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OES OCEAN ENERGY SYSTEMS ANNEX IV

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Annex IV Environmental Research Webinar Series

Artificial Reefs and Benthic Changes in Relation to MRE

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Presenters

- Sharon Hendrix Kramer
  - Marine Biologist/Fish Ecologist, H. T. Harvey & Associates
- Olivia Langhamer
  - Research Fellow, Department of Energy and Environment, Chalmers University of Technology

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Sharon Hendrix Kramer

Evaluating the Potential for Marine and Hydrokinetic Devices to Act as Artificial Reefs or Fish Aggregating Devices

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Evaluating the Potential for Marine and Hydrokinetic Devices to Act as Artificial Reefs or Fish Aggregating Devices

Presented by Sharon Hendrix Kramer,
Marine Biologist/Fish Ecologist

OES Annex IV Webinar

April 25, 2017

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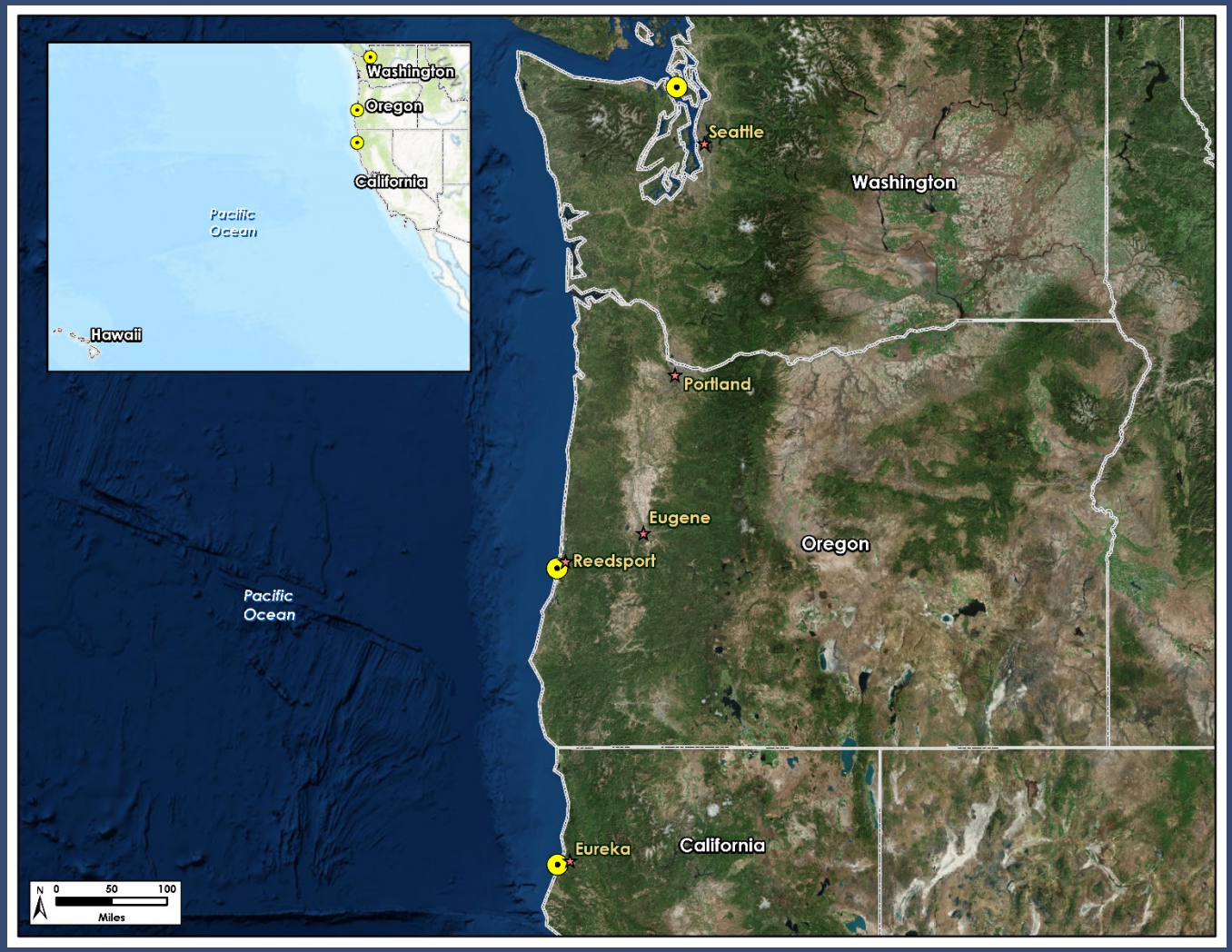
Introduction



- Information gaps identified through project permitting
- Surrogates help to understand effects

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Potential Environmental Effects

