LABORATORY EXPERIMENTS OF BUBBLE FORMATIONS AND BEHAVIORS IN SURFACTANT SEAWATER

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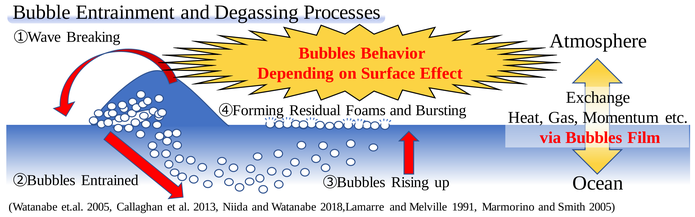
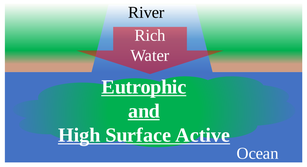
Introduction

Bubble Entrainment and Degassing Processes



(Watanabe et.al. 2005, Callaghan et al. 2013, Niida and Watanabe 2018,Lamarre and Melville 1991, Marmorino and Smith 2005)

Ocean Surface Active



Surfactants in Ocean

Produced by Biological Activity
(e.g. ammonium, polysaccharide)

(Wurl et.al. 2011)

Surface active has Locality !

Potential of Surfactant as Characteristics Local Air-sea Transport

Objective

Identify dynamics of surfactant bubbles and foams

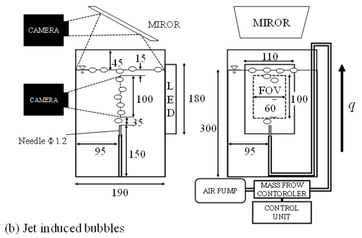
This Study

Investigate surfactant effects on geometric and kinematic features of bubble plumes and residual foams.

Laboratory experiments using high-resolution backlit image measurements

Experiments

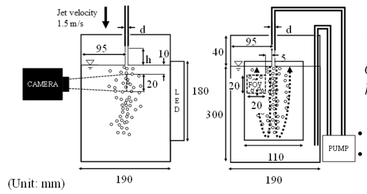
(a) Needle generated bubbles



Case	C (μg/L)
Pure water	0
Surfactant Water (Oligotrophic)	200
Surfactant Water (Mesotrophic)	400
Surfactant Water (Eutrophic)	800
Artificial seawater	—

(a)	q (cc/min)				
Case	10	50	100	200	400

(b) Jet induced bubbles

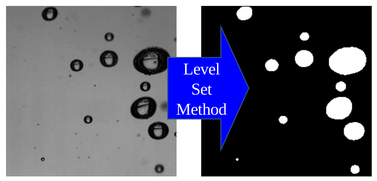


(b)	h (mm)			d(mm)	
Case	10	30	50	3	6

C : Surfactant concentration, q : Air discharge
h : elevation from surface, d : pipe diameter

- Surfactant : Triton-X100 (nonionic surfactant)
- Shooting Condition : 250 Hz

Image Analysis

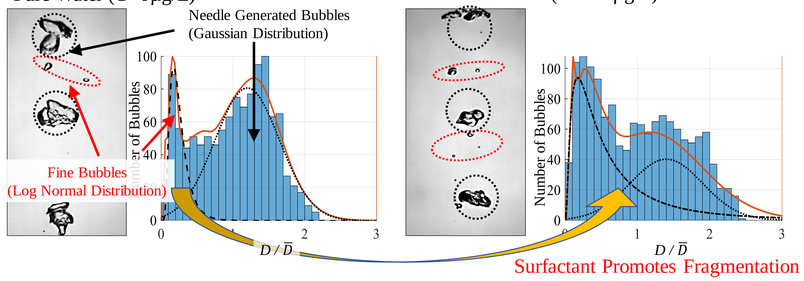


- Bubbled Detected by Level Set Method (Watanabe and Ingram 2015)
- Each Size of Bubbles Determined as Equilibrium Diameter D.
- Bubbles Velocity Estimation by Tracking their Centers Over Sequential Images

Result① Needle Generated Bubbles

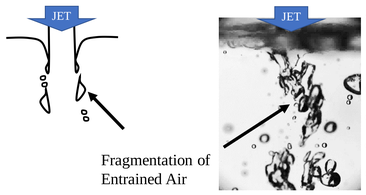
Size Distributions

Pure Water (C=0μg/L)



- Needle Generated Bubbles → Gaussian Distribution
- Fine Bubbles(Created by Breakup of Larger Ones) → Log Normal Distribution.
- Surfactant → Frequently Fragmentation

