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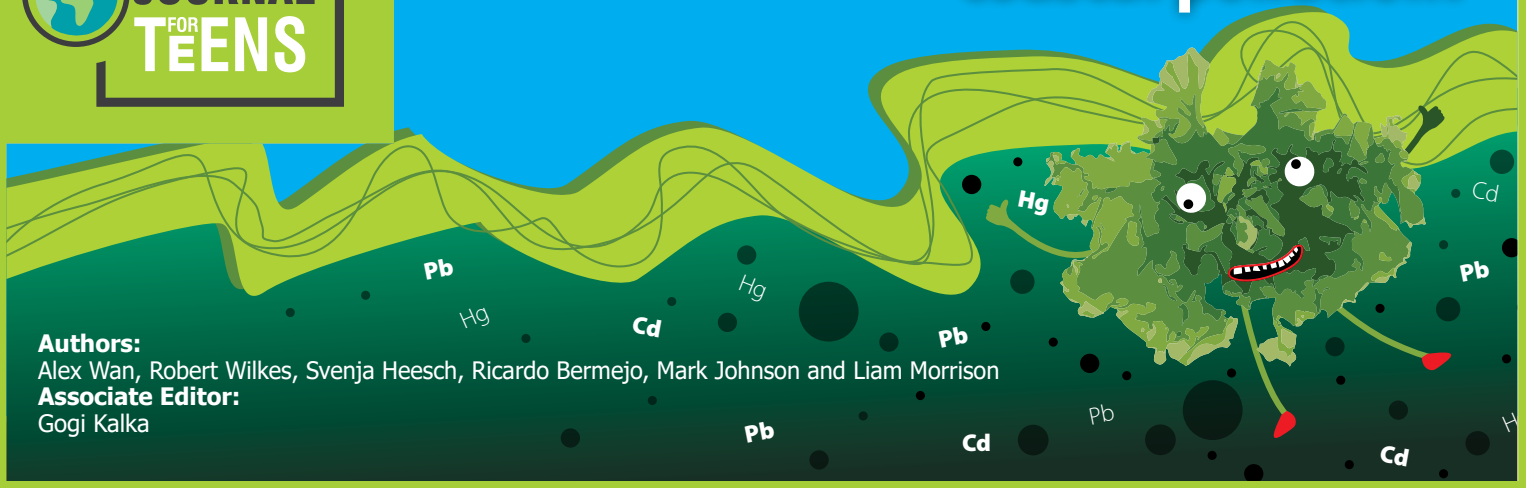
What can sea lettuce tell us about coastal pollution?



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Abstract

Did anyone ever say you looked green when you were sick? This can happen to oceans, too! In fact, people sometimes observe the coastal waters of Ireland (and in many other parts of the world) turning green. So green that they call it a *"green tide"*. What is going on?

The green color comes from certain seaweed that grow so much that they can change the color on the beaches. These "*seaweed blooms*" occur after nitrogen or phosphate pollution from human activities such as agriculture, farms, factories or towns enters coastal waters.

We wanted to find out if one particular seaweed, the commonly found sea lettuce (*Ulva rigida*), could serve as a living *(bio-)indicator* of water quality at the coast. (It can.) We also looked for a clear connection between the amounts of these seaweed and certain harmful metals in the water (but did not find a significant one).

Introduction

Ireland is famous for its green countryside, but this shouldn't include the beaches too (Fig. 1). In fact, the seaweed blooms that are responsible for the green color are often toxic to both marine animals and humans. Their decomposition uses up most of the oxygen in the water or can release harmful gases (such as hydrogen sulphide).

But they do tell an important story about pollution in the ocean. Usually, when scientists want to know *how* polluted a body of water is, they measure chemical (salt or metal concentration, or pH) or physical (temperature) components in the water.

We wanted to see if we could detect pollution levels just by looking at the seaweed alone.

Figure 1:
Mats of sea lettuce can be so large and thick that they almost appear like field of green grass. Photograph taken at Courtmacsherry, Co. Cork. Mudflats can be really dangerous so to get around them safely, the scientists used a hovercraft! The hovercraft flies over the surface of the beach on a cushion of air so you can move around without getting stuck in the mud.

Specifically, we set out to investigate 3 questions:

1. What can sea lettuce, a *cosmopolitan* seaweed often found in green tides, tell us about pollution levels of coastal areas in Ireland?
2. Which seaweed species are found in these tides?
3. Is there a connection between the pollution levels and certain harmful metal concentration within the seaweed?

The last question is especially important given that people are working hard to remove these seaweeds from our beaches when they occur in such large amounts. Often, they are dumped into landfills, but this is very costly. We wanted to find out if cheaper solutions were possible, such as using the seaweed as fertilizer for farms or feed for animals. But of course, first we have to make sure they would not cause any harm.