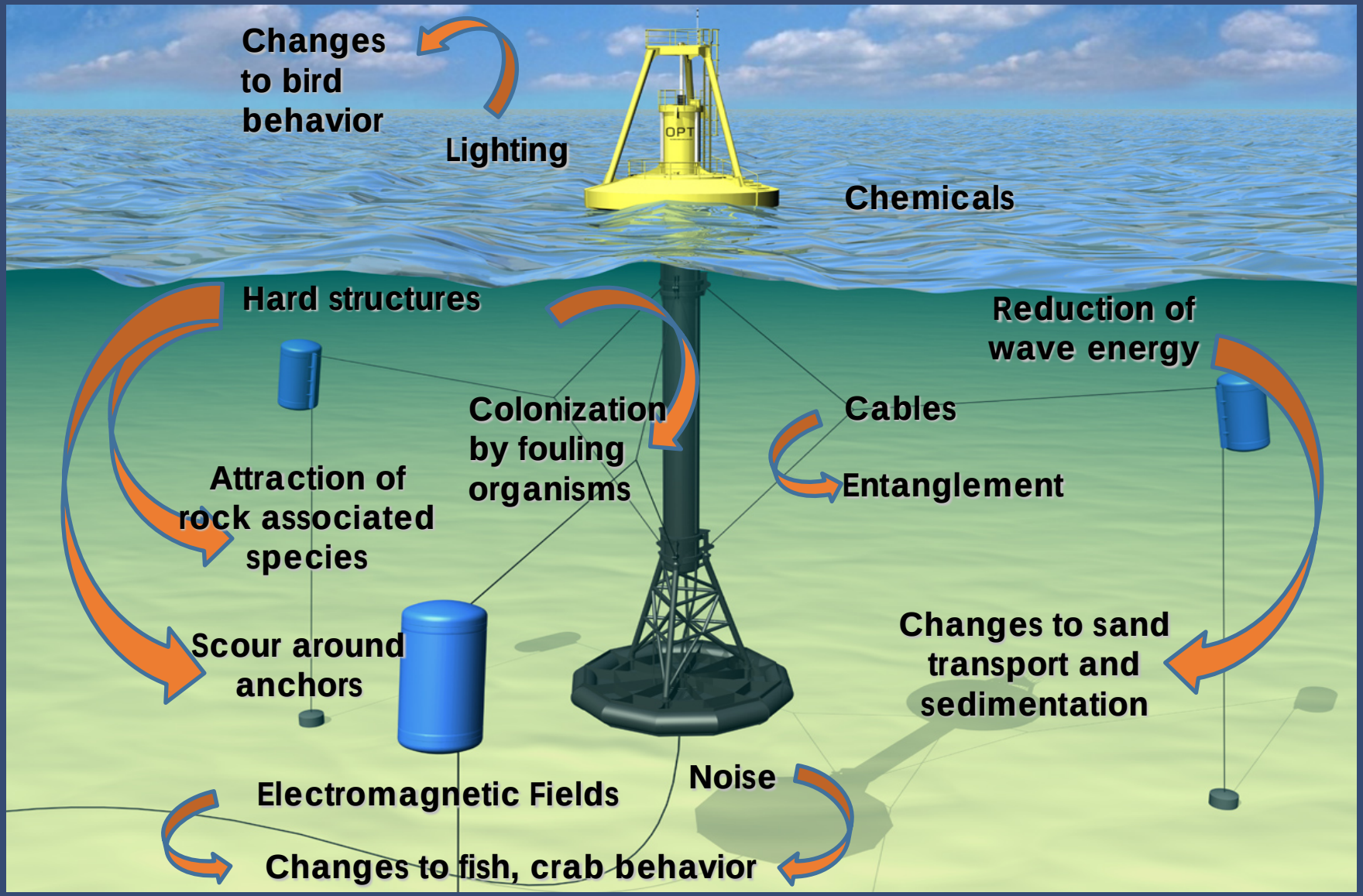

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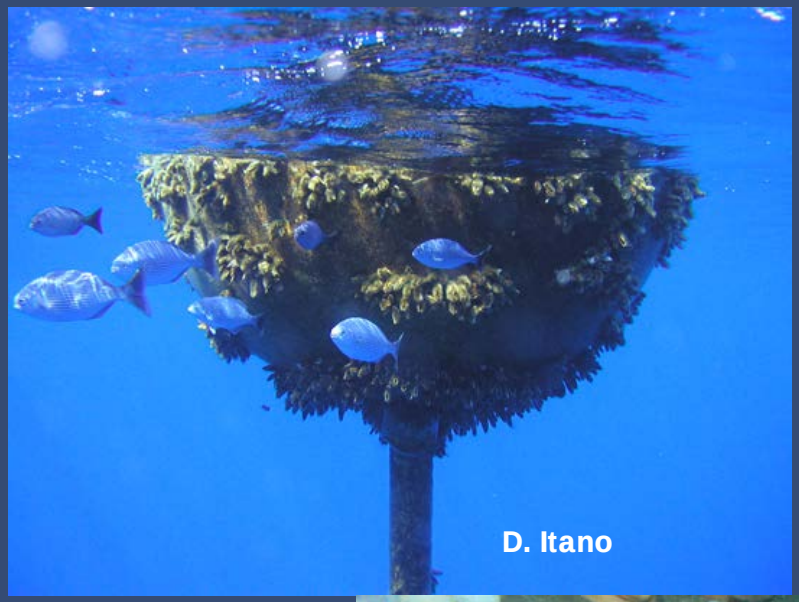
Image provided by NNMREC/OSU

Artificial Reef/Fish Aggregating Device



Mooring lines, buoys, devices

Fish aggregating device?

Anchors, foundations

Artificial reef?

Surrogate Structures

FADs

Mariculture net-pens

Rocky reefs/kelp beds

Artificial reefs

Piers and docks

Oil platforms

Marine debris

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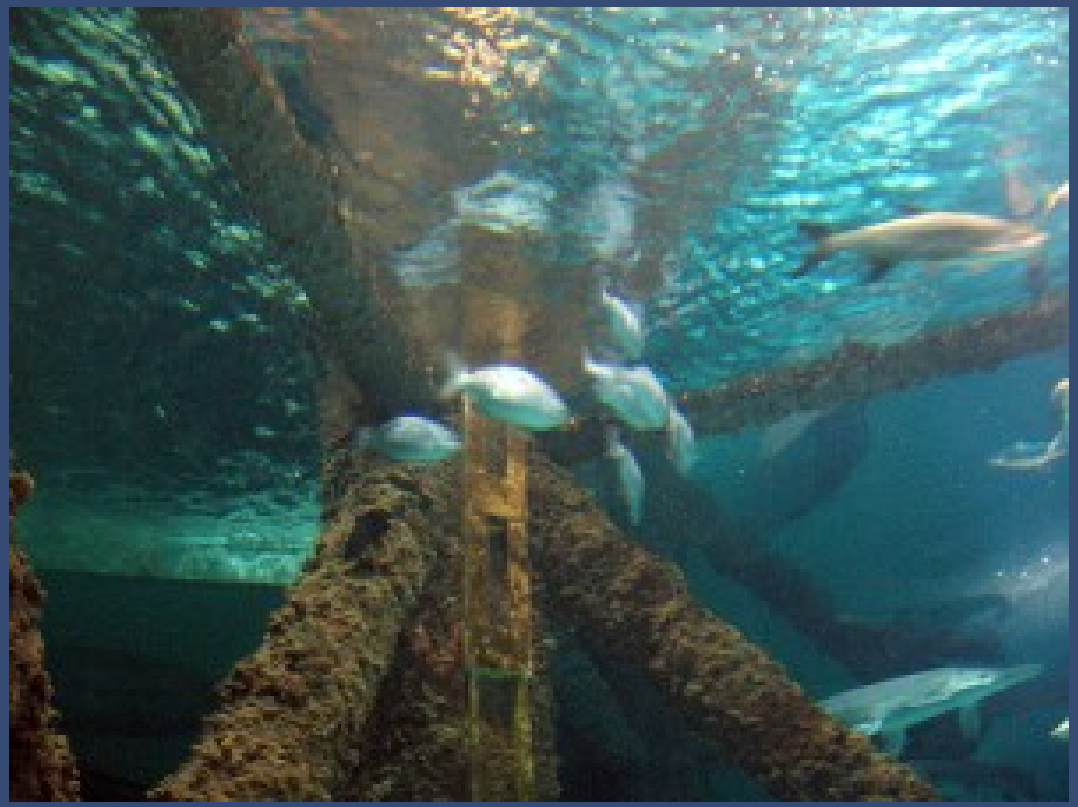
Surrogate Studies Elucidate…..

- Fish assemblages
- Special-status fish interactions
- Ecological interactions
- Interactions/ocean processes
- Seasonality



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Approach

1. Analyzed literature on surrogate structures in 4 regions: 3 off West Coast and 1 in Hawai‘i.
2. Held guided discussions with subject matter experts.
3. Accounted for physical, bio, and structural variables.
4. Asked:
   - Do surrogate structures attract fish?
   - Which species? What about special-status species?
   - If attraction occurs, are there negative effects?
   - What variables are important in predicting effects?


