Using Unmanned Aerial Vehicles (UAV's) to Measure Jellyfish Aggregations: an inter comparison with net sampling

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Schaub, J., B. P. V. Hunt, E. A. Pakhomov, K. Holmes, Y. Lu, and L. Quayle. 2018. Using unmanned aerial vehicles (UAVs) to measure jellyfish aggregations. Marine Ecology Progress Series 591:29-36.

INTRODUCTION

It is inherently difficult to determine the density, biomass, spatio-temporal distributions of gelatinous zooplankton

- Fragile
- Large size range
- Clumped distributions

This compromises our ability to scale up estimated rates to whole populations, and quantify their ecological role.

INTRODUCTION

Fragile

- Solutions – Video, specialized nets

Large size range

- Solution – range of nets

Clumped distributions (aggregations)

- Solution – spatially intensive net surveys; towed bodies; ROVs; aerial photography

UNMANNED AERIAL VEHICLES - DRONES

Using unmanned aerial vehicles (UAVs) to investigate shark and ray densities in a shallow coral lagoon

Jeremy J. Kiszka[1,*], Johann Mourier[2,3], Kirk Gastrich[1], Michael R. Heithaus[1]

Unmanned Aerial Vehicles (UAVs) for Surveying Marine Fauna: A Dugong Case Study

Hodgson, Amanda; Kelly, Natalie; Peel, David. PLoS One; San Francisco Vol. 8, Iss. 11, (Nov 2013): e79556.
DOI:10.1371/journal.pone.0079556

Report

Bears Show a Physiological but Limited Behavioral Response to Unmanned Aerial Vehicles

Mark A. Ditmer [1], John B. Vincent [2], Leland K. Werden [2], Jessie C. Tanner [3], Timothy G. Laske [4, 5], Paul A. Iaizzo [5], David L. Garshelis [6], John R. Fieberg [1]

Measuring behavioral responses of sea turtles, saltwater crocodiles, and crested terns to drone disturbance to define ethical operating thresholds

Bevan, Elizabeth; Whiting, Scott; Tucker, Tony; Guinea, Michael; Raith, Andrew; et al.
PLoS One; San Francisco Vol. 13, Iss. 3, (Mar 2018): e0194460. DOI:10.1371/journal.pone.0194460

Unmanned aerial vehicles for surveying marine fauna: assessing detection probability

Amanda Hodgson, David Peel, Natalie Kelly

Unmanned Aerial Vehicles - drones

Using unmanned aerial vehicles (UAVs) to
investigate shark

Jeremy J. Kiszka[1,*], Johann

Benefits

High resolution spatial coverage

Cost-effective

Non-invasive

High quality imagery

Rapid

eying Marine Fauna:

v 2013): e79556.

Report

Bears Show a Phy

Response to Unm

Mark A. Ditmer [1], John B. V

[4, 5], Paul A. Iaizzo [5], David L. Ga

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Unmanned aerial vehicles for surveying marine fauna: assessing detection probability