Result② Jet Induced Bubbles

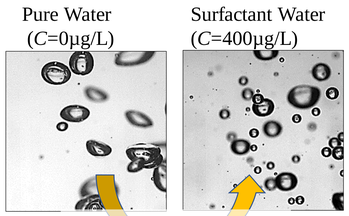


- Fragmentation of Entrained Air→Bubbles

Surfactant

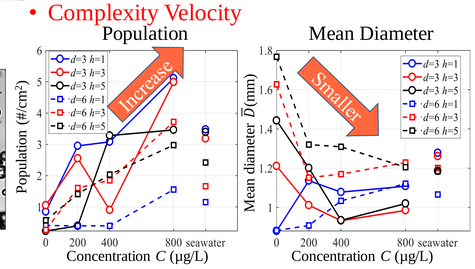
- Frequently Fragmentation
- Increasing Population of Bubbles
- Small Mean Diameter
- Size Distribution→Log Normal Distribution
- Complexity Velocity

Pure Water (C=0μg/L) / Surfactant Water (C=400μg/L)

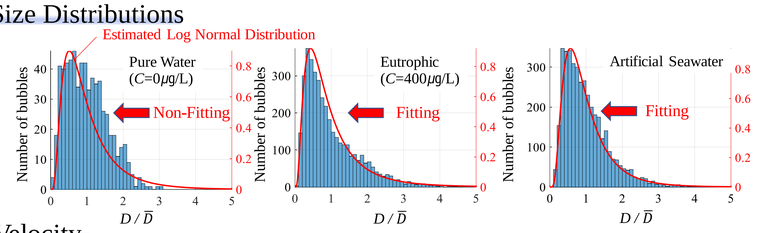


Increase and Smaller

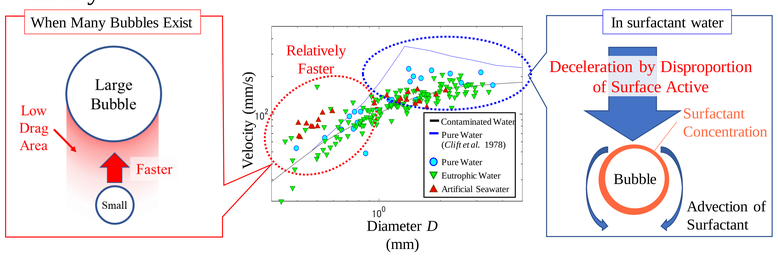
Population / Mean Diameter



Size Distributions

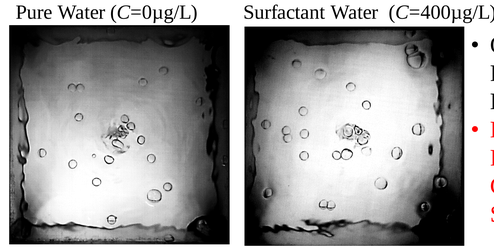


Velocity

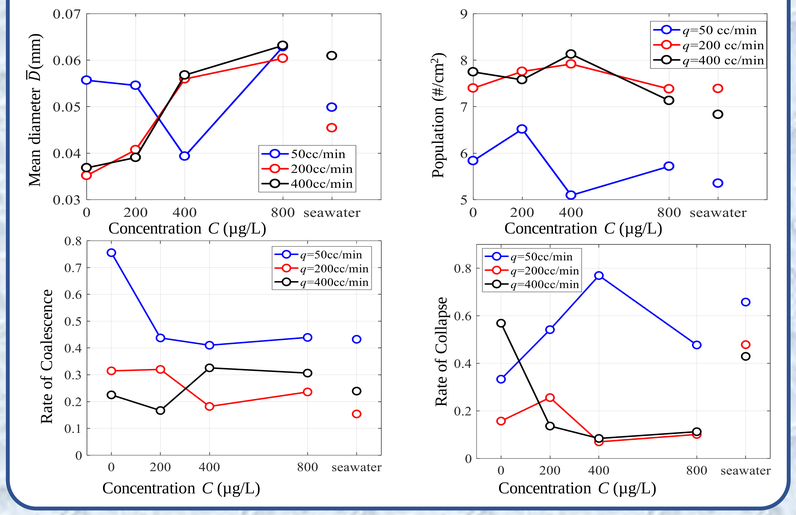


Result③ Residual Bubbles

Pure Water (C=0μg/L) / Surfactant Water (C=400μg/L)



- Observation of Residual Foams in Needle Bubbling Experiment
- Diameter, Population, and Rate of Coalescence and Collapse Highly Depend on Surfactant Concentration



Conclusion

- Surfactant promotes fragmentation of bubbles.
- Fine bubbles size follows log normal distribution.
- Bubbles kinetic feature in surfactant water have complexity.
- Foams behaviors highly depend on surfactant concentration.

Air-sea Transport Varies with Local Oceanic Biological Activity.

References

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