Photo Credit Dave Itano

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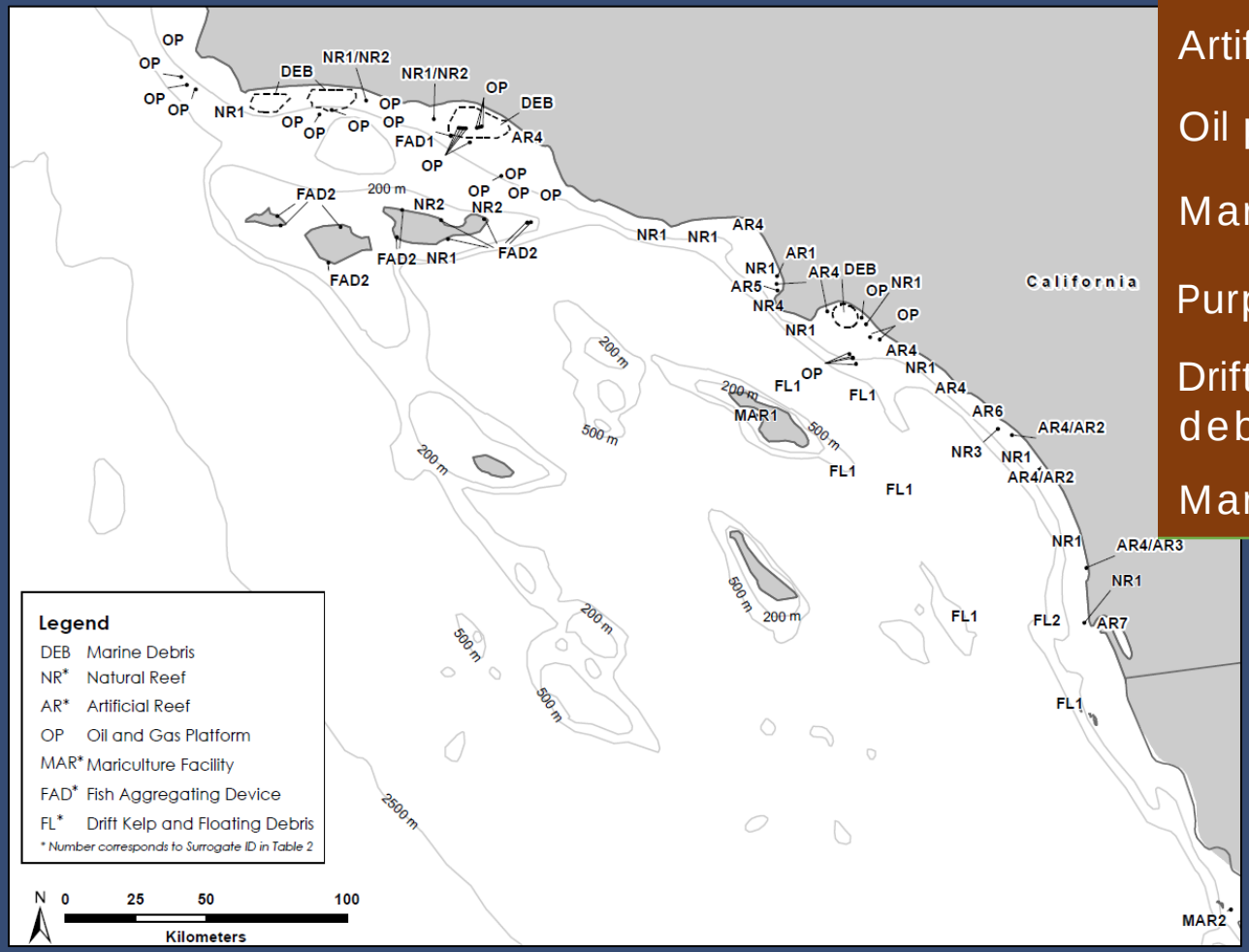
Surrogate Structures: Southern California Bight

Surrogate	# Sites
Natural reefs	80+
Artificial reefs	21
Oil platforms	27
Mariculture net-pens	2
Purpose-built FAD	10
Drift kelp, floating debris	50+
Marine debris	100+



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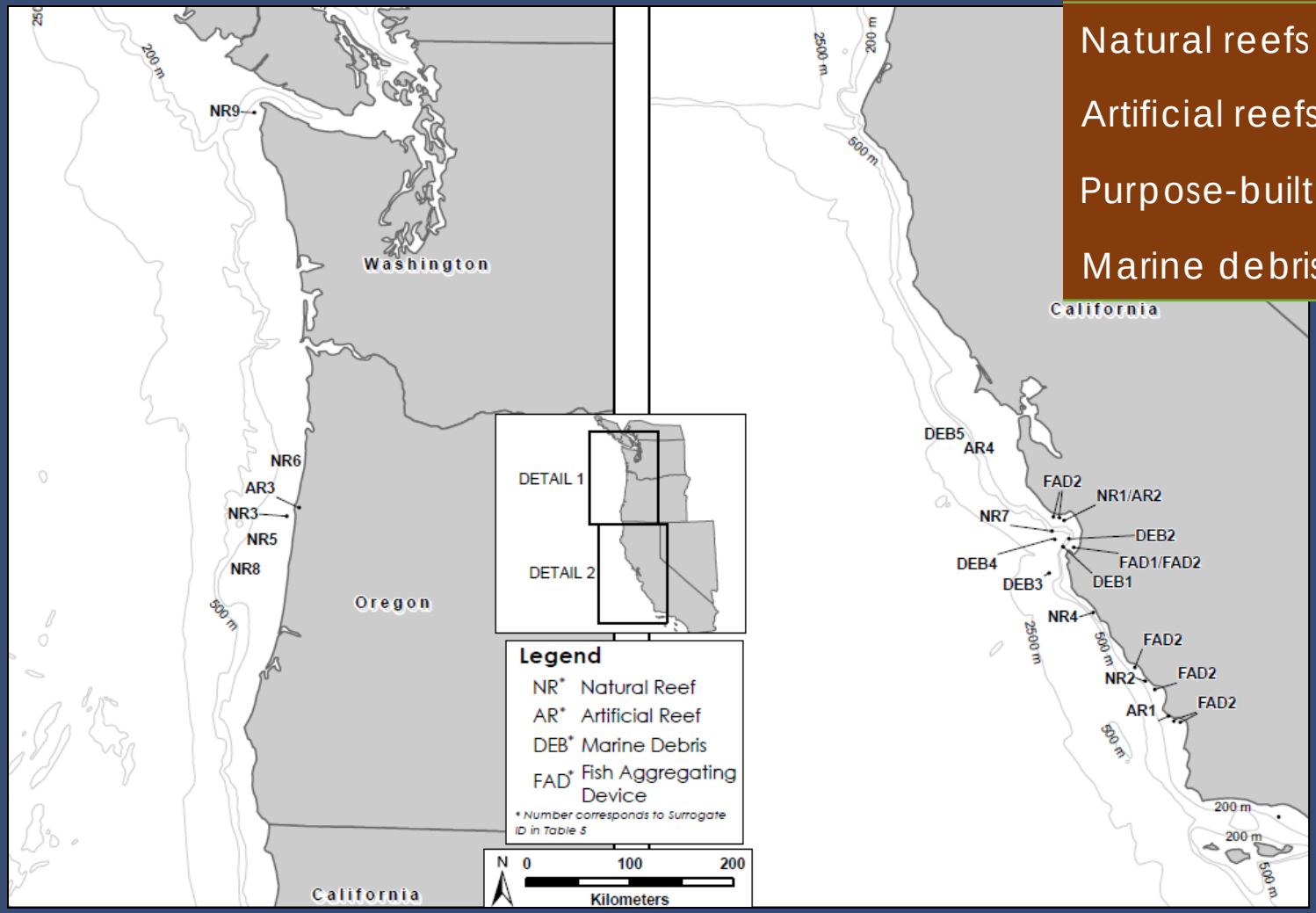
Fish Association: Southern California Bight

Common Name	Position in Water Column		Affected by Depth of Bottom Structure? (Y/N)	Associated with Midwater/ Surface Structure? (Y/N)
	Juvenile	Adult		
Bocaccio	WC	B	N	Y
Canary rockfish	WC	B	Y	N
Cowcod	B	B	Y	N
Yelloweye rockfish	B	B	Y	Maybe
Pacific Ocean perch	B	B	N	N
Steelhead	WC	WC	N	N
Pacific bluefin tuna	WC	WC	N	N