Amanda Hodgson, David Peel, Natalie Kelly

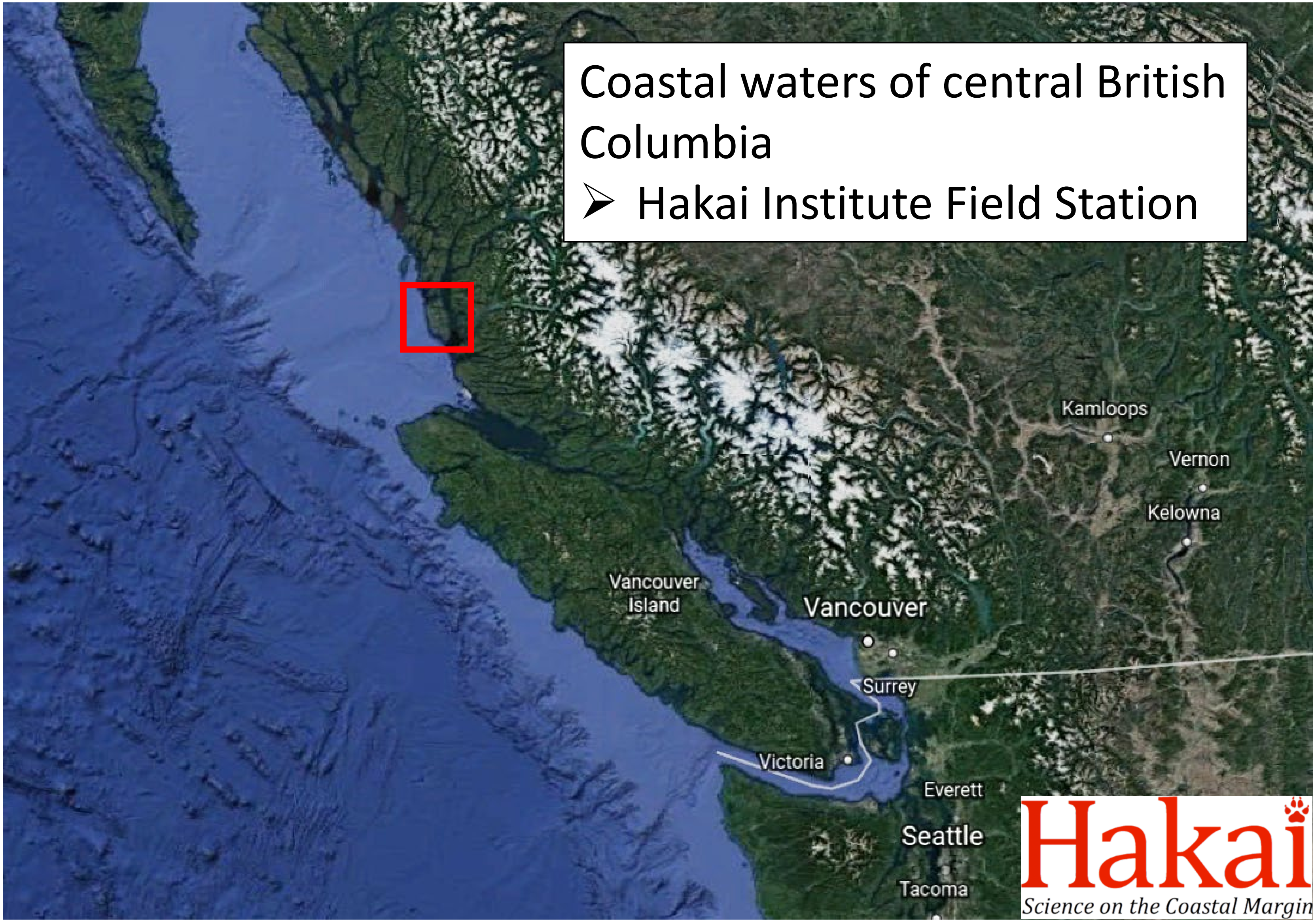
OBJECTIVES

Determine if:

1. Can drones be used to effectively measure and monitor near surface gelatinous zooplankton?

2. Drone data provide useful measures of gelatinous zooplankton biomass / density?

STUDY AREA



Coastal waters of central British Columbia

- Hakai Institute Field Station

Regular and reliable summer “blooms” of *Aurelia* spp.

