FACT SHEET

OCEAN TRACKING NETWORK
Headquartered at Dalhousie University, Canada

Assessment of marine animal tag data for ocean observations

Karl Lagman[1], Katja Fennel[1], Damian Lidgard[2]
Don Bowen[2,3], Richard Davis[1], John Cullen[1], Sara Iverson[2]

Photo by Damian Lidgard

45 seals tagged from 2009-2011

Data collected every 10s

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Inspiring Minds

Electronic tags can be an excellent source of in-situ oceanographic data since measurements can be collected at high frequencies (up to 1 observation per second). Data collection in important biologically active regions is also naturally included since animals with electronic tags frequent these regions for foraging.

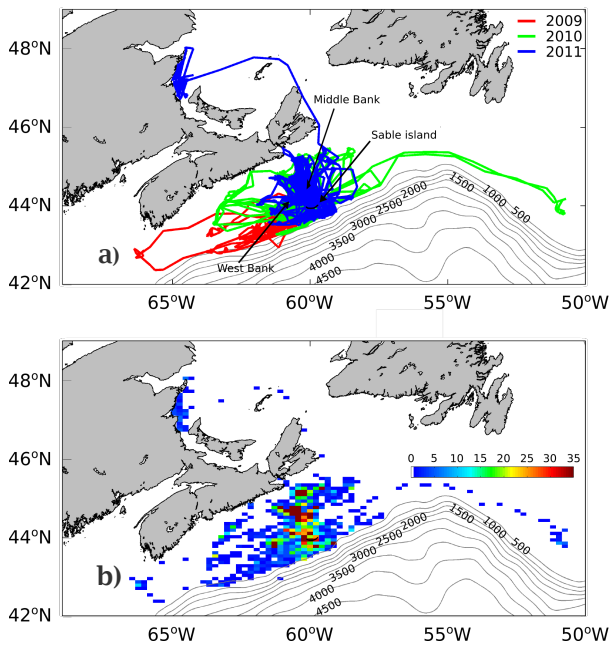


Figure 1. Seal tracks for the years 2009, 2010 and 2011. a) Tracks of 45 seals from 2009-2011. b) Mean daily position density of seals from 2009-2011. Each bin is about 225 km^2.

Diving Behaviour

Seal tags were mounted on the back to the seals in Sable Island in June and September, and were recovered in January and February for 3 consecutive years, from 2009-2011. The seals move around the Scotian Shelf as seen in figure 1. The tags measure irradiance, depth, and temperature every 10 s.

Figure 2 shows time series of dive, temperature and irradiance profiles for one seal for one day. In this example the seal dove approximately 180 times per day (top). Because of the seals' diving pattern and frequency, and the sensors sampling rate we can reconstruct a temperature profile (middle) of the seals dive cycles. The time series of the temperature profile suggests that the surface mixed layer, for which we estimated the light attenuation coefficient, is about 40-50 meters deep.

The time series of irradiance (bottom) shows a clear distinction between day and night. The fluctuations correspond to the seals diving behaviour.

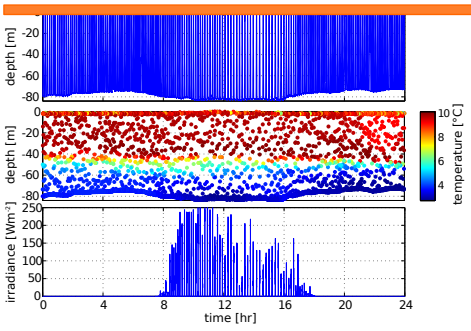


Figure 2. Time series of the dive and temperature profiles, and irradiance as measured by the seal tags.

[1]Department of Oceanography, Dalhousie University, Halifax, NS
[2]Department of Biology, Dalhousie University, Halifax, NS
[3]Bedford Institute of Oceanography, Dartmouth, NS

Correspondence to: Karl Lagman (karl.bryan.lagman@dal.ca)