B = bottom; WC = water column

Surrogate Structures: Central California, Washington

Surrogate	# Sites
Natural reefs	20+
Artificial reefs	4
Purpose-built FAD	8
Marine debris	100+



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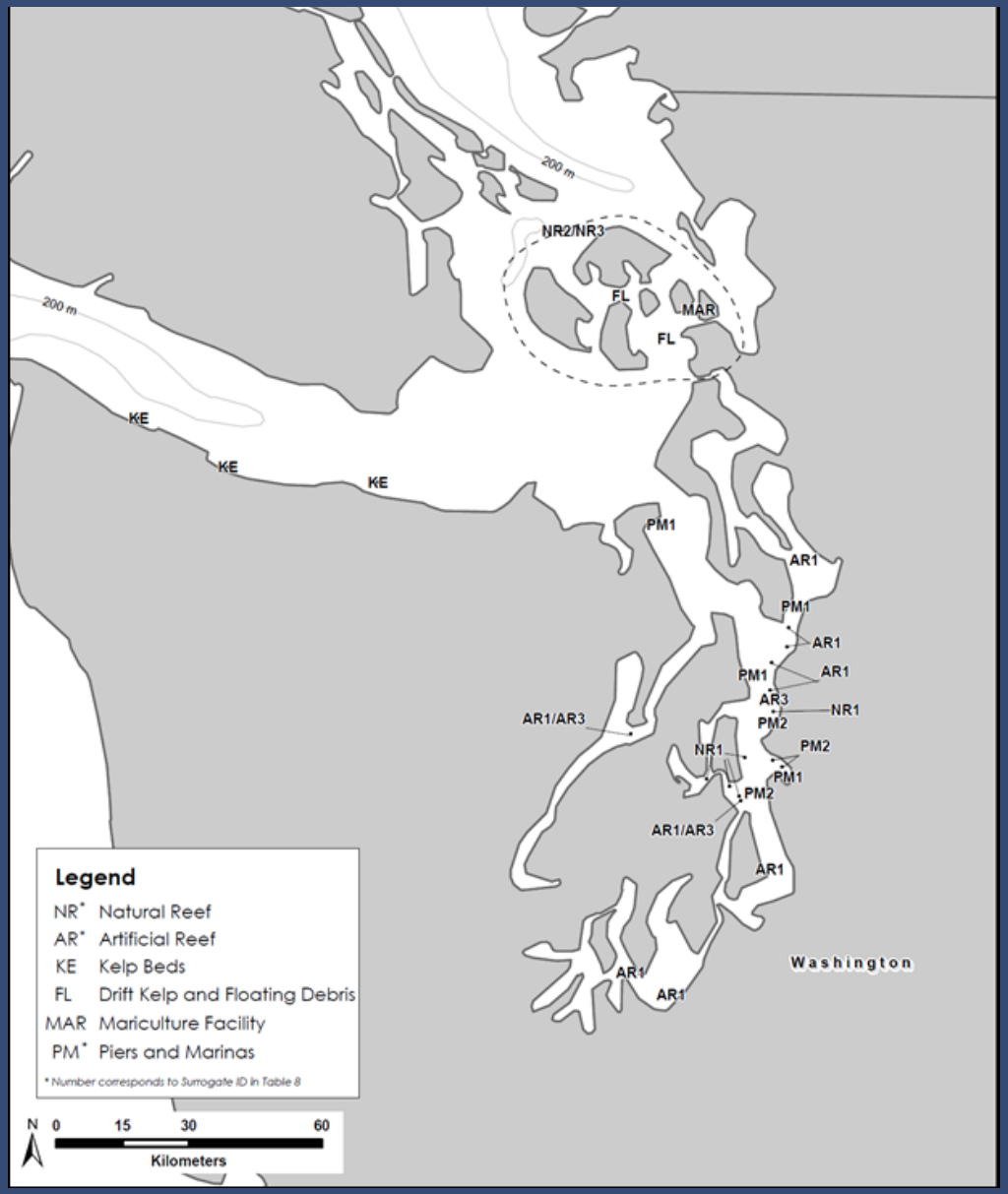
Fish Association: Central California, Washington

Common Name	Position in Water Column		Affected by Depth of Bottom Structure? (Y/N)	Associated with Midwater/ Surface Structure? (Y/N)
	Juvenile	Adult		
Green sturgeon	–	B	Y	N
Eulachon	WC	WC	N	N
Bocaccio	WC	B	N	Y
Chinook salmon	WC	WC	N	N
(Etc.)				

B = bottom; WC = water column

Surrogate Structures: Puget Sound

Surrogate	# Sites
Natural reefs	20+
Artificial reefs	23
Piers and docks	10+
Mariculture net-pens	1
Drift kelp, floating debris	2
Kelp beds	4



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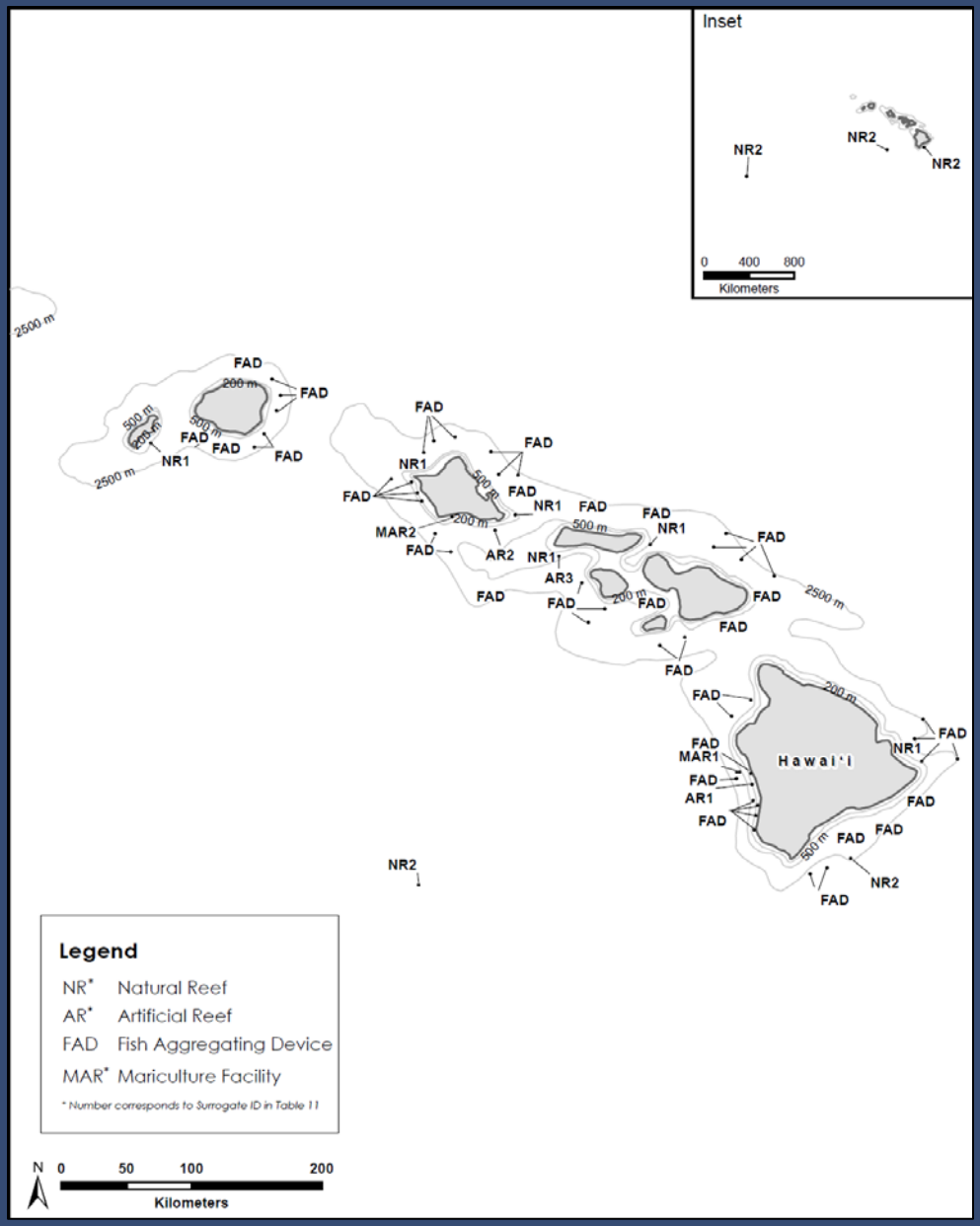
Fish Association: Puget Sound

