 9%, pyrosomes 6%, siphonophores 5%.

Clayoquot Slope



- 45 taxa identified based on the 3 years of video transects performed in Clayoquot Slope;
- No taxa dominated the pelagic community through the entire 1200 m of the water column in 2015 and 2017; with 5 species of jellies and two siphonophores being the most representative;
- In 2018, however, like for Barkley Canyon, a dense layer of myctophids between 400-600 also in 2018;

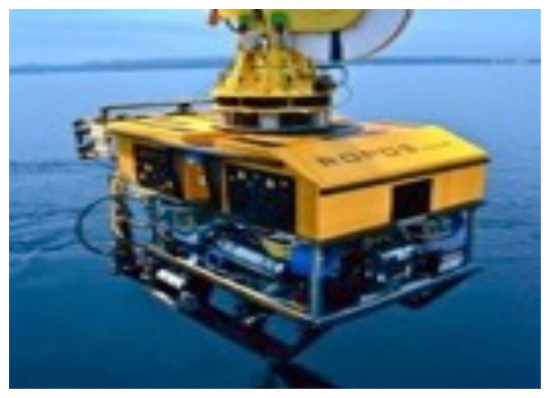
Cascadia Basin Abyssal Plain



- 42 taxa identified from the 3 years of observations at Cascadia Basin;
- 5 species of jellies accounted for ~22% of the total abundance, while myctophids accounted for 18%; an unidentified species of shrimp 5%;
- While pyrosomes appeared in modest numbers at the upper 200 m of the water column in 2016; in the following year they were very abundant at 50-100 m and also at 200-250 depth horizons;

Methods

- Opportunistic surveys, currently under consideration for implementation as a long-term monitoring program;
- Initiated in 2015 and ongoing (5 years of data);
- Initial challenges: (1) ONC funding model focused on operation and maintenance of observatory infrastructures (i.e, need for additional $$ for ship and ROV time); (2) use of multiple ROV platforms (e.g., 10 ROV providers since 2009). This means different video camera and lighting set-ups, sampling capabilities and variable ancillary oceanographic instruments among platforms (CTDs, dissolv. O2, etc – i.e., need for careful sensor quality control and calibration protocols);
- Minimum required video survey protocols (adding ~45-60 min per dive);
- ROV descends at 10 m/min. for at least the upper 1000 m of the water column (video quality for faunal identifications);
- Vertical video transects in all NEPTUNE observatory stations (during descent, ascent or both)
- ROV moving vertically slightly forward and towards incoming current; video in near-field focus (maximizing good visual observations of gelatinous plankton);
- 20 vertical video transects from 18 dives were analyzed, approximately ~26 hr of video.



ONC Sea Tube V2 annotation tool

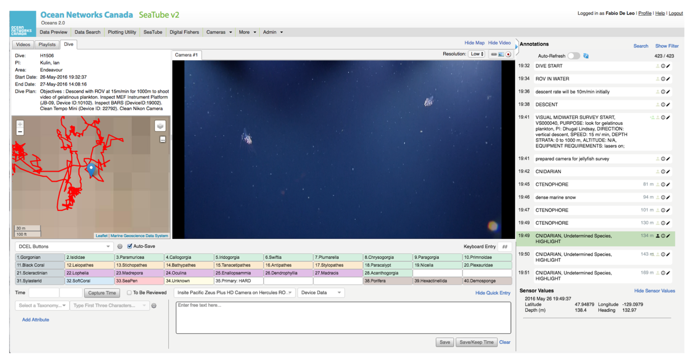
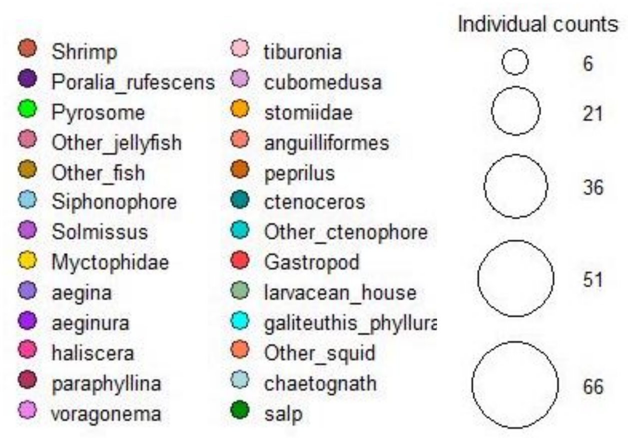


