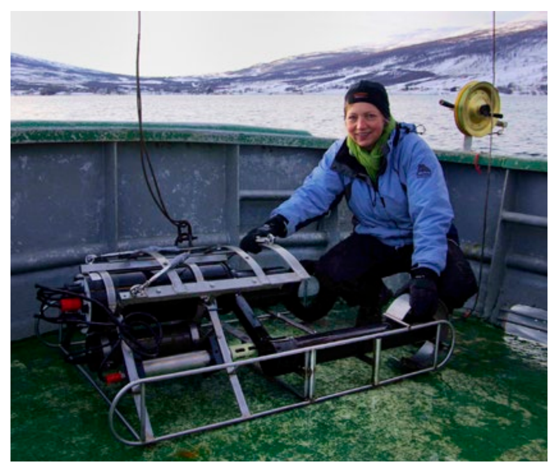
Fredrika Norrbin // UiT The Arctic University of Norway

A focus on plankton

Some of the world's most important creatures are tiny. Infinitesimal marine organisms make life on earth possible, yet most people have never seen them. Even the scientists who study them rarely get to observe them alive and in their natural habitat. But now there is a way to see marine plankton in action.

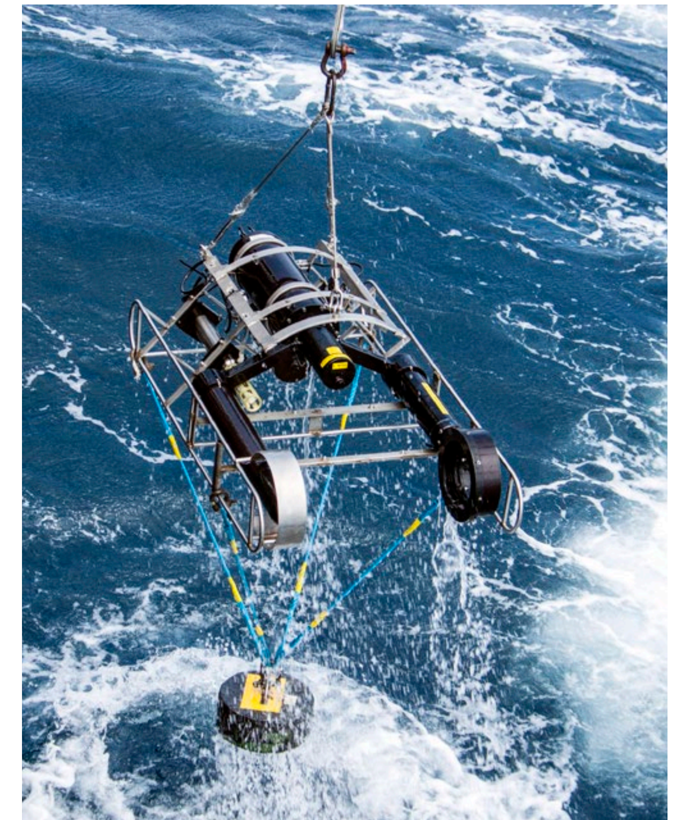
ZOOPLANKTON are tiny creatures that populate the seas, much as insects swarm in the air. They feed on even smaller organisms: phytoplankton, which convert sunlight and nutrients to energy, and microplankton that eat particles. Zooplankton are adapted to the seasonal cycle, and are sensitive to temperature. Because they have little motility of their own, they depend on water currents to move from place to place. What makes zooplankton so important to study is that they provide the major pathway of energy to fish and higher organisms. Environmental changes may alter the composition of plankton so that the ecosystem becomes unfavourable to species that humans rely on. Clearly we need detailed knowledge about plankton, for instance if we want to know whether there is enough of the right kind of plankton at the time of year when fish larvae need abundant food.