Common Name	Position in Water Column			Affected by Depth of Bottom Structure? (Y/N)	Associated with Midwater/ Surface Structure? (Y/N)
	Juvenile	Adult			
Green sturgeon	–	B		N	N
Eulachon	WC	WC		N	Maybe
Bocaccio	WC	B		Y	N
Chinook salmon	WC	WC		N	N
(Etc.)					

B = bottom; WC = water column

Surrogate Structures: Hawai‘i

Surrogate	# Sites
Natural reefs	9
Artificial reefs	3
Mariculture net-pens	4
FADs	60+



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Fish Association: Hawai‘i

Common Name	Position in Water Column (Juv. and Adult)	Affected by Depth of Bottom Structure? (Y/N)	Affected by Midwater/ Surface Structure? (Y/N)
Silverjaw snapper	B	Y	N
Squirrelfish snapper	B	Y	N
Longtail snapper	B	Y	N
Pink snapper	B	Y	N
Von Siebold’s snapper	B	Y	N
Brigham’s snapper	B	Y	N
Hawaiian sea bass	B	Y	N

B = bottom; WC = water column

Resemblance of Surrogates to WECs/TECs by Subregion

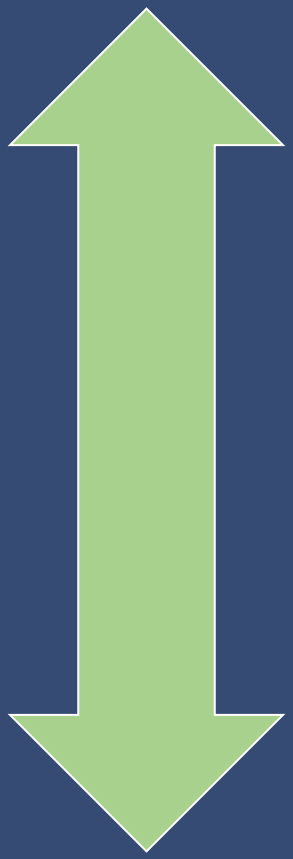
Surrogate Structure	Resemblance of Surrogate Structure to WECs/TECs		Distribution and Quantity of Surrogate Structures			
	Bottom Structure	Midwater/ Surface Structure	SCB	CA-WA	Puget Sound	Hawai'i
Natural reef	Low	n/a	High	High	High	High
Natural reef/kelp bed	Low	Low	High	High	High	None
Artificial reef	Low	n/a	High	Low	High	High
Artificial reef/kelp bed	Low	Low	High	Low	High	None
Oil and gas platform	High	Low	High	None	None	None
Marine debris	Low	n/a	Low	Low	None	None
Mariculture net-cage	High	High	Low	None	Low	Low
Purpose-built FAD	High	High	Low	Low	None	High
Drift kelp, floating debris	n/a	Low	Low	None	Low	None
Piers and docks	High	Low	None	Low	High	None

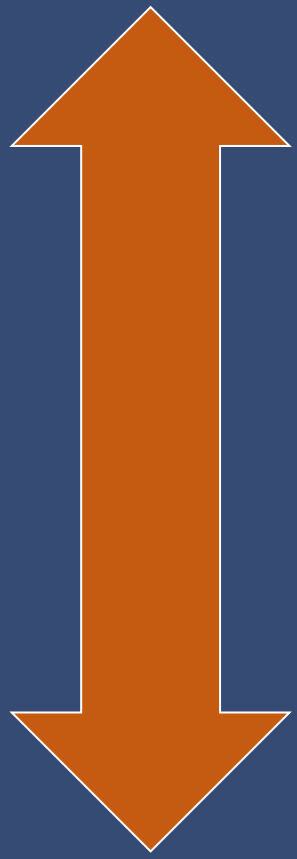
Findings

High Certainty

High Attraction

FAD Effect	Artificial Reef
Hawai‘i	All regions
Southern California Bight	
Central California-Washington	
Puget Sound	





Less Certainty

Less Attraction

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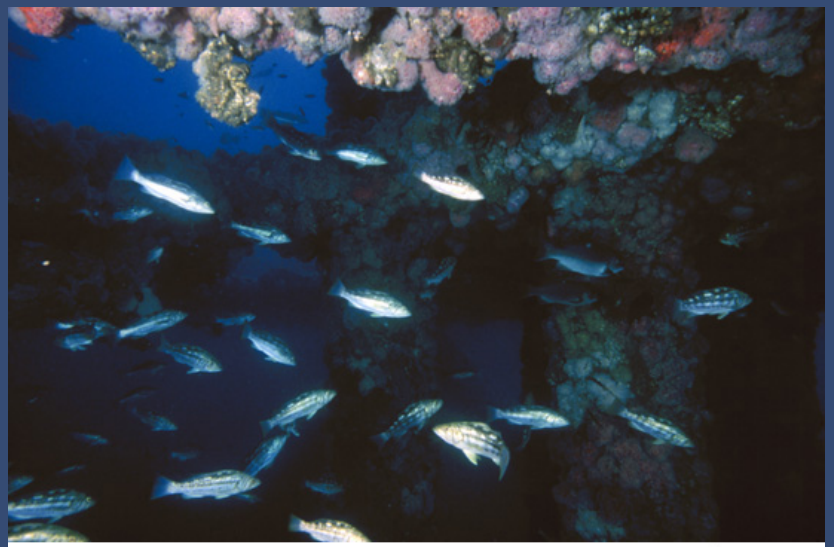
Findings

- **Uncertainties:**
  - FAD effect in temperate waters?
  - Effects of installation scale?
- **Adverse effects on special-status fish unlikely.**



Kelp bass, *Paralabrax clathratus*, Platform Gina, © James Forte

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Inform Permitting

- Provide supporting information to:
  - address uncertainties that can hold up permitting
  - support analysis of effects for NEPA and ESA documents
- Focus monitoring to address anticipated effects:
  - build on understanding as projects are built
  - minimize need for extensive monitoring at every project