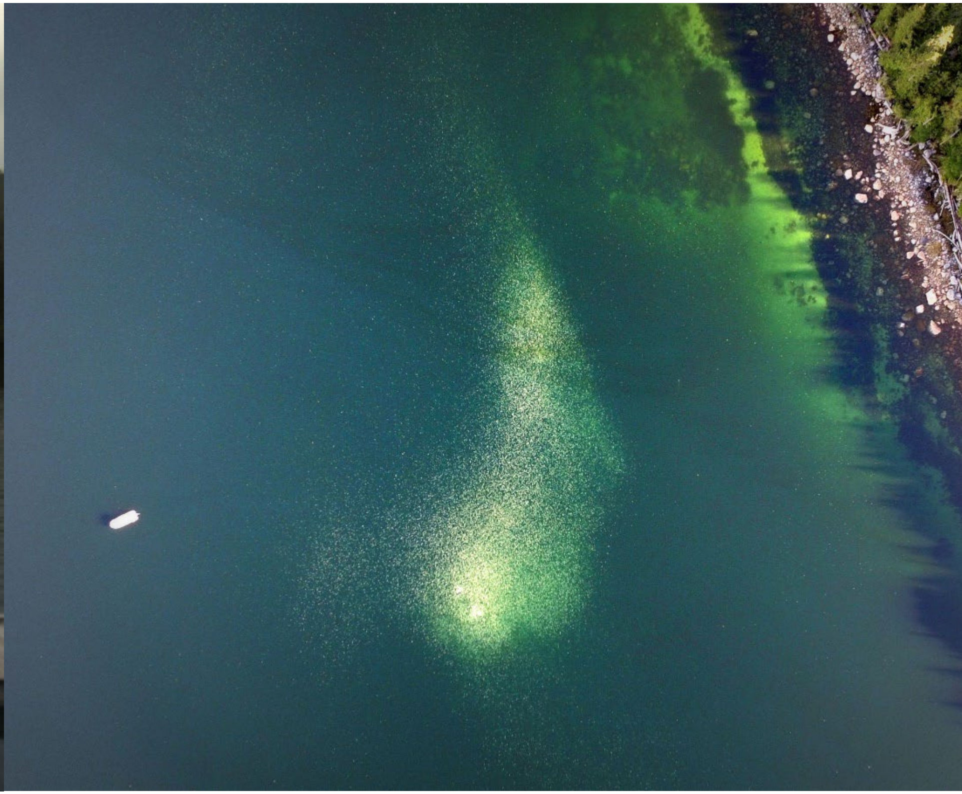
METHODS

Detect aggregation

Drone operator collected images using standardized protocol

Oceanography team conducted vertical net hauls to measure density, size structure and biomass

METHODS – DETECTING AGGREGATIONS



Credit: Keith Holmes, Hakai Institute

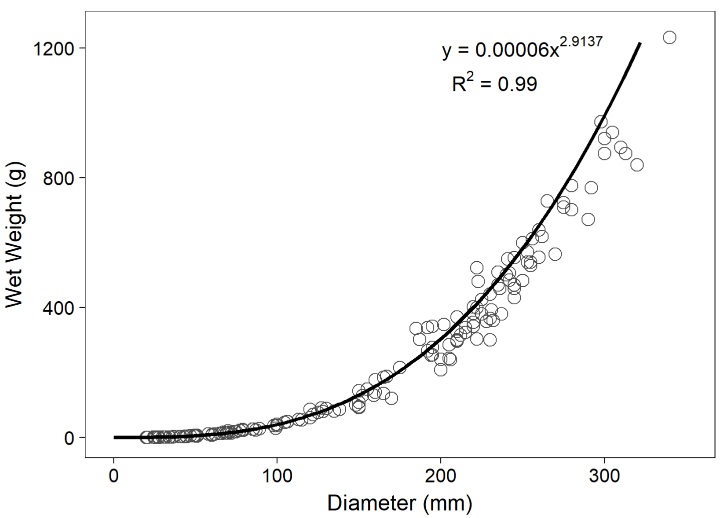
METHODS – NET SAMPLING

1m diameter vertical net, 1mm mesh

- 3 net tows per aggregate

Aurelia spp. counted & measured

- Wet weight estimated using a regionally specific length-weight relationship
- Mean size of 230mm (range = 70-360 mm)
- Count data were converted to densities using volume filtered data (jellyfish m^{-3}).