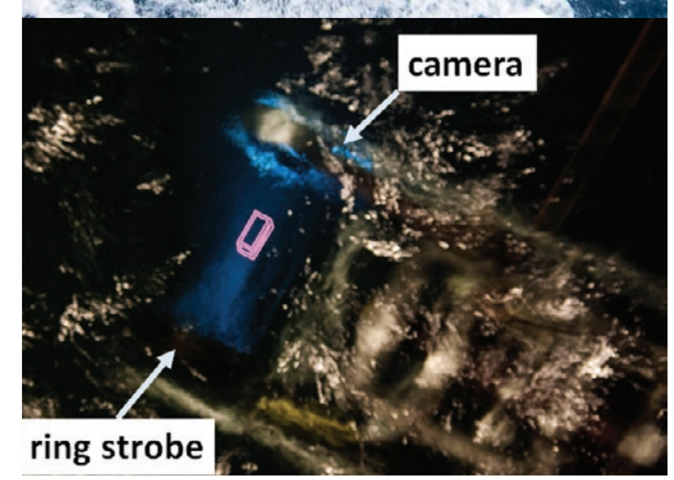
The author on deck with the VPR.
Photo: Fredrika Norrbin

THE VIDEO PLANKTON RECORDER

We use an instrument called the Video Plankton Recorder (VPR) to study the abundance and distribution of common types of zooplankton. The VPR consists of a digital video camera, a strobe light, and sensors for salinity, temperature, chlorophyll fluorescence and turbidity. This device is deployed from a winch and either raised and lowered repeatedly at a single station, or towed behind a ship moving through the water. What is so fascinating about this instrument is that it provides images of undisturbed plankton and particles in the water column, with exact information on the depth of each observation. Some of these animals are too fragile to be caught with plankton nets, so marine biologists rarely see them in a natural state.



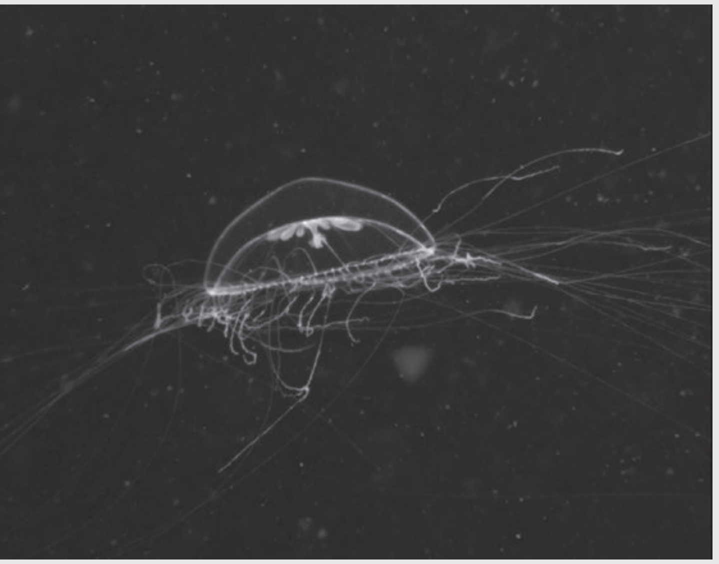
Deployment of the Video Plankton Recorder (VPR).



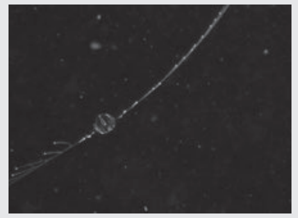
The VPR at the surface, showing the illumination from the Xenon ring strobe. The focus of the 1.4 megapixel B/W camera is midway between the two arms, providing an almost undisturbed sampling area. Twenty images (22 × 32 mm – sampling volume 26 ml) are taken every second.

Photos: Fredrika Norrbin

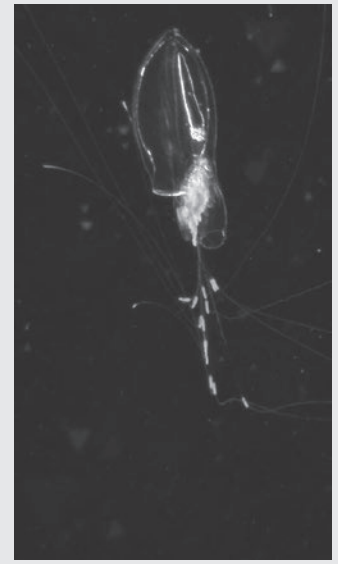
We use the VPR to investigate zooplankton in North Norwegian fjord areas, partly within the Fram Centre Flagship program "Effects of climate change on sea and coastal ecology in the north". The VPR work package is concerned with zooplankton composition and vertical structure. Many models assume that plankton are homogeneously distributed in the water column, but high-resolution studies have shown a large degree of aggregation, and especially layering of the plankton. Although zooplankton are weak swimmers, they can easily adjust their vertical position in the water column. Thus they can choose optimal environmental conditions, and approach or avoid other plankton. Even in rather turbulent coastal waters, plankton form distinct horizontal layers a few metres to tens of metres thick.