Acknowledgements

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Link to report:
http://tethys.pnnl.gov/publications/evaluating-potential-marine-and-hydrokinetic-devices-act-artificial-reefs-or-fads
or
http://www.boem.gov/2015-021/

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Olivia Langhamer

Reef effects of offshore wind and wave power parks - Swedish case studies

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Reef effects of offshore wind and wave power parks - Swedish case studies

OLIVIA LANGHAMER
PHD
Department of Energy and Environment

Annex IV webinar, 25.4.2017


Photo: O.Langhamer

Research interests

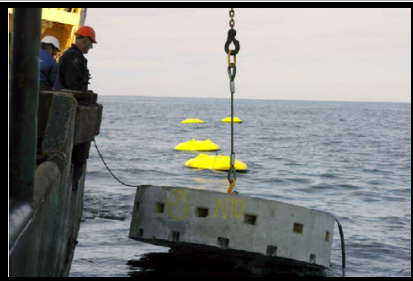


Photo: O.Langhamer

Marine renewable energy conversion and the marine environment

- **Earlier work:**
  - **Wave Energy Conversion and the Marine Environment. Colonization Patterns and Habitat (PhD, Uppsala University, Sweden)**
  - **Population dynamics in an offshore wind park (Statkraft postdoc, Norwegian University of Science &Technology)**

Photo: O.Langhamer

Marine biodiversity is under severe pressure

- Habitat destruction
- Fragmentation and degradation
- Over-exploitation & non-sustainable practices
- Eutrophication
- Invasive species
- Climate change & ocean acidification
- Pollution

Artificial Reefs

Submerged structures deliberately placed on the seabed to mimic some functions of a natural reef such as protecting, regenerating, concentrating and/or enhancing population of living marine resources (UNEP 2009)

Reasons for deploying ARs

- Enhance fisheries *(e.g. Seaman et al. 1991)*
- Protection of fish stocks/habitats *(e.g. Jensen 2002)*
- Restoring marine habitats (including spawning areas) *(e.g. Clark & Edwards 1995)*
- Create sites for recreational diving and fishing *(e.g. Wilhelmsson et al. 1998)*
- Research *(e.g. Seaman et al. 1991)*

www.reefball.org

www.hammerfest.kommune.no

ARs & colonization: influencing factors

- Reef location, isolation *(McArthur & Wilson 1967, Moffit et al. 1989)*
- Reef height *(Jesse et al. 1985, Rilov and Benayahu 2002)*
- Complexity *(Sale 1974)*
- Reef size (*Ambrose & Swarbrick 1989)*
- Epibiota , biofouling organisms *(Bailey-Brock 1989)*
- Surrounding habitat (*Einbeinder 2006)*

www.reefball.org

www.urbanghostsmedia.com

www.toxipedia.org

www.hammerfest.kommune.no

Offshore wind and wave power installations as secondary artificial reefs?

Lysekil Wave Power Research Site

Photo: O.Langhamer

Photo: O.Langhamer

Lillgrund Offshore Wind Farm

Photo: O.Langhamer

Lysekil Research questions

- What are the effects of wave power foundations on benthic species distribution patterns of mobile organisms in this area?
- To what extend will the deployment of wave power foundations on barely sandbottoms affect local distribution patterns of motile species?
- What are the effects of low-cost enhancements of shelter availability and compartment through holes?

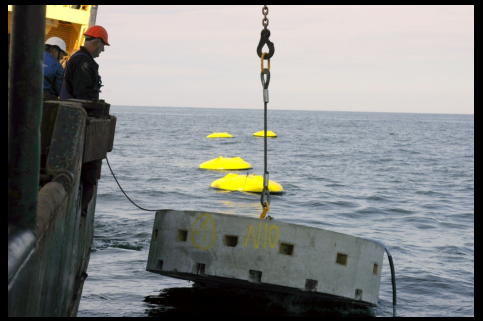
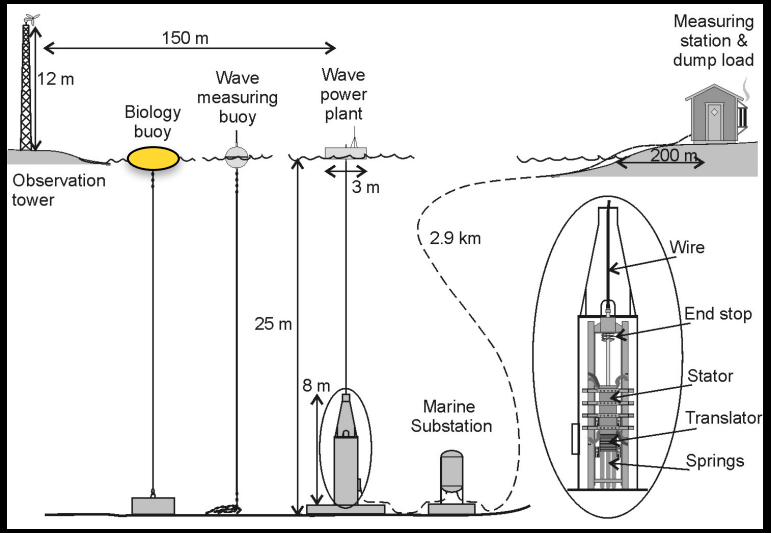
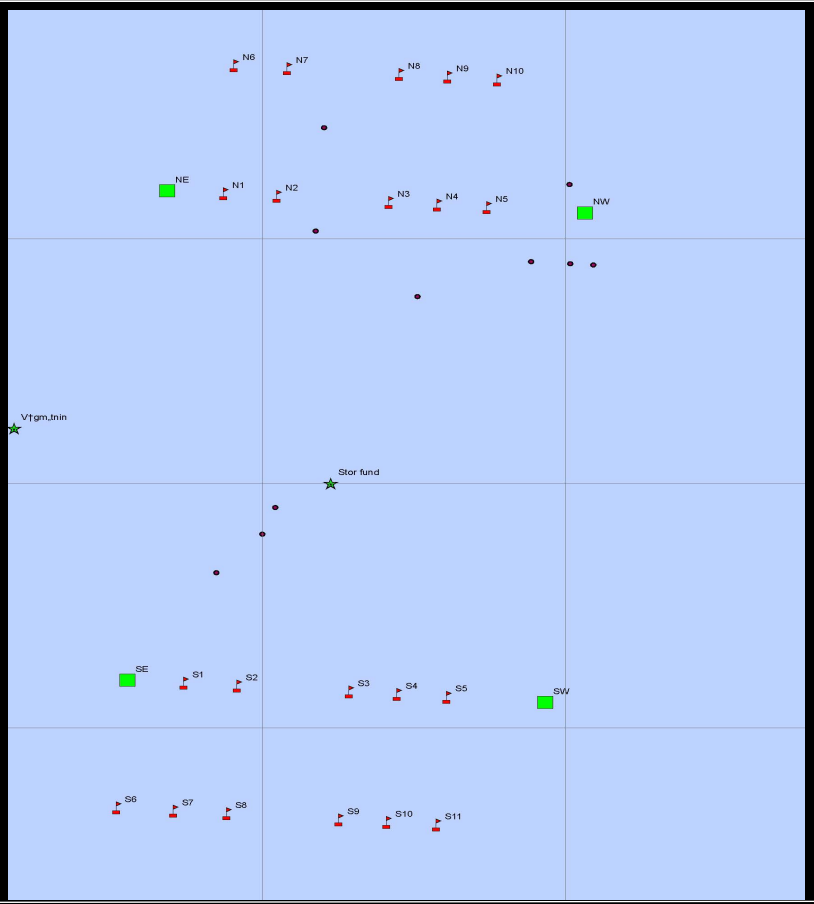