Methods

To answer our questions, we chose eight study sites around the coast of Ireland where sea lettuce blooms tend to occur (Fig. 2). Some sites were near cities or farmland, others were at less impacted sites.

We then estimated the area in each site that was suitable for seaweed growth. Within each area, we assessed what percentage of the beach was covered by seaweed mats. Finally, we translated these ratios into 5 water quality levels (bad, poor, moderate, good and high).

To find out which species were part of the seaweed mats, we collected samples from each of the study sites and took them to the lab for DNA analysis. (These seaweed species often look so similar that some of them can only be distinguished by their DNA).

Lastly, we analyzed metal concentrations in the seaweed from all study locations.

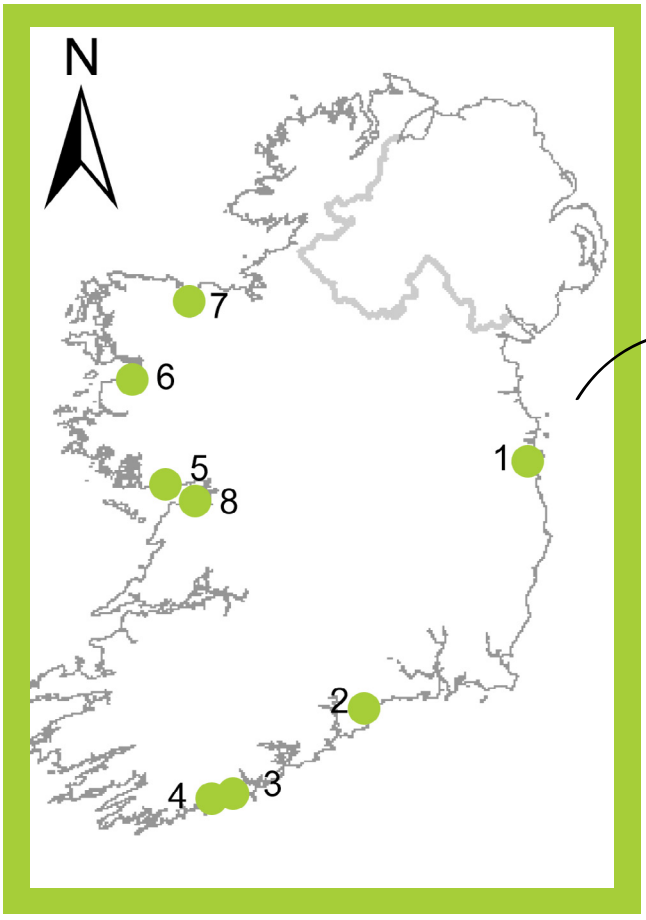

Figure 3: The eight study sites where researchers sampled Irish *Ulva* blooms.

Results

Our seaweed mat assessment showed that:

- 3 of our eight study sites were not polluted,
- 3 were moderately polluted,
- 2 were highly polluted.

The sites with the largest green tides had seaweed weighing over 2000 metric tons (that's about the weight of 16 blue whales or 160 school buses)!

Even more massive seaweed blooms have been observed in France and China, with over 20 million tons of seaweed in 2008 (equivalent to over 1.6 million blue whales, or 16 million school buses!).

DNA analysis proved that the sea lettuce Ulva rigida was present in 7 of the 8 seaweed blooms in our study.

We did find potentially harmful metals in the seaweed we analyzed (Fig. 3). However, we could not find any clear connection between the concentrations of these metals and observed water pollution levels.