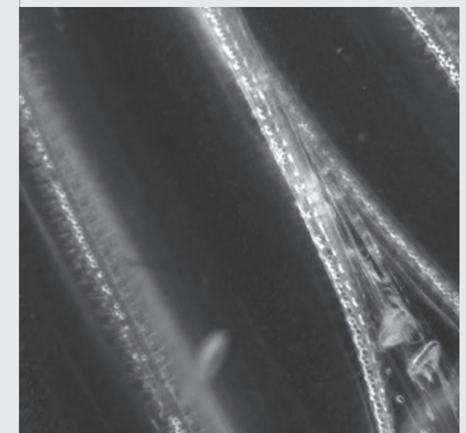
Hydromedusa (10 mm in diameter; Porsanger, October)



A small comb jelly spreads its tentacles to catch plankton (0.5 mm in diameter; Rijpfjorden, January)



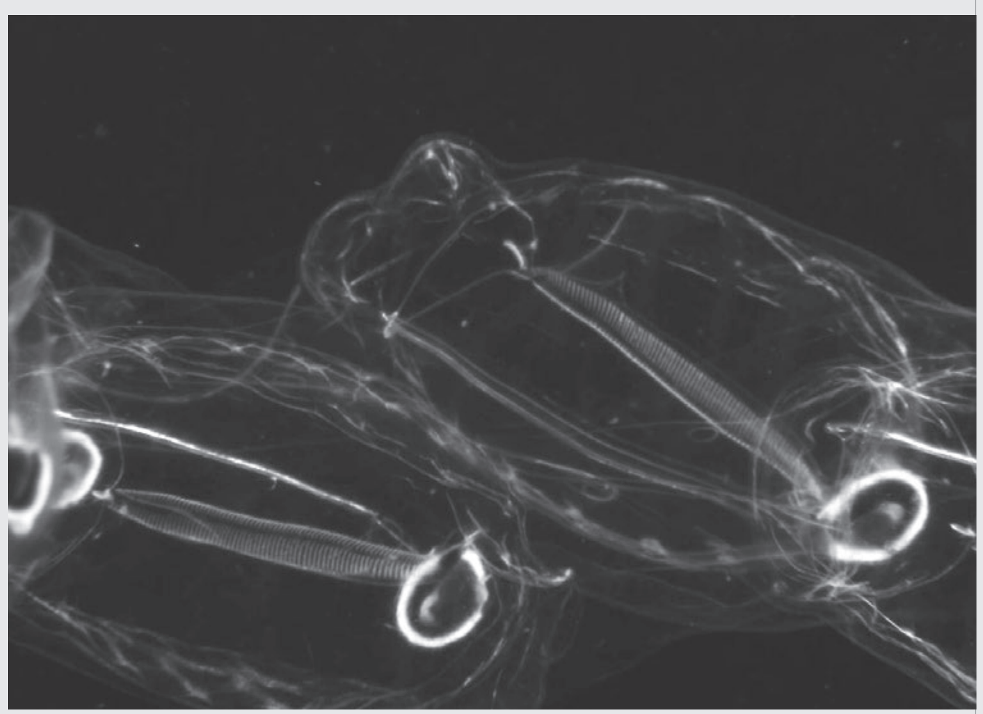
Siphonophore (the main bell is less than 0.5 mm high; Loppahavet , October)



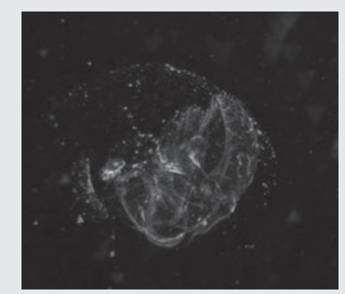
A comb jelly has caught some *Calanus* in its lobes (Porsanger, August)

Fragile organisms are often voracious predators competing with fish larvae for copepod prey. Some, like salps and larvaceans, feed on phytoplankton and particles.