Photo: O.Langhamer

Photo: O.Langhamer

Lysekil: Experimental setup

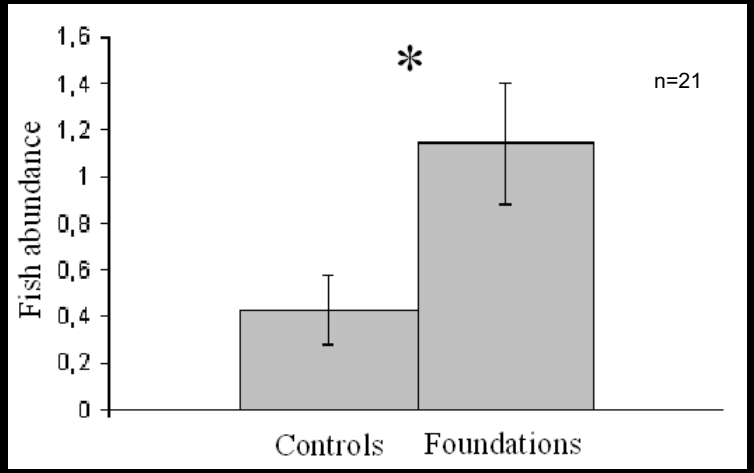


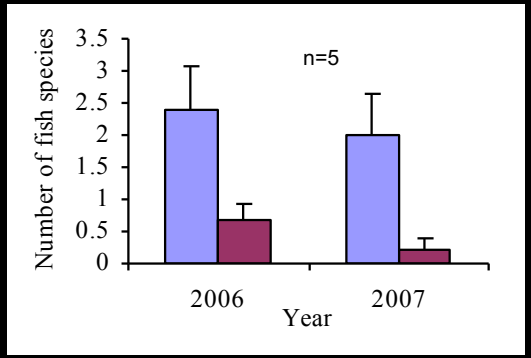


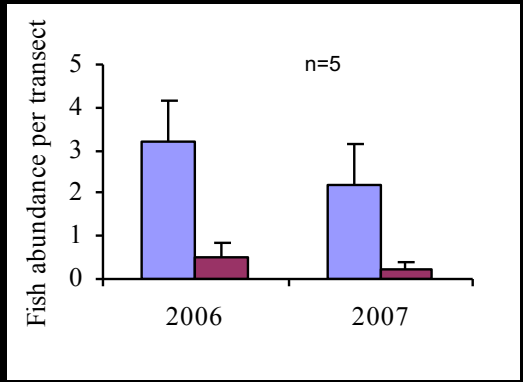
Mean abundance of benthic species recorded on wave power foundations in 2007

Taxa		Foundations without holes	Foundations with holes	Foundations	Control
Common name	Latin name				
Echinoderms					
Spiny seastar	Marthaserias glacialis	1,4	0,18	0,76	-
Common starfish	Asterias rubens	0,1	0,09	0,10	0,10
Sand star	Astropecten irregularis	0,2	-	0,10	1,8
Decapods					
Norwegian lobster	Nephrops norvegicus	-	0,09	0,05	-
European lobster	Homarus gammarus	-	0,09	0,05	-
Hermit crab	Pagarus bernardus	0,9	0,82	0,86	1,52
Harbour crab	Liocarcinus depurator	0,9	0,82	0,86	0,95
Edible crab	Cancer pagurus	0,9	4,82	2,95	-
Great spider crab	Hyas araneus	0,2	0,09	0,14	0,10
Fish					
Cod	Gadus morhua	0,3	0,18	0,24	-
Juvenile codfish	Gadidae	0,3	0,09	0,19	-
Pipefishes	Nerophis spp.	-	0,09	0,05	-
Bullrouts	Cottidae	0,1	0,09	0,10	-
Goldsinny wrasse	Ctenolabrus rupestris	0,1	0,09	0,10	-
Rock gunnel	Pholis gunnellus	0,1	0,18	0,14	-
Sand goby	Pomatochistus minutus	0,2	-	0,10	0,10
Dragonets	Callionymus spp.	0,1	0,18	0,14	0,38
Flatfishes	Pleuronectidae	0,2	-	0,10	0,10

Fish abundance and number of species observed in the Lysekil wave power site







In: Langhamer & Wilhelmsson 2009. Marine Environmental Research

In: Langhamer et al. 2009. Estuarine, Coastal & Shelf Science

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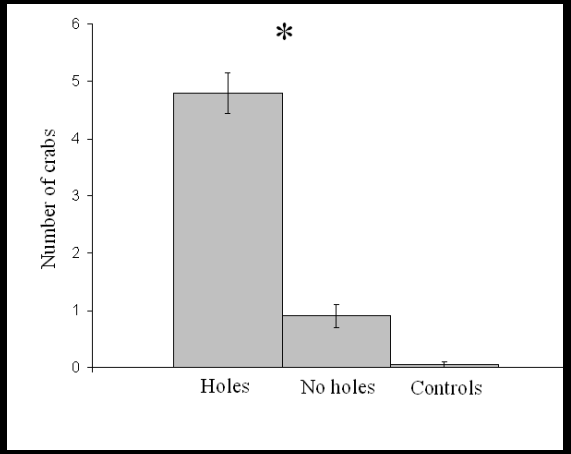
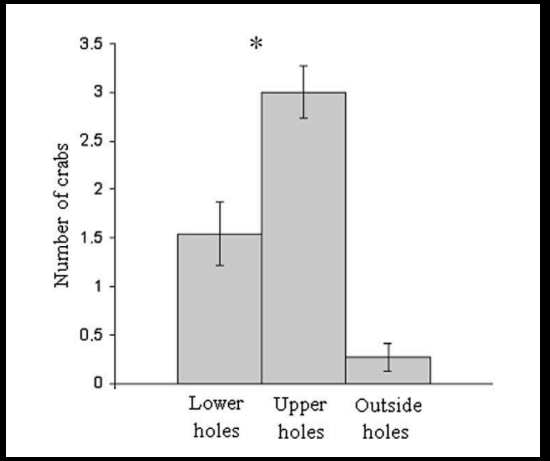
Colonization patterns of edible crab

Photo: O.Langhamer



Average number ± SE of edible crabs on foundations and controls.

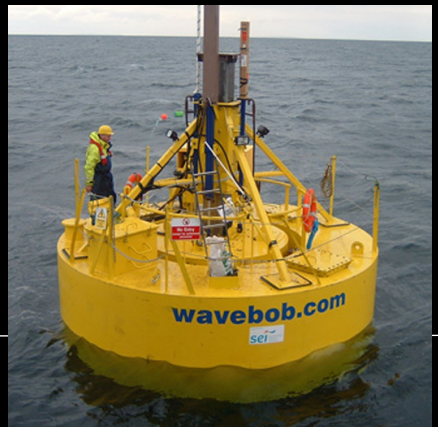


Overview over microhabitat used by average number ± SE of edible crabs on foundations.