Calibration Experiment in Bedford Basin

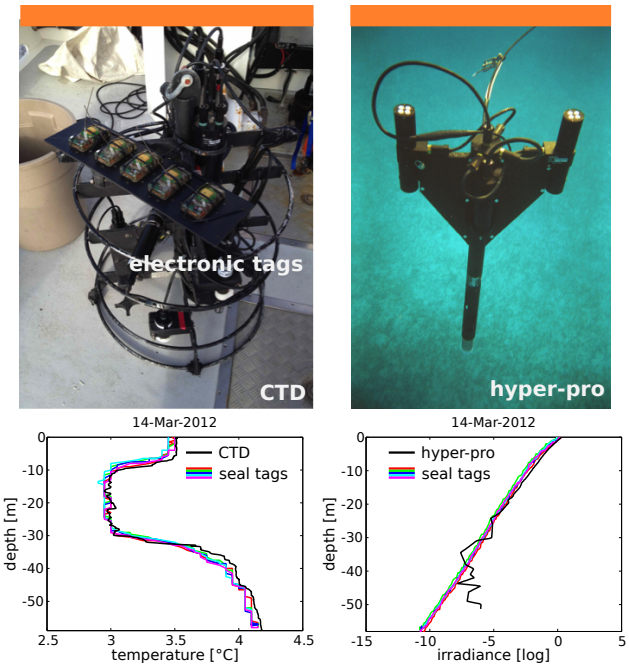
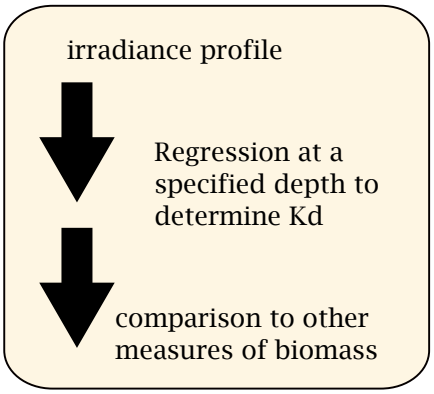


Figure 3. Temperature, depth and irradiance sensors (upper panels) used to calibrate measurements from electronic tags and samples from profiles measured (lower panels)

A calibration experiment in Bedford Basin was carried out to learn about the reliability of electronic tags in measuring oceanographic variables, especially irradiance. This is important since electronic tags were not originally intended for quantitative measurements of irradiance. Another goal of this experiment is to determine whether a sensor sensitive only to 550 nm can be used to infer changes in phytoplankton biomass in seawater.

Our results show that temparature and irradiance profile measurements from electronic tags are comparable to measurements from CTD and the hyper-pro (lower panel, figure 3). Results from irradiance comparisons further reveal that light sensors in electronic tags can realiably measure light attenuation even at low ambient light (deeper than 30 m).

Using the log-irradiance, the attenuation coefficient, Kd(550), was calculated from regression (at 10 m). Figure 4 shows that Kd(550) estimates follow a similar temporal pattern to other indicators of biomass including the capture of spring bloom. Table 1 shows a strong correlation between Kd(550) and other possible indicators of biomass, in particular with chl suggesting that despite limited information about phytoplankton that can be deduced in using a sensor sensitive only to 550 nm, temporal changes in phytoplankton biomass can be inferred correctly.



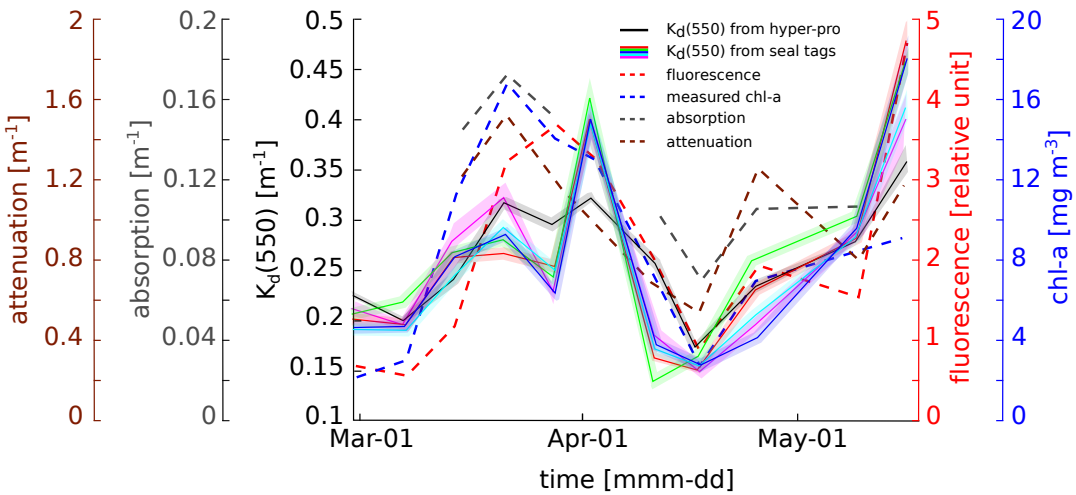


Figure 4. Time series of the estimated Kd(550) from seal tags (solid coloured lines) and the hyper-pro (black line) absorption (broken grey line) and beam attenuation (broken brown line) excluding contribution from seawater, fluorescence (broken red line), and mean of the measured chl-a for the upper 10 m (broken blue line).