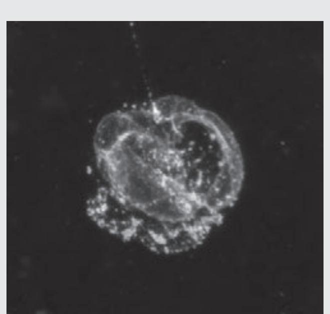
Photos: Fredrika Norrbin



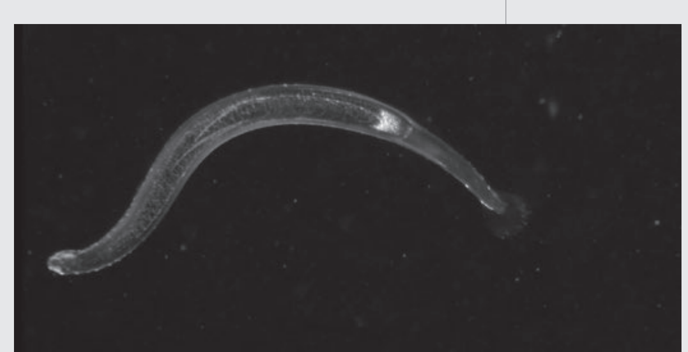
Salps form colonies of barrel-like organisms that filter the water (individual length 20 mm; Loppahavet , October)



Larvaceans build mucus houses, that are really food-collecting sieves, and sit inside beating their "tail" to create a water current (about 11 mm in diameter; Kongsfjorden, January)



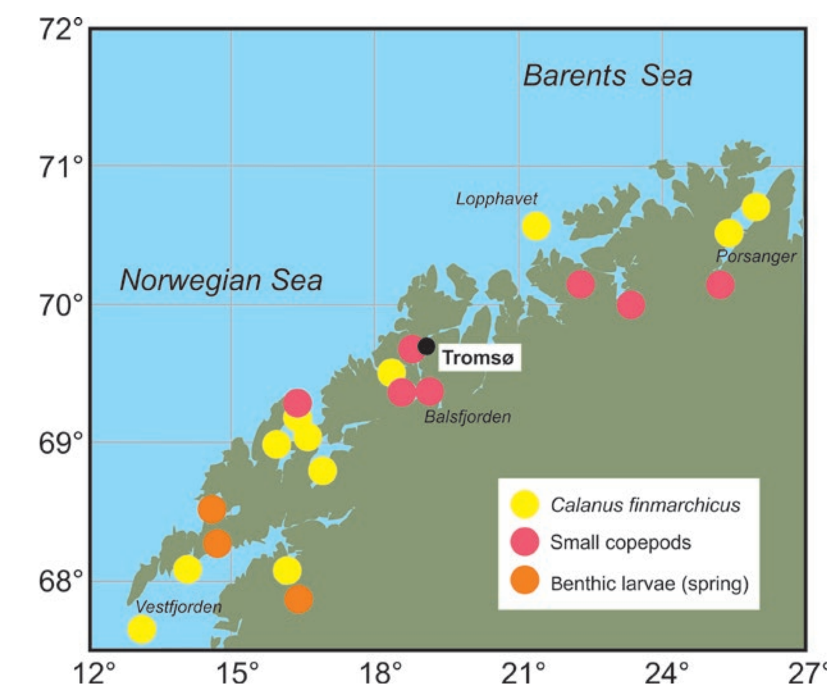
Larvacean houses clog up and are shed several times per day, ultimately forming "marine snow" (Billefjorden, January)



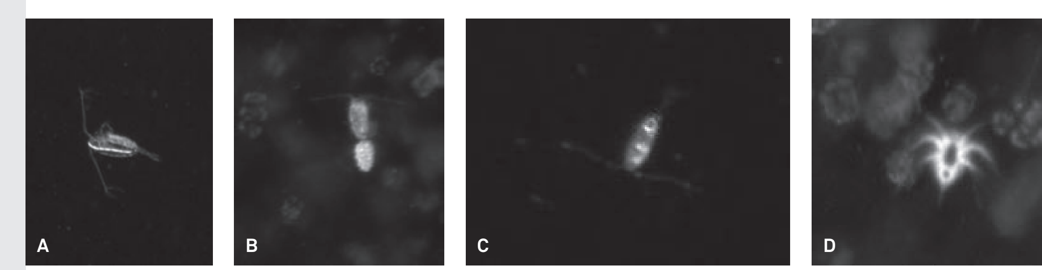
An arrow worm can eat several copepods per day (length = 3 cm; Rijpfjorden, January)

EARLY FINDINGS – INSIGHT FROM IMAGES

From VPR stations taken at various times of the year, a pattern emerges of outer fjords and coastal areas dominated by the copepod *Calanus finmarchicus*, while inner fjord arms are populated by smaller species of copepods and hydromedusas. Although these facts could also have been determined using plankton nets, the VPR provides additional information about depth segregation of species (termed "habitat selection") and the position of invertebrate predators in relation to their prey.