Methods – Drone operation

DJI Phantom 3 Professional UAV

- DJI 12 megapixel camera

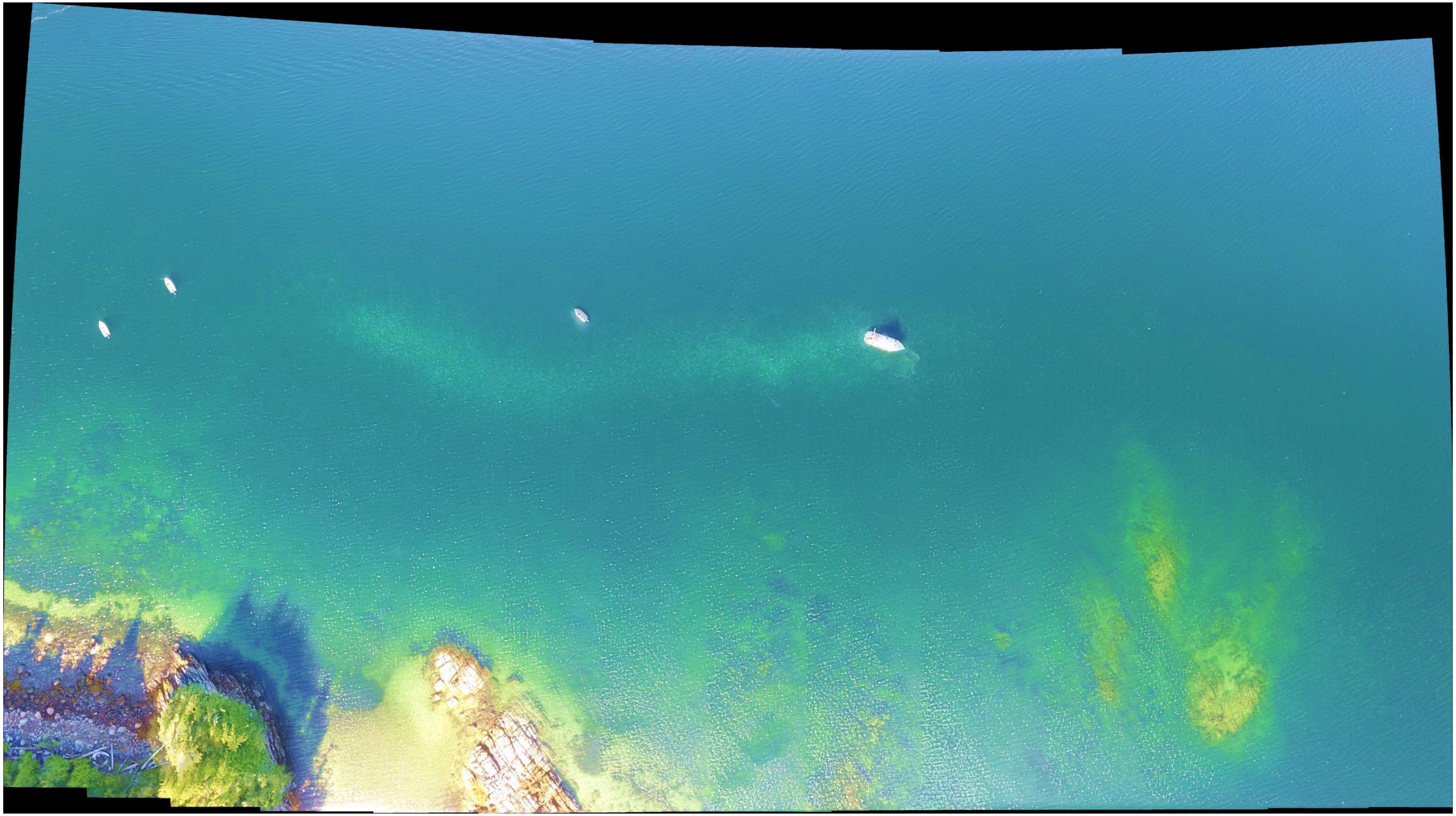
Transects were flown at ≥ 10 m s^{-1}

- Maximize image clarity while limiting any effect of drift.

Manual image collection

- Image every 1s
- 80 % front image overlap
- Included shoreline to facilitate image stitching.
- Image pixel size varied from 30 mm to 160 mm depending on the flight altitude.