Table 1: Correlation matrix showing relationships among possible indicators of phytoplankton biomass in the upper 10 m

		Kd(550)									
		tag1	tag2	tag3	tag4	tag5	hyper-pro	F	a(550)	α(550)	chl
Kd(550)	tag1	1	–	–	–	–	–	–	–	–	–
	tag2	0.9579	1	–	–	–	–	–	–	–	–
	tag3	0.9095	0.8423	1	–	–	–	–	–	–	–
	tag4	0.9533	0.8919	0.9637	1	–	–	–	–	–	–
	tag5	0.8779	0.8135	0.9756	0.9441	1	–	–	–	–	–
	hyper-pro	0.6655	0.5479	0.5309	0.6842	0.5164	1	–	–	–	–
	F	0.4449	0.3079	0.3770	0.5537	0.3877	0.8443	1	–	–	–
	a(550)	0.7147	0.5725	0.7136	0.7877	0.7837	0.8222	0.7800	1	–	–
	α(550)	0.6999	0.6763	0.5646	0.6952	0.6373	0.7516	0.7213	0.8610	1	–
	chl	**0.7204**	**0.5883**	**0.7343**	**0.8094**	**0.7580**	0.8334	0.8446	0.9542	0.8604	1

Units: $K_d(550)$ [m^{-1}], F[μgL^{-1}], a(550) [m^{-1}], α(550) [m^{-1}], and chl-a[mg m^{-3}]

Symbols: K_d- downwelling attenuation coefficient, F-fluorescense, α-beam attenuation, a-beam absorption

Spatio-temporal distribution of $K_d(550)$ estimates from seal tags along Scotian Shelf

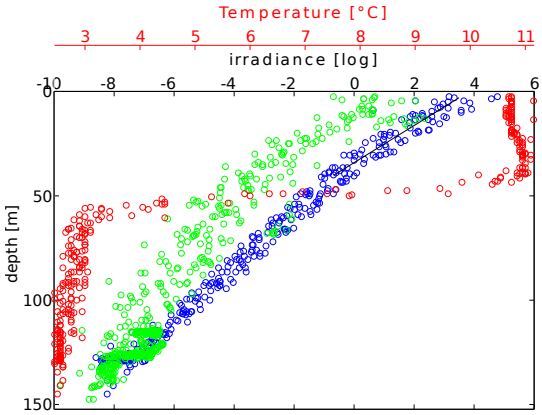


Figure 5. Irradiance profile for the ascent and descent phase and temperature profile for one day

Pre-processing of the irradiance data reveals that there is a difference between the ascent (blue circles) and descent (green circles) phase of the seal dives in terms of the irradiance measured (figure 5). In plotting the irradiance profile, we only considered data collected from the ascent phase (light sensor facing upward) and between 10:00 to 14:00 hours only. The attenuation coefficient is calculated by regression (black line) of the data points in the mixed layer. The temperature profile (red circles) is plotted as well, which sets the limit for regression since the attenuation coefficient is only estimated at the mixed layer.

Figure 6 shows the spatial distribution of the estimated Kd(550) for 2009-2011. There seems to be a consistent spatial pattern that is independent of time. A closer look at figures 6a-6c reveals that there is a higher probability of finding $K_d(550)$ estimates higher than 0.15 m^{-1} at the west of Sable Island (box 1) than at any region in the Scotian Shelf (fig. 6d). Similarly, values of Kd(550) over the Middle Banks remain below 0.15 m^{-1} (box 2).