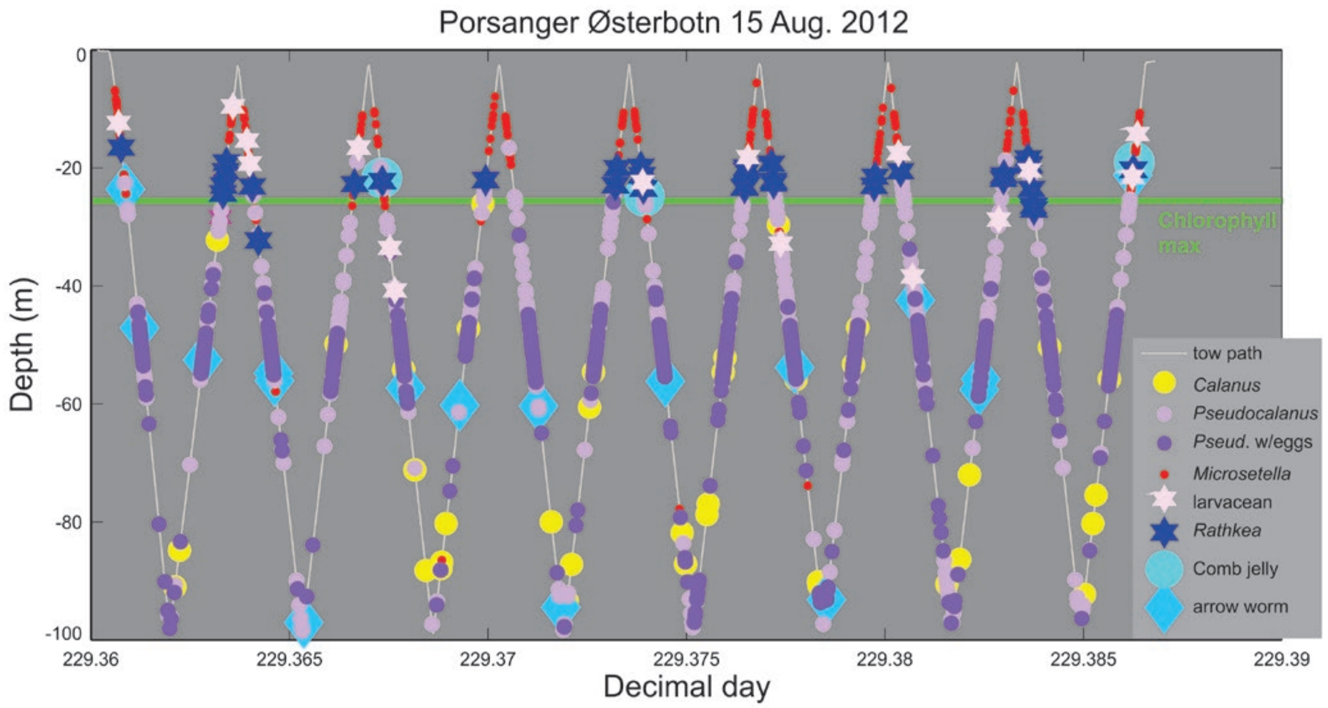


North-Norwegian VPR stations, showing dominance of *Calanus* and smaller plankton, respectively. Larvae of benthic organisms can be very abundant in spring.

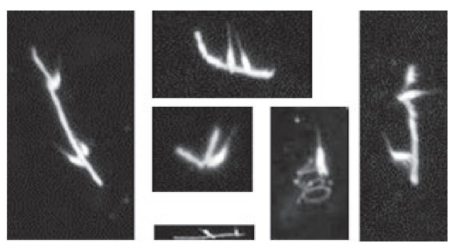


A. *Calanus* (length = 3-4 mm) stores energy in an oil sac. **B.** *Pseudocalanus* (1-1.5 mm) female with egg sac. **C.** *Acartia* (1-1.5 mm) has two little droplets of oil in the body. **D.** Barnacle larvae swarm and feed in the plankton for a few weeks before settling on rocky shores.