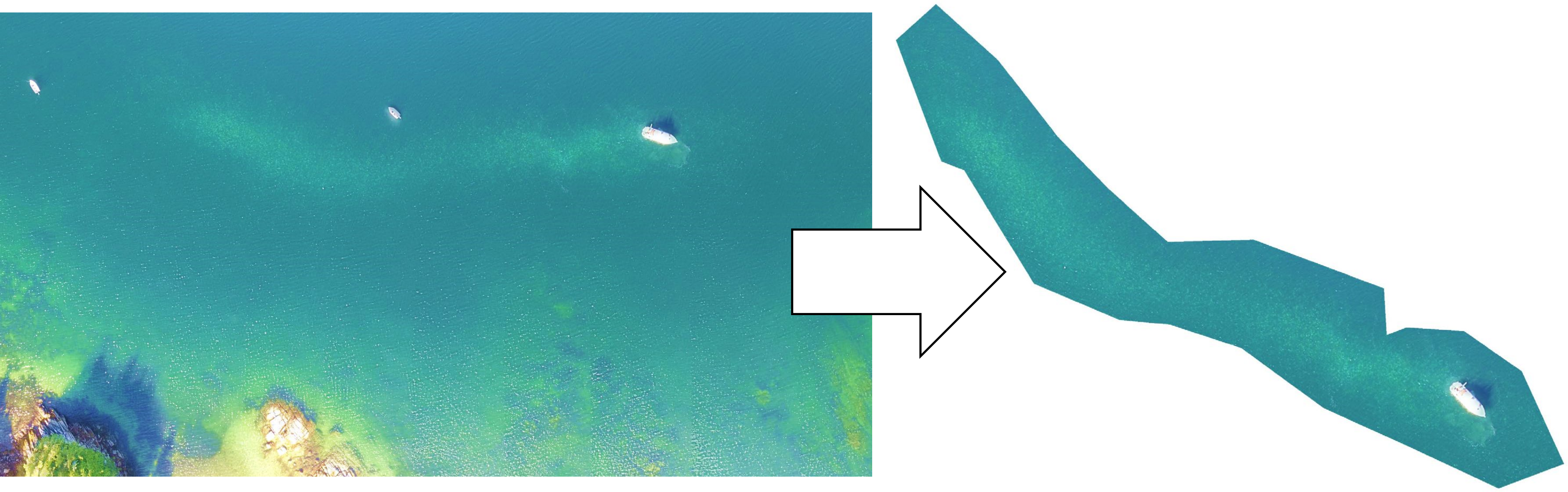
METHODS – IMAGE PROCESSING



PROCESSING – DRONE DATA

Georeference image

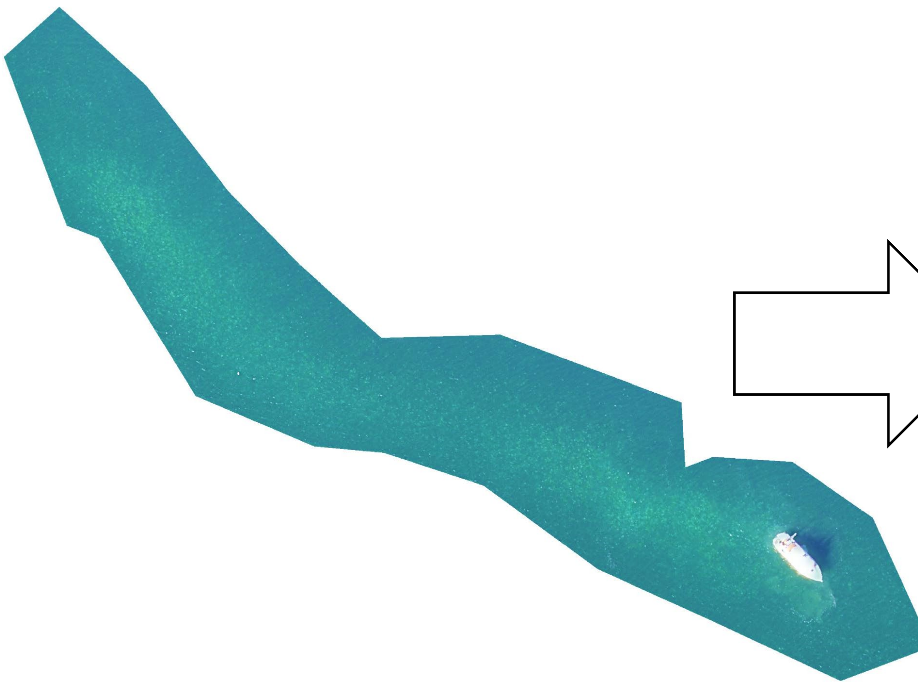
Crop to remove shoreline



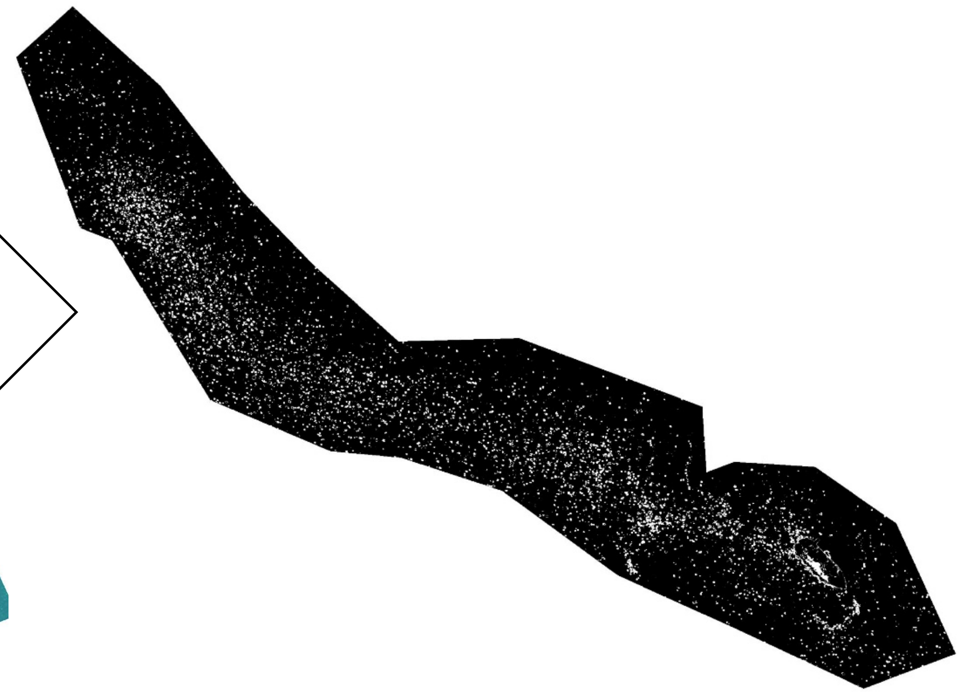
Schaub *et al.* (2018)