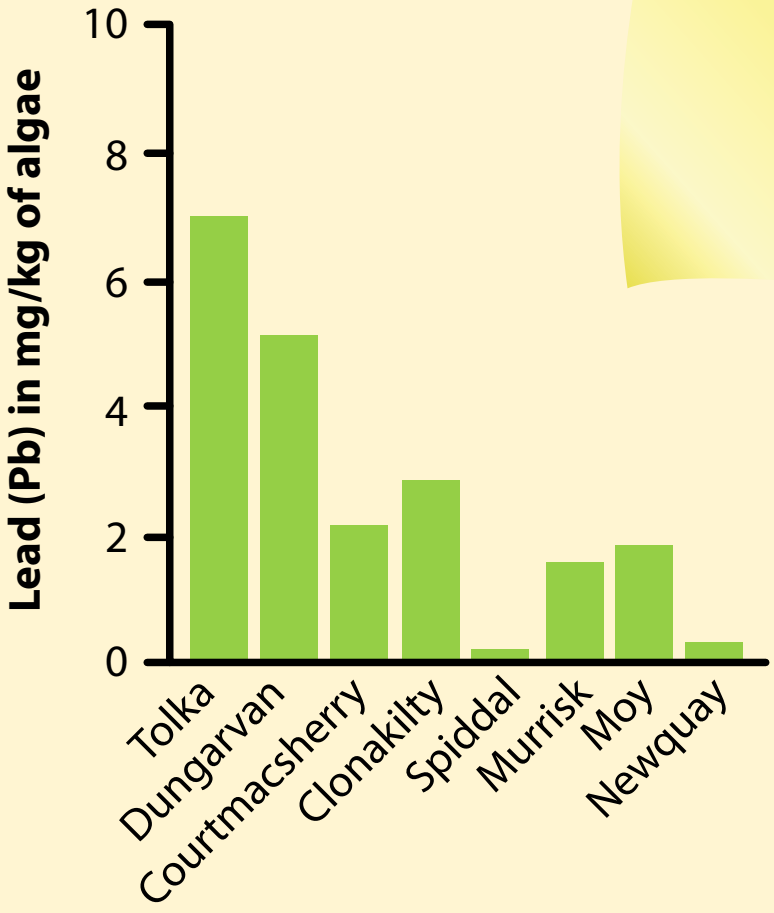

Figure 3: Lead concentration in each of the study sites.

Discussion

Green tides are a serious problem, and seem to be getting worse around the coast of Ireland and elsewhere. Inputs of nutrients act as a fertilizer, leading to massive seaweed growth.

We could not find a clear link between current sources of pollution near the coast and toxic metal concentrations in the seaweed. For instance, we found high amounts of harmful metals in seaweed in an area (Dungarvan - see figure 3) that is not very close to cities or farms. However, we know that in the past, there was a tannery at that part of the coast. Tanneries often used harmful chemicals and toxic metals, which leaked into the water and can still be present on the seafloor. This shows how important seaweeds are as long-term monitors of water quality even if the source of the pollution is long gone.

The amounts of harmful metals we found in the sea lettuce from Irish seaweed blooms were low enough that the seaweed could be used as animal feed. This could greatly reduce the cost of disposing of these massive seaweed mats. However, we need more studies to understand if these seaweed are really safe to eat.

Conclusion

Seaweed blooms present a large and costly problem for humans and coastal ecosystems. As bio-indicators, they tell us that too many nutrients entered the water. This pollution mostly stems from human activities. We need to work harder on trying to keep these pollutants out of the water – for instance through improved farming practices and by using phosphate-free laundry detergent, at home. But we're also looking for useful applications of these big seaweed mats by carefully monitoring metal levels. If we can keep these in check, we could put the seaweed mats (and all their nitrogen) back on the fields before they do more harm in the ocean.

Glossary of Key Terms

Green tide – is a mass growing of phytoplankton or seaweed in the coastal water. Since these organisms are green (which lets us know that they photosynthesize), and there are so many of them, they can make the ocean water appear green.

Seaweed bloom – similar to green tide, a massive growth of certain marine plant forms. Please note that the term "bloom" here has nothing to do with blooming (as in producing flowers) in higher plants that occur on land. Seaweed do not make flowers. "Blooming" just refers to their massive growth after pollution enters the water.

Bioindicator – an animal or plant species that can tell us something about the quality of its environment. For instance, heavy occurrence of the sea lettuce seaweed usually tells us that the water is polluted with macronutrients (nitrogen and phosphorus).

Cosmopolitan – in biology this term means that a species occurs all around the world, or in most places of the world. (The opposite of cosmopolitan is "endemic" which means a species is restricted to a certain area).

Eutrophication – describes the process that occurs when too many nutrients enter a body of water. The nutrients, often phosphate or nitrogen compounds, stimulate massive growth of seaweed or phytoplankton. Once these die off, the decomposition of these large amounts of dead plant materials uses up so much oxygen in the water that many fish and other marine animals suffocate. Eutrophication is often started by fertilizers, or sewage, entering bodies of water.

Metals – Some metals are important nutrients for plants, animals and humans (like iron and zinc). But some can be highly poisonous (like cadmium, mercury, or lead). These are the metals we are mostly concerned about when looking at the edibility of seaweed.

Macronutrients – Chemicals that are required in large quantities for plant (or seaweed) growth.

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http://www.seamatproject.net/

Sea-MAT Project

Check your understanding

1. In this study, the seaweed Sea Lettuce is used as a bioindicator for ocean water quality. Can you think of other organisms that can be used as bioindicators?

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2. Why are sudden occurrences of large amounts of seaweed (so called seaweed blooms) problematic for the marine ecosystems – and often also for humans?

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3. Can you think of a good and efficient way to monitor the occurrence and size of green tides like the ones in Ireland?

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4. Metal contamination can make the normally edible seaweed "sea lettuce" toxic for humans. Where does the metal come from?

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5. Can you think of other dangerous sources of metals in your daily life that you are more likely to encounter than sea lettuce?