In: Langhamer O, Wilhelmsson D 2009. Marine Environmental Research

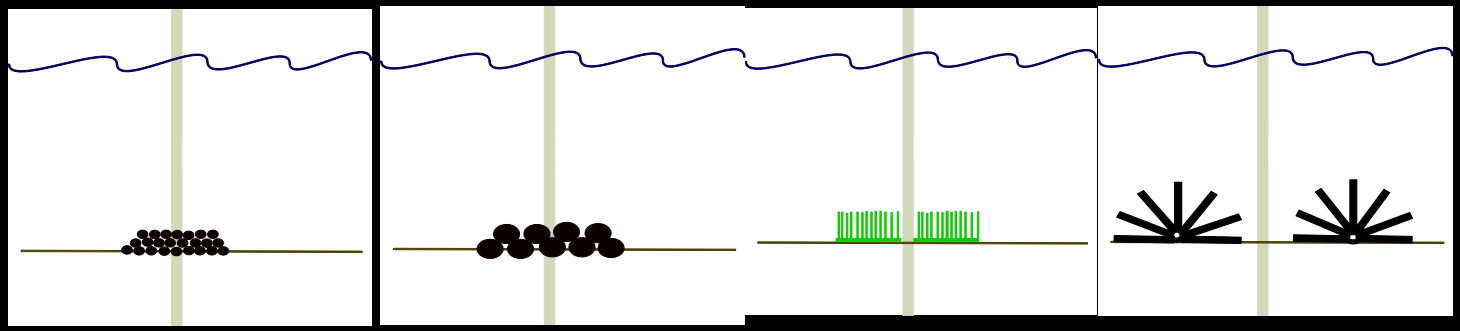
The potential for Wave Energy Devices to Provide Artificial Habitats and Protect Areas from Fishing.

Organisms	Seabased	Pelamis	Wavebob
Benthic fish	+ (foundation+ generator	0 (embedded anchor)	+ (suction anchor+ "floating reef")
Pelagic fish (FAD)	++ (large number +/-)	++ (large horizontal shelter)	++ (sticks deep)
Crustaceans	++ (respond stronger than fish, but most at shallow sites)	0	+ (suction anchor+ "floating reef")
Blue mussels	++	+++ (large surface)	+++ (rel. large and dense surface)



In: Wilhemsson D, Langhamer O. 2010. Report, IUCN/Vattenfall AB

Offshore wind and scour protection



	Habitat loss (m^2)	Habitat created (m^2)	Net loss/gain (m^2)
Gravel protection	452	1102	650
Boulder protection	452	1129	677
Synthetic fronds	452	439,5	-12,5
Reef ball	452	3616,6	3164,6
SeaCult	452	5464	5012

(adapted from Wilson & Elliott 2009)

In: Langhamer 2012. Scientific World Journal

Species aggregation around offshore wind turbines

Monopiles with scour protection:

Pouting (Reubens et al. 2011)

Cod (Couperus et al 2010)

Monopiles without scour protection:

Benthic fish species/assemblages (Wilhelmsson et al. 2006)

Gravity based foundations:

European eel, cod, short-horn sculpin, goldsinny wrasse (Bergström et al. 2012)

Eelpout (Bergström et al. 2012, Langhamer et al. in prep.)

Shore crabs (Bergström et al. 2012, Langhamer et al. 2016)

Population studies on shore crabs and viviparous eelpout in relation to offshore renewable energy installations (OWF)

- capture-mark recapture study fyke nets
- estimating population size and density, morphological characteristics, sex determination for crabs and condition
- CI, HIS, GSI and brood analyses for female eelpout

Photo: O.Langhamer

Photo: O.Langhamer

Effects of an OWF on *C. maenas*

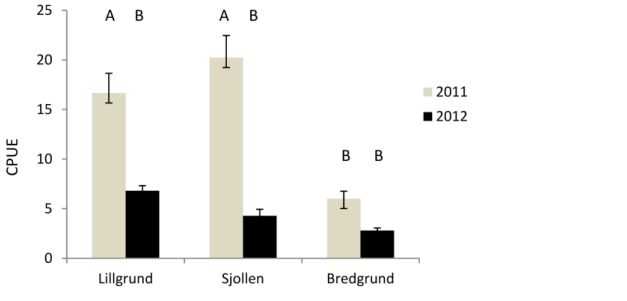


Figure 2. Calculated mean± SE in catch per unit effort (CPUE) of the common shore crab, *Carcinus maenas* in Lillgrund wind park and the two control sites Bredgrund and Sjollen in 2011 and 2012. Letters above bars indicate significantly different means based on Tukey`s post-hoc comparisons.

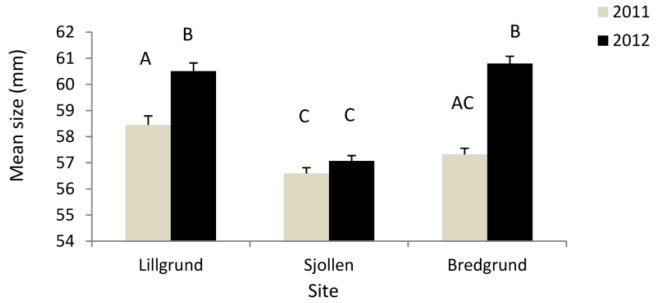
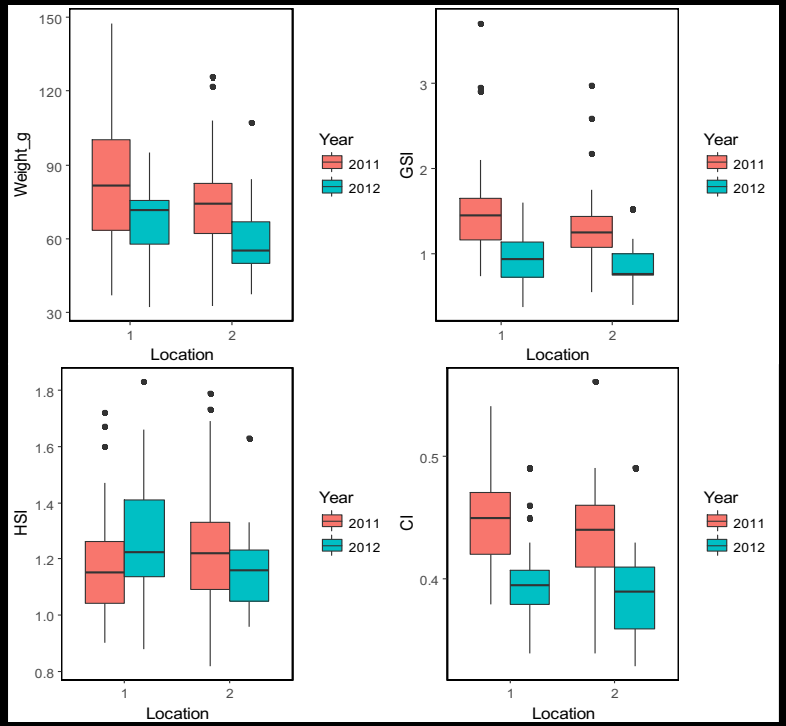


Figure 3A. Calculated mean± SE in carapace size of the common shore crab, *Carcinus maenas* in Lillgrund wind park and the two control sites Bredgrund and Sjollen in 2011 and 2012. Letters above bars indicate significantly different means based on Tukey`s post-hoc comparisons.

(Langhamer et al. 2016. Plos-One)

Effects of an OWF on *Z. viviparous*



(Langhamer et al. in prep.)

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Thank you for your attention!

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Questions?

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