PROCESSING – DRONE DATA

Cluster analysis – group pixels based on colour (classify jellyfish)



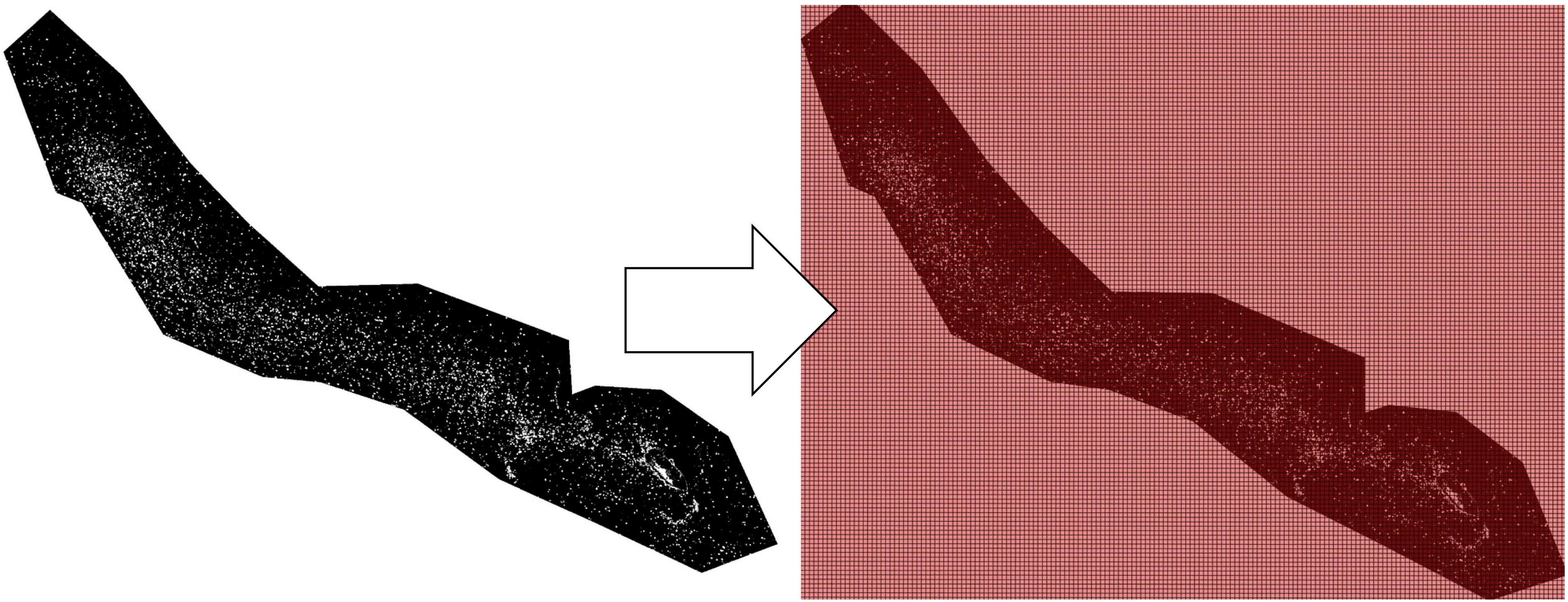
Jellyfish True/False raster image



Schaub *et al.* (2018)