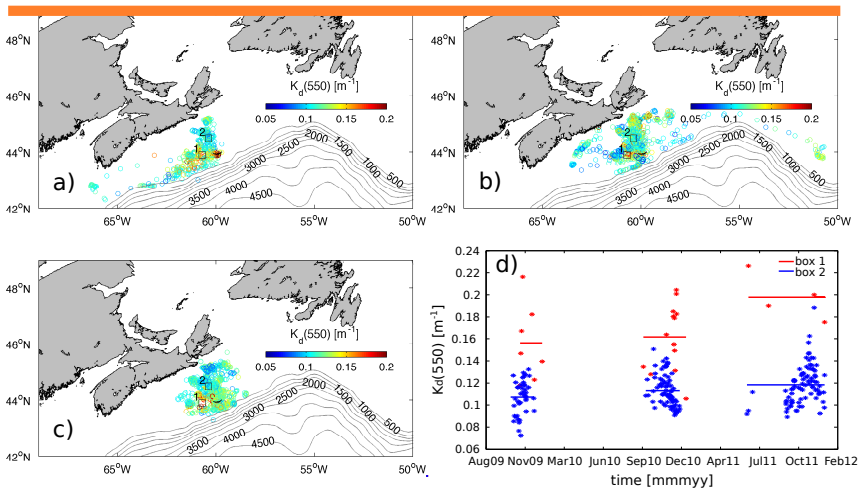


Figure 6. Spatial distribution of the estimated Kd(550) for years 2009-2011 (a-c). d) Time series of the Kd(550) estimates in boxes 1 and 2. The solid lines are the mean values of the estimates. The boxes are at the same locations for all years and covers an area of ~676 km^2.

Figure 7 shows the time series of the estimated Kd(550) at each region (~676 km^2) visited by at least 5 grey seals for the year 2009. The estimated Kd(550) fluctuates between 0.09-0.15 m^{-1}, except when seals cross the West Bank and in regions immediately adjacent to Sable Island. The relatively stationary trend in Kd(550) is not surprising since chl concentration in summer and fall is fairly low at around 1-2 mg chl m^{-3} (Greenan et al., 2004). Estimates of Kd(550) might change however in the spring as primary production on the Scotian Shelf has a peak chl concentration of ~8 mg chl m^{-3}.
[Time series for the years 2010 and 2011 are not shown but a similar trend is observed.]

The consistency of measurements among electronic tags can also be seen in figure 7b. The time series show estimates from different electronic tags in the same region are comparable except for measurements near the coast and west of Sable Island.

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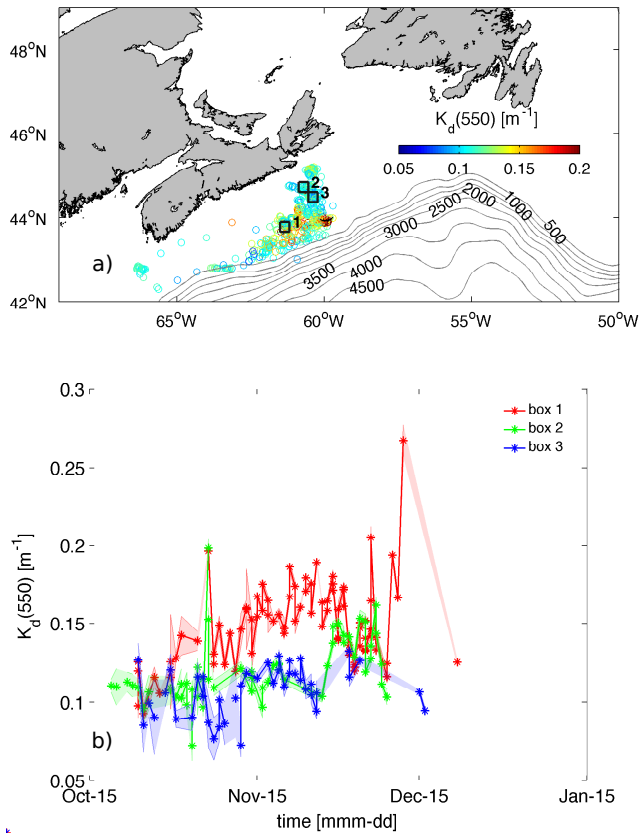

Figure 7. Time series of the estimated Kd(550) from selected regions along the Scotian Shelf. a) Similar to figure 7a with emphasis on the regions of interest. b) The corresponding time series of Kd(550) for each box. The location of the boxes were chosen such that there are at least 30 day Kd(550) estimates and there are interaction with at least 5 grey seals.

Take Home

Electronic tags data capture a wide range of physical and biogeochemical conditions. The tags can:

- reliably measure physical variables (i.e. temperature, irradiance)
- Using Kd(550) estimates, can uncover temporal pattern associated with phytoplankton biomass
- Using Kd(550) estimates, can uncover spatio-temporal pattern that is consistent each year

Reference

Greenan, B., B. Petrie, W. Harrison, and N. Oakey, Are the spring and fall blooms on the Scotian Shelf related to short-term physical events?, Continantal Shelf Research, 24, 603-625, 2004.