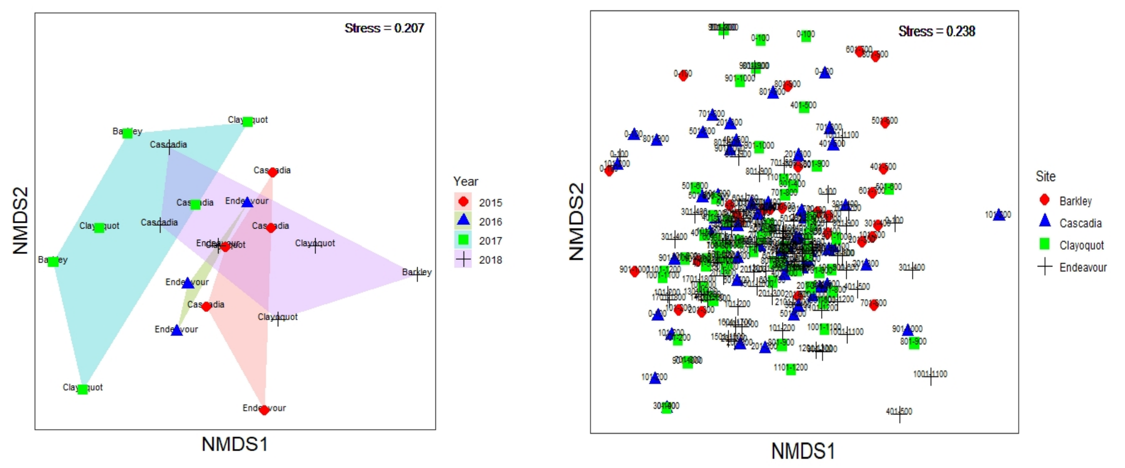
Image and Data Analysis

- Manual annotations performed on the high-resolution video;
- A single person analyzed the entire video dataset, minimizing intrinsic biases in faunal identifications and abundance estimations;
- Taxa annotations matched with timestamp and depth data from video close captioning based on ROV positioning and pressure (CTD) sensors;
- ONC's 'Marine Species Field Guide' was used as a base reference for the more abundant and representative taxa;
- Non-metric multidimensional scaling (MDS) analysis was performed based on square-root transformed taxa abundance data, and using Bray-Curtis similarity matrix. Data was also binned in 100-m depth strata to allow comparisons with previous studies;
- Total abundance and species richness were calculated from individual video transects;
- * Due to the initial opportunistic character of this program, the 4-year time series is only complete for Endeavour. Barkley Canyon was surveyed only in 2017 and 2018, and Clayoquot Slope and Cascadia Basin in 2015, 2017, 2018.
- ROV dissolved oxygen data is not available for 2016 and 2017.

Pelagic taxa



Community Structure



- Considering entire vertical transects as individual samples, the combined gelatinous plankton and nekton communities appeared to be primarily structured by the temporal variability in the environmental conditions (MDS plot 1 - left);
- When data is binned in 100 m depth intervals spatial structuring is also not evident (MDS plot – right).

Future directions

- Fine-tune taxonomic identity of gelatinous plankton species;
- Further explore data by depth-strata (100 m bins);
- Quantify role of environmental variables (temp., dissolved O_2, and surface productivity);
- Implement artificial intelligence in automating the detection and classification of species;
- Seek additional funding for dedicated research program on pelagic biodiversity;
- Improve on survey protocols (oblique transects?) as we implement a permanent monitoring program.

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