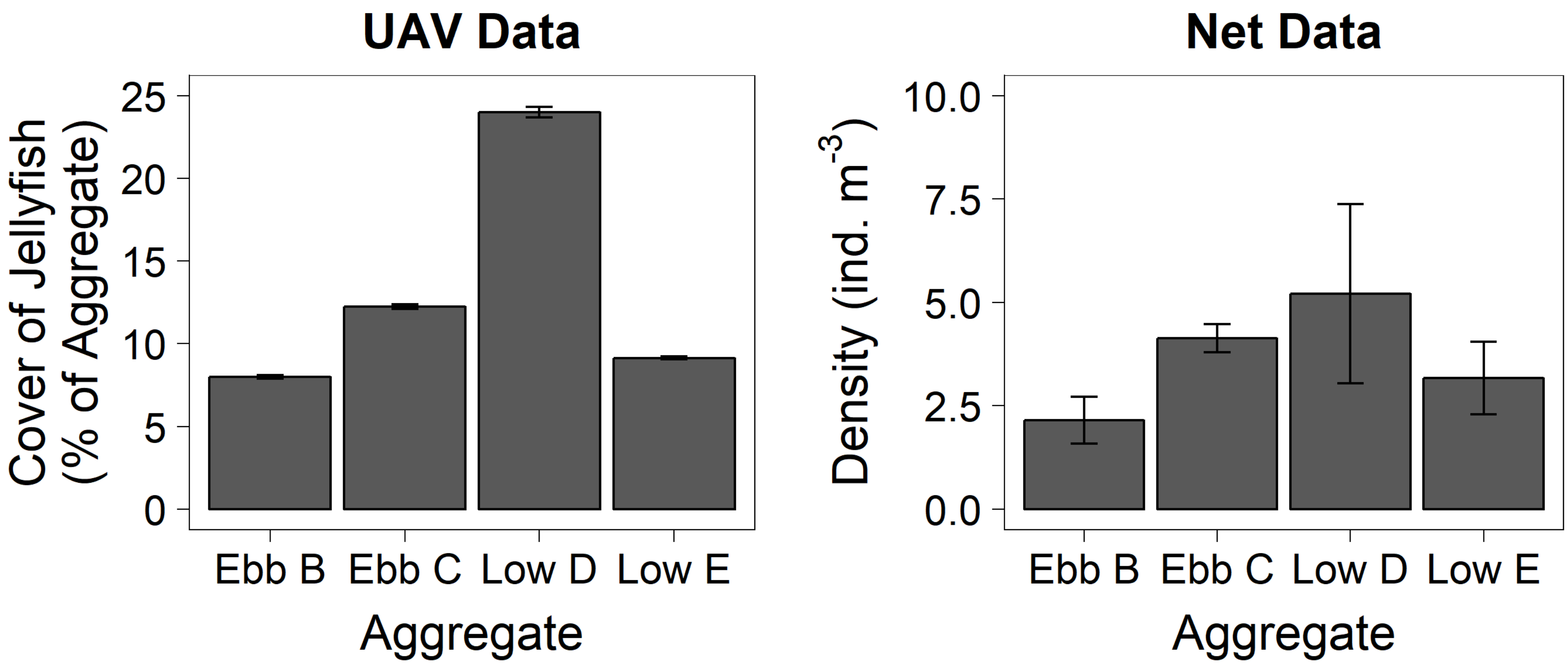
Processing – Drone Data

Overlay grid of 1m² quadrats Cluster analysis – spatial analysis, e.g. % jellyfish cover / quadrat



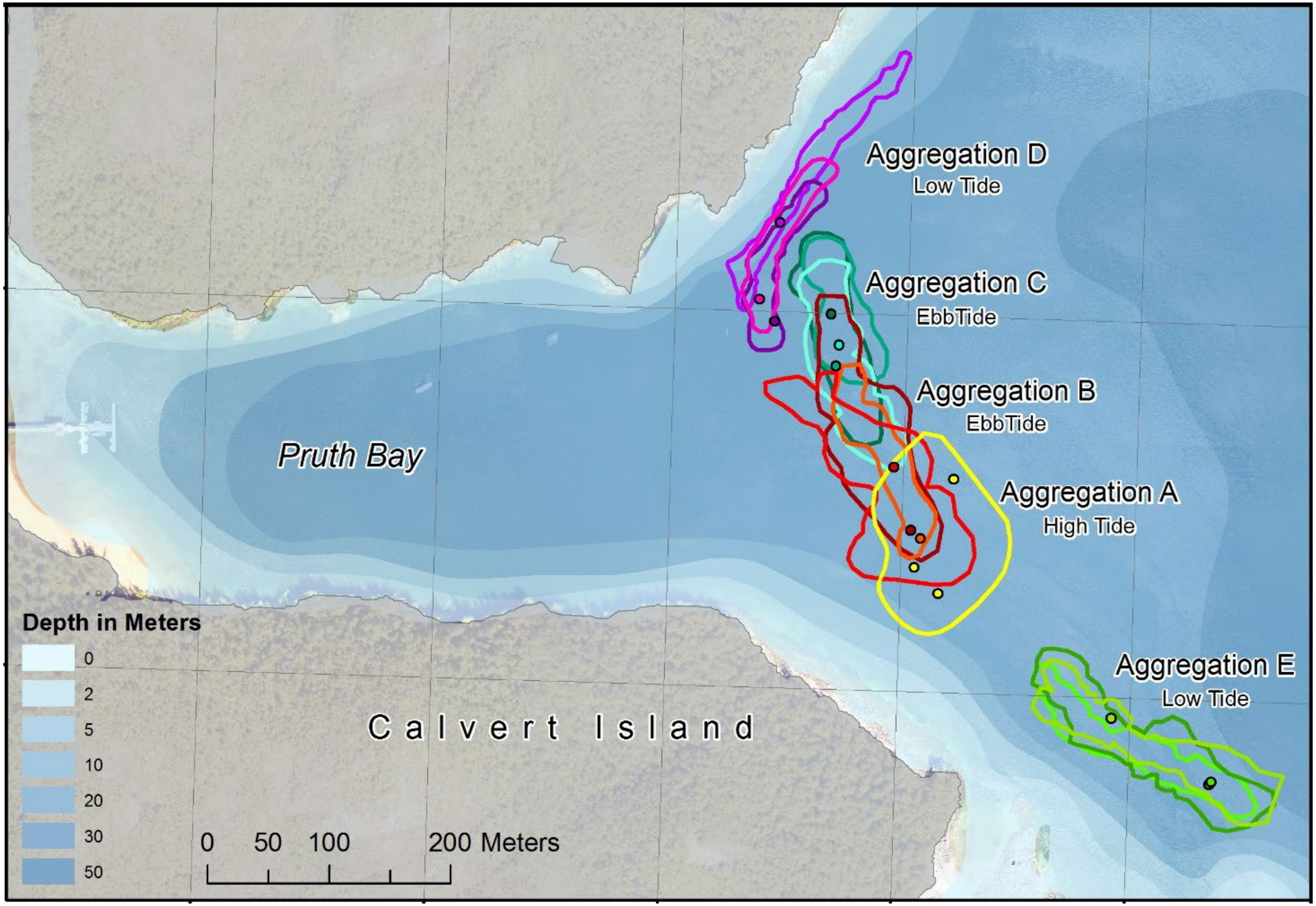
Schaub *et al.* (2018)