Photos: Fredrika Norrbin



Porsanger Østerbotn, individual observations of plankton in a "mini-transect", sampled with the ship adrift. Egg-carrying *Pseudocalanus* females are concentrated around 50 m depth, and predatory species are abundant in the layers both below (arrow worms) and above (comb jellies and the small hydromedusa *Rathkea*) 50 m depth.



Microsetella on marine snow.
Photos: Fredrika Norrbin

We also observed that the tiny copepod *Microsetella* was almost always associated with detritus in the water column. Detritus, or "marine snow", is formed from decaying plankton, and eventually sinks to the bottom, providing food for benthic organisms. Small bacteria and plankton colonise and start to break down the detritus even as it falls through the water.

The VPR lets us visualise many aspects of the lives of plankton, such as environmental preferences and behaviour. The individual observations build up to thousands of data points to be used in statistical analyses of the data. This is valuable information for modellers, and can contribute greatly to predictions related to environmental change.

FURTHER READING:

Gallager SM, Yamazaki H, Davis CS. (2004) Contribution of fine-scale vertical structure and swimming behavior to formation of plankton layers on Georges Bank. Mar Ecol Prog Ser 267:27-43

Jacobsen HP, Norrbin MF. (2009) A fine-scale layer of hydromedusae is revealed by the Video Plankton Recorder (VPR) in a semi-enclosed bay in northern Norway. Mar Ecol Progr Ser 380:129-135

Norrbin F, Eilertsen HC, Degerlund M. (2009) Vertical distribution of primary producers and zooplankton grazers during different phases of the Barents Sea spring bloom. Deep-Sea Research II 56:1945-1958

Primicerio R. (2003) Habitat choice and community dynamics of zooplankton in the subarctic lakes Takvatn and Lombola (northern Norway). Dissertation, University of Tromsø, Norway

Torkjel M. Sandanger // UiT The Arctic University of Norway, Department of Community Medicine, and NILU – Norwegian Institute for Air Research
Pernilla Carlsson // AMAP, Arctic Monitoring and Assessment Programme, and Akvaplan-niva

Seafood and environmental pollutants

We humans have created many chemical compounds to make our lives safer or easier; the insecticide DDT is a prime example. When these compounds escaped into the environment, some of them turned out to be harmful. The worst offenders, like DDT, have been banned. But we needed their beneficial effects, so we replaced them. What effects do these new man-made compounds have?

PERSISTENT ORGANIC POLLUTANTS (POPs) are a group of environmental contaminants that break down very slowly, accumulate in living organisms - and are poisonous. Many of them have now been banned or strictly regulated and are therefore called "traditional" POPs. Some were used as flame retardants (polybrominated diphenyl ethers), some as insecticides (hexachlorocyclohexanes and DDT) and some mainly in hydraulic oils and electronic insulators (PCBs). When the old POPs were phased out, new chemicals were developed to replace them. One class of replacement chemicals, perfluorinated alkylated substances (PFAS), has raised concerns during the last decade after being detected in animals in remote areas, such as marine mammals and birds in the Arctic. The PFAS are used in fire extinguishers, Goretex® and ski wax. Although their effects differ from those of the traditional POPs, they also interfere with cellular processes in humans and animals.

Not only manmade compounds are of concern. Mercury, lead and cadmium are all present naturally in the environment. However, our use of these heavy metals has increased the levels circulating in nature and in the food we eat.

All these pollutants cause concern because of their potential to harm living organisms. Several of the POPs are structurally similar to hormones, which means they can interfere with endocrine systems. Mercury can have detrimental effects on brain development and the immune system. To make matters worse, the pollutants affect health even at low concentrations.

POPs are semi-volatile and persistent. Because of their ability to evaporate and their resistance to breakdown, they can be transported great distances by air and ocean currents. Those that reach the Arctic accumulate primarily in the marine food chain. The highest concentrations of POPs are found in fatty tissues of fish and animals high up in the food chain.