Measuring From the Sky: Methods to Quantify Moon Jellyfish (*Aurelia labiata*) Aggregations Using Aerial Photographs

Lucy Roussa (Eastern Washington University), Julie Keister (University of Washington), Haila Schultz (University of Washington) Skip Albertson, and Christopher Krembs (WA Department of Ecology)

BACKGROUND

- Moon jellyfish blooms can cause declines in forage fish populations because they compete for the same food source of zooplankton.
- Jellyfish blooms can lead to an increase in dissolved nitrogen and a decrease in dissolved oxygen, which can harm fish and other marine organisms.
- WA Department of Ecology (DOE) has been taking pictures of Puget Sound for years in their surveying program "Eyes Over Puget Sound," which aims to identify ecosystem health indicators.
- These pictures aim to create a qualitative measurement of the health of the Sound based on observable changes, such as the visible jellyfish aggregations, but need to be processed to gain estimates of aggregation area.
- Image processing will provide a 2-D spatial estimate for the area covered by jellyfish, and if determined to be reliable, will be used as a jellyfish biomass index.

OBJECTIVES

- Develop an up-to-date and refined image processing protocol to go forward with analysis of future images.
- Determine whether image processing of orthorectified images can provide a quantitative measurement of jellyfish aggregations in Puget Sound.

Image of thick moon jellyfish blooms in Puget Sound

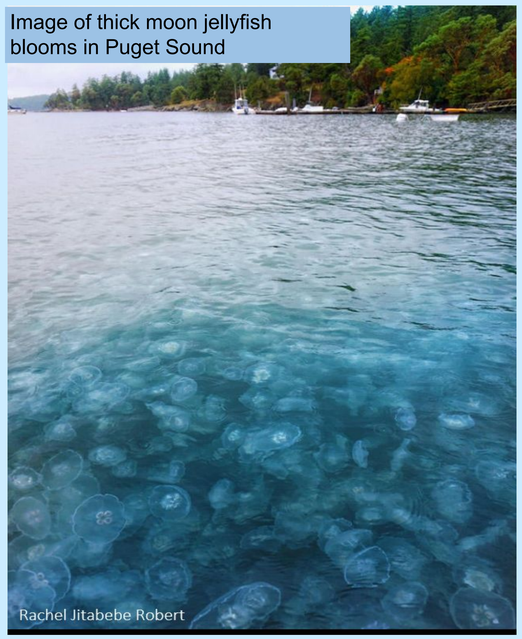
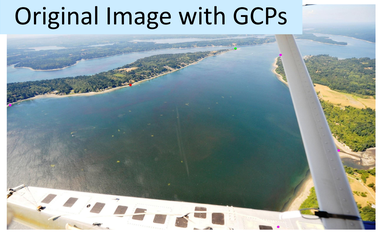
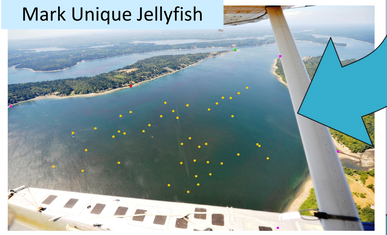


IMAGE PROCESSING METHODS

Original Image with GCPs

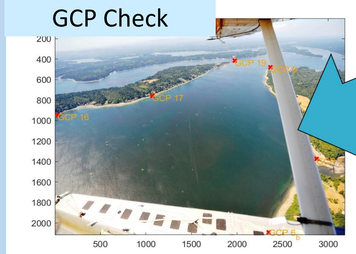


Mark Unique Jellyfish



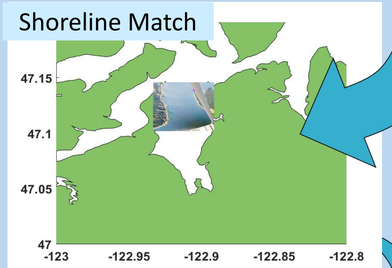
- Images of Budd Inlet were sorted into usable and unusable images: the minimum criterion for a usable image is the presence of two shorelines and visible jellyfish aggregations. Next, ground control points (GCPs) were added to the images in ImageJ by identifying known structures (i.e. buildings, buoys, docks) which were marked in Google Earth Pro.
- Once GCPs were identified, the multipoint tool was used to locate X,Y pixel coordinates of the marked locations of GCPs and jellyfish aggregations. Only unique aggregations are marked to avoid double counting.