RESULTS – DRONE % COVER VS NET DENSITY



Schaub *et al.* (2018)

Results – aggregation surface area



RESULTS – TOTAL AGGREGATION BIOMASS

Table 1. Details of sampling at each tidal period and the associated net and unmanned aerial vehicle (UAV)-based aggregation parameter estimates. Aggregation surface area was calculated from UAV data (see Fig. 2a)

Net haul	Time	Tide	Tidal peak time (h)	Aggre-gation	UAV transect	Flight altitude (m)	Pixel size obtained (m)	Smallest possible pixel size (m)	Aggre-gation surface area (m^2)	Net haul density (ind. m^{-3})	Net haul biomass (t m^{-2})	Total aggregation biomass (t)
1	09:26	High	09:55	A	D1[a]	50	0.058	0.022	12914[b]	0.314	0.001	85.3 ± 63.1
2	09:33				D2	60	0.099	0.026		2.099	0.011	
3	09:48				D3[a]	50	0.030	0.022		1.417	0.008	
4	11:39	Ebb	12:30	B	D4[a]	117	0.079	0.051	12531	2.439	0.012	83.1 ± 58.6
5	11:48				D5	120	0.081	0.052	4507	2.951	0.014	
6	11:58				D6[a]	120	0.078	0.052	10667	1.065	0.004	
7	12:17			C	D7	150	0.098	0.065	7067	3.455	0.014	117.4 ± 27.9
8	12:27				D8	150	0.167	0.065	4888	4.539	0.021	
9	12:43				D9[a]	150	0.123	0.065	6464	4.403	0.023	
10	15:08	Low	15:10	D	D10	100	0.071	0.043	3265	8.861	0.032	65.5 ± 39.3
11	15:19				D11	90	0.065	0.039	3167	5.400	0.020	
12	15:29				D12	100	0.065	0.043	4136	1.354	0.006	
13	15:56			E	D13	120	0.071	0.052	7671	1.462	0.008	106.1 ± 48.5
14	16:07				D14	120	0.065	0.052	9123	4.401	0.017	
15	16:17				D15	120	0.065	0.052	5567	3.655	0.018	

[a]Mapped with 2 transects instead of 1; [b]Due to fog, only 1 estimate of surface area for the 3 hauls was possible

BENEFITS OF DRONES

Confirmed benefits identified by previous studies:

- High resolution spatial coverage
- Inexpensive
- Non-invasive
- High quality images
- Efficient
- Excellent tool for aggregate detection

DRAWBACKS WITH DRONES

- Operational restrictions exist, e.g., urban areas, airports
- Turbidity will limit depth of image capture
  - *should be calibrated with each study*
- Reflectance (sun glare)
- Wind strength affects operation and clarity of imagery (wave action)

CONCLUSIONS

1. **Can drones be used to effectively measure and monitor near surface gelatinous zooplankton?**
    - Yes, they provide an effective means to estimate aggregation surface area;
    - Unlikely that this can be effectively achieved using nets.

2. **Drone data provide useful measures of gelatinous zooplankton biomass / density?**
    - Estimates of relative density for aggregations followed the same trends as net data.