Mapping *Macrocystis pyrifera* beds from satellite images in New Zealand

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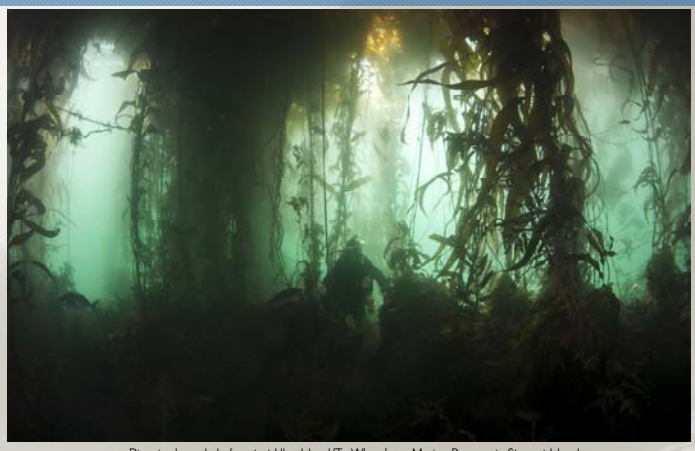
Summary

Recent advances in the resolution of images provided by satellites mean that it is now possible to cost-effectively map the **surface canopy of *Macrocystis pyrifera*** beds remotely, which allows for the analysis of time-series data. We present analysis using near infrared bands and normalized difference vegetation index (NDVI) from WorldView-II satellite imagery to map *Macrocystis* beds in the Marlborough Sounds (Tory Channel and Long Island).

The main findings from this study are that:

1. Current resolution of **satellite images** and analytical methods makes possible the large-scale mapping of *Macrocystis pyrifera* beds in New Zealand waters using this method.
2. It is possible to follow the **evolution through time** of *Macrocystis* surface canopy, satellite images being acquired every two weeks.
3. Comparisons of progression or regression of *Macrocystis* surface canopy **between sites** can be made.

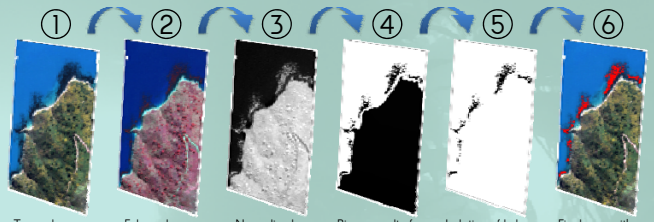


Diver in dense kelp forest at Ulva Island/Te Whawhara Marine Reserve in Stewart Island.

Background

1. Giant kelp *Macrocystis pyrifera* (bladder kelp) is a large perennial kelp that forms dense beds with layers of **floating surface canopies**.
2. These beds are at the base of many temperate coastal food webs, provisioning **important habitat**.
3. Because giant kelp is a foundation species that responds to a range of pressures, it is a potentially **good indicator** species for monitoring the **ecological integrity** of the New Zealand marine environment.
4. Although there is some evidence that the extent of some of New Zealand's *Macrocystis* beds are **declining**, there has to date been little quantitative evidence to assess the extent and rate of this decline.

Method [1,2,3]



- Multispectral satellite images (WorldView-II) were acquired for two areas in the Marlborough Sounds (around Long Island and in Tory Channel).
- For each location, satellite images were acquired for the winter of 2010 and 2013 when the growth of *Macrocystis* is maximal[4].
- Image resolution: pixel size of 50cm in panchromatic and 2m in multispectral.
- Images bands: blue (450-510nm), green (510-580nm), red (630-690nm) and near infrared (NIR, 770-895nm) + 4 additional bands.
- Images were geo-referenced in ENVI/ArcMap.
- 4 images were created: true colour image (Red, Green, Blue), false colour image 1 (Near Infrared, Red, Green), false colour image 2 (Red Edge, Red, Green) and normalized difference vegetation index (NIR-Red/NIR+Red). Vegetation strongly absorbs NIR.
- The 4 images were compared to identify the canopy of *Macrocystis*.
- Band math tool was used to process NDVI into binary result (if NDVI ≥ 0.001 then x = 10 else x = 20). NDVI ≥ 0.001 is characteristic of vegetation.
- Raster result was converted to vector file. Vector result was edited by cutting and deleting noisy information such as water, coast line and rocks.

Results

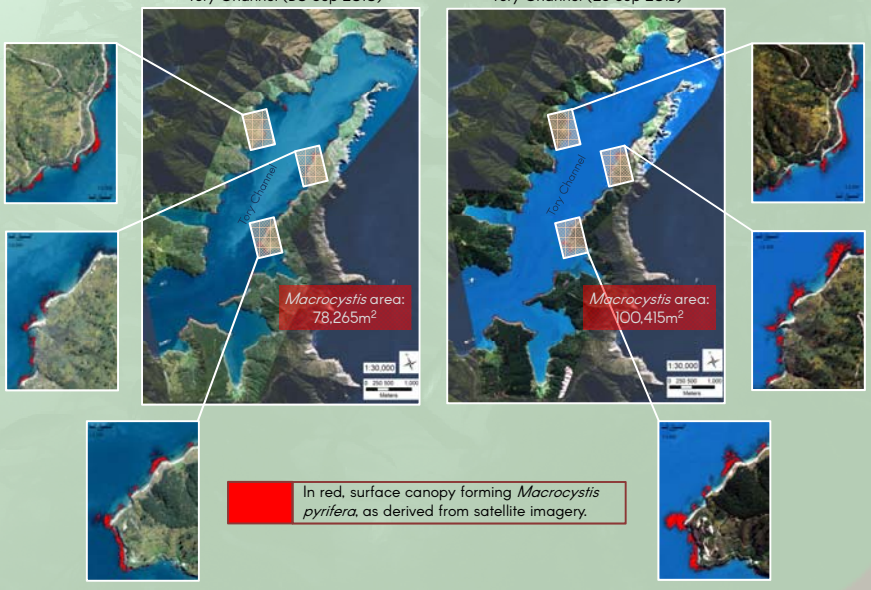
Long Island (30 Sep 2010)

Long Island (18 Oct 2013)

- The classification results of satellite images could pick up the signal of canopy forming kelps (red layer in above images).
- Significantly different *Macrocystis* canopy extent were detected between areas and years.
- The extent of *Macrocystis* canopy beds were 53,030m², 45,022m², 78,265m² and 100,415m² for Long Island 2010, Long Island 2013, Tory Channel 2010, Tory Channel 2013.

Tory Channel (30 Sep 2010)

Tory Channel (26 Sep 2013)



In red, surface canopy forming *Macrocystis pyrifera*, as derived from satellite imagery.

Prospects

- Satellite images could provide a powerful tool to remotely map the extent of *Macrocystis pyrifera* beds.
- The potential exists for quickly mapping large areas and creating robust reference points for past and future time series.
- Further tests are required to assess the effect that tidal levels, currents or turbidity might have on the signal picked up by satellites.

References

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[2] Cavanaugh, K. C., Siegel, D. A., Kinlan, B. P. & Reed, D. C. (2010). Scaling giant kelp field measurements to regional scales using satellite observations. *Marine Ecology Progress Series*, 403: 13-27.

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[4] Pirker JG. 2002. Demography, Biomass Production and Effects of Harvesting Giant Kelp *Macrocystis Pyrifera* (Linnaeus) in Southern New Zealand. PhD thesis thesis, University of Canterbury. 244 pp.

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