GCP Check



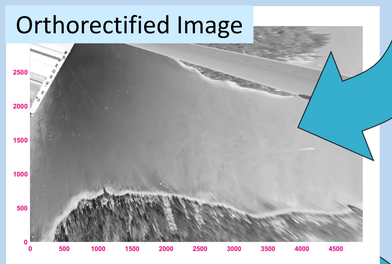
- By using the X,Y pixel location, and latitude and longitude of the GCPs, the images are then processed in MATLAB. This will ultimately create an orthorectified photo that is uniform in pixel dimensions and suited for measuring jellyfish aggregations. The step shown to the left is a confirmation of correct GCP location in MATLAB.

Shoreline Match



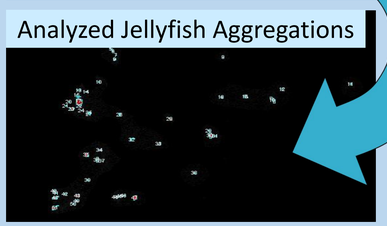
- The last quality control check before the final orthorectified image is made is a shoreline match test. If all previous steps are accurately done, then the shoreline seen in the image will match perfectly when overlayed on a map.

Orthorectified Image



- The orthorectified photo is then analyzed in ImageJ. This process involves creating a meter:pixel ratio, converting to 8-bit, subtracting the background, adjusting the brightness and contrast, adjusting the threshold, deleting everything except for jellyfish aggregations, and then analyzing the remaining particles in the image.

Analyzed Jellyfish Aggregations



- This image is the final product of the image processing protocol. All the jellyfish aggregations in this image were converted into pixels and counted. ImageJ is a vital part of this methodology and can pick up on most of the jellyfish present in the water.

RESULTS

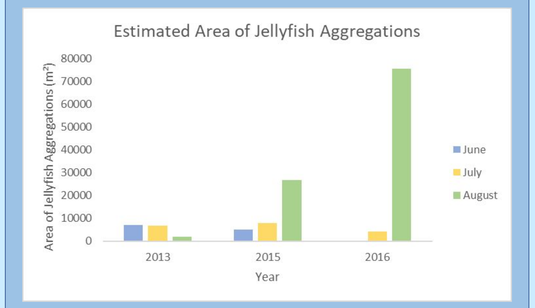


Figure 1: The above graph shows a comparison between three separate years. A pattern of increasing estimated area of jellyfish aggregations can be observed, especially in the month of August when the jellyfish tend to bloom. This data could suggest that the unusually high temperatures in 2015 and 2016 had a positive effect in jellyfish abundance.

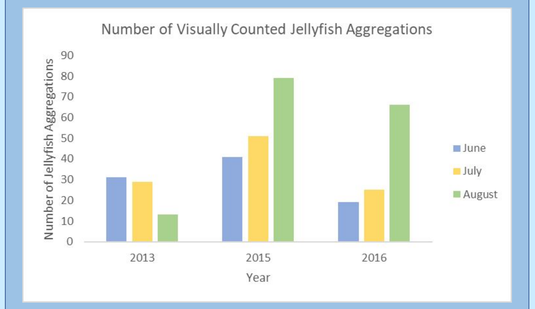


Figure 2: The above bar graph depicts a similar comparison between the same three years. Even without the image analysis process providing area data, an increase in the number of aggregations from 2013 to 2016 is apparent.

- ❖ The resulting measurement from this process provides the area in square meters of jellyfish aggregations.
- ❖ Using this data, I made comparisons between different months across years of available images.
- ❖ The data was organized into respective date files for future use by WA DOE and UW scientists. The jellyfish aggregation area will be used as part of efforts to understand the effects of increasing jellyfish biomass in Puget Sound.

DISCUSSION

- This method of image analysis is proving to be a useful tool in quantitatively measuring jellyfish abundance.
- There are concerns and limitations to this image processing protocol such as:
  - Very small jellyfish patches will not show up in ImageJ which can underestimate the real area of coverage.
  - Some jellyfish patches are not a perfect shape but resemble waves or smoke. This makes it seem like there are more jellyfish patches than are present. Therefore, counting the jellyfish patches using ImageJ is unreliable.
  - Many images are not suited for this process, such as images with one or no shoreline, images with land masses in the center of the image, and images with high reflectivity.

NEXT STEPS

- Many images still need processing, and the work is planned to continue this fall.
- The jellyfish abundance data will need to be combined with other surveys such as zooplankton and phytoplankton data for an assessment on jellyfish's role in the ecosystem.
- A final protocol will be written and tested for use on future images.

AKNOWLEDGMENTS

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