Fish interactions with marine renewable devices: lessons learned, from ecological design to improving cost-effectiveness

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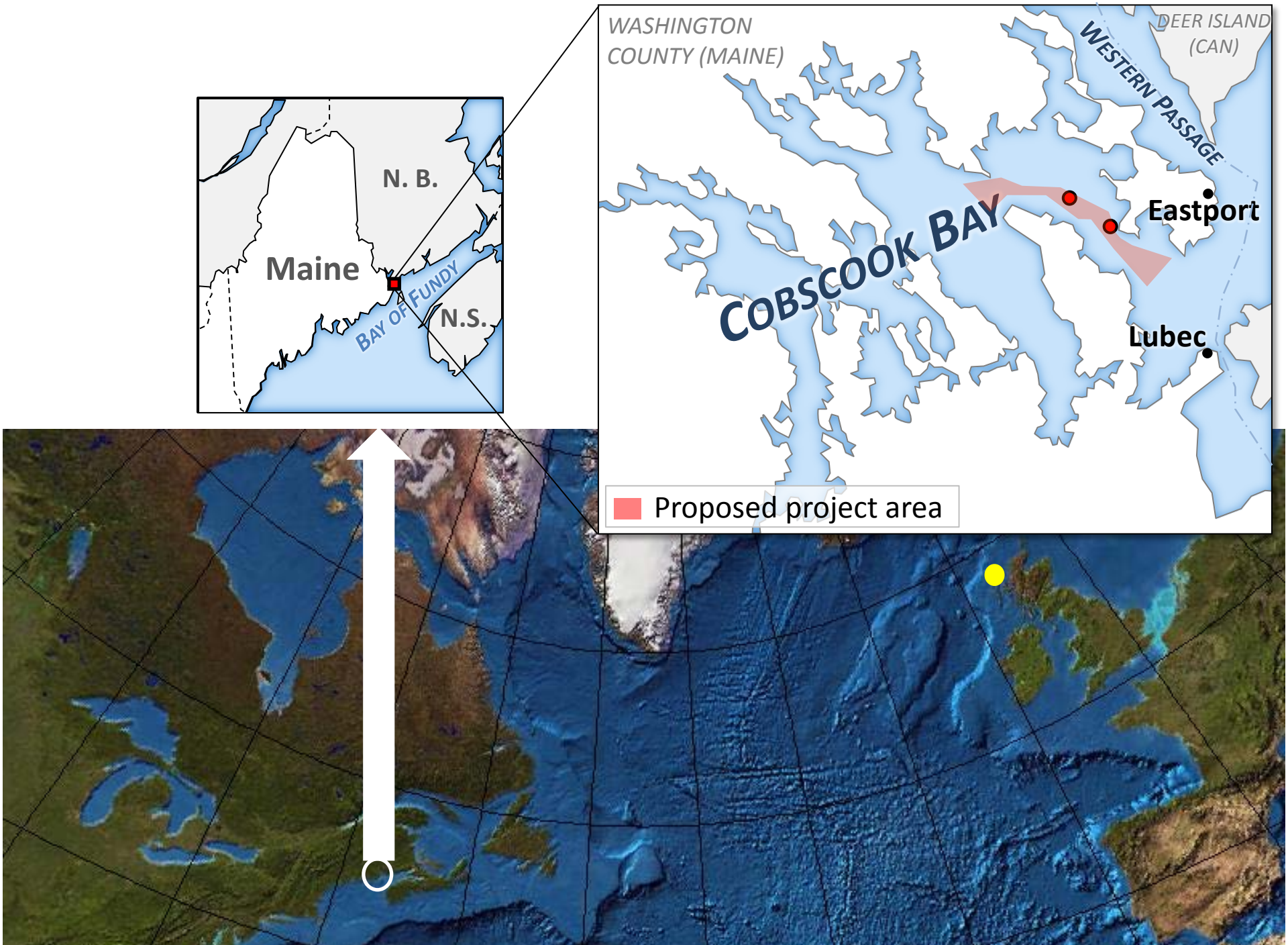
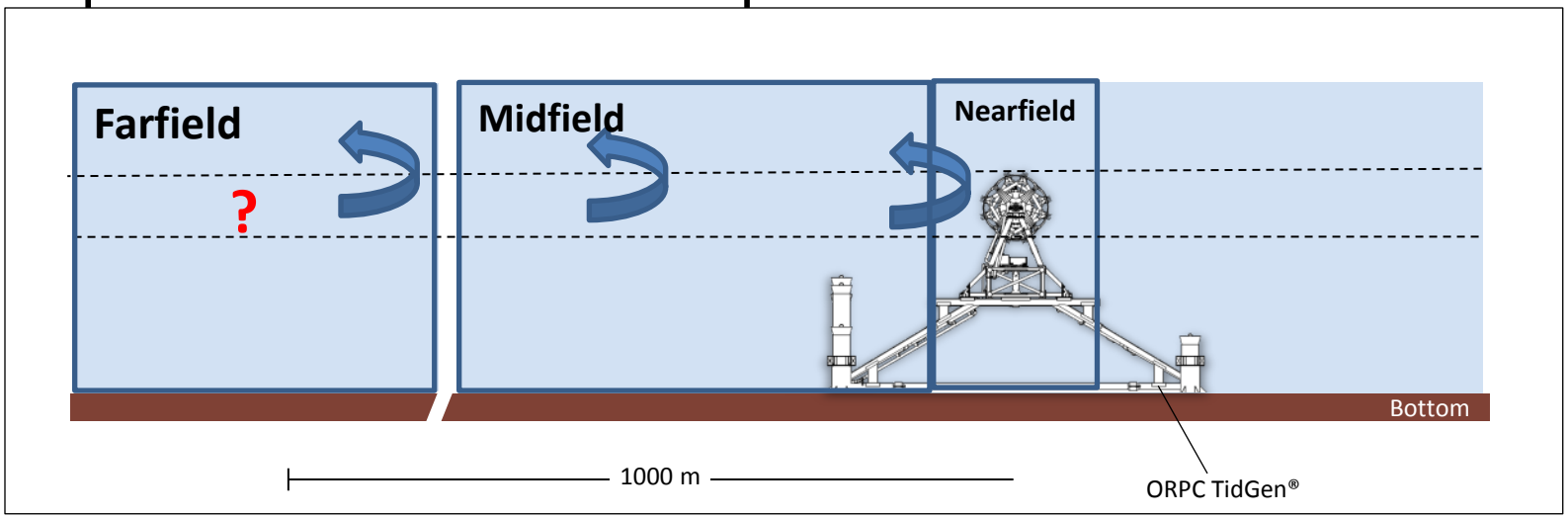
MTPI
Maine Tidal Power Initiative
environment • resource • community • engineering


WASHINGTON
COUNTY (MAINE)
DEER ISLAND
(CAN)
WESTERN PASSAGE
COBSCOOK BAY
Eastport
Lubec
Proposed project area
N. B.
Maine
BAY OF FUNDY
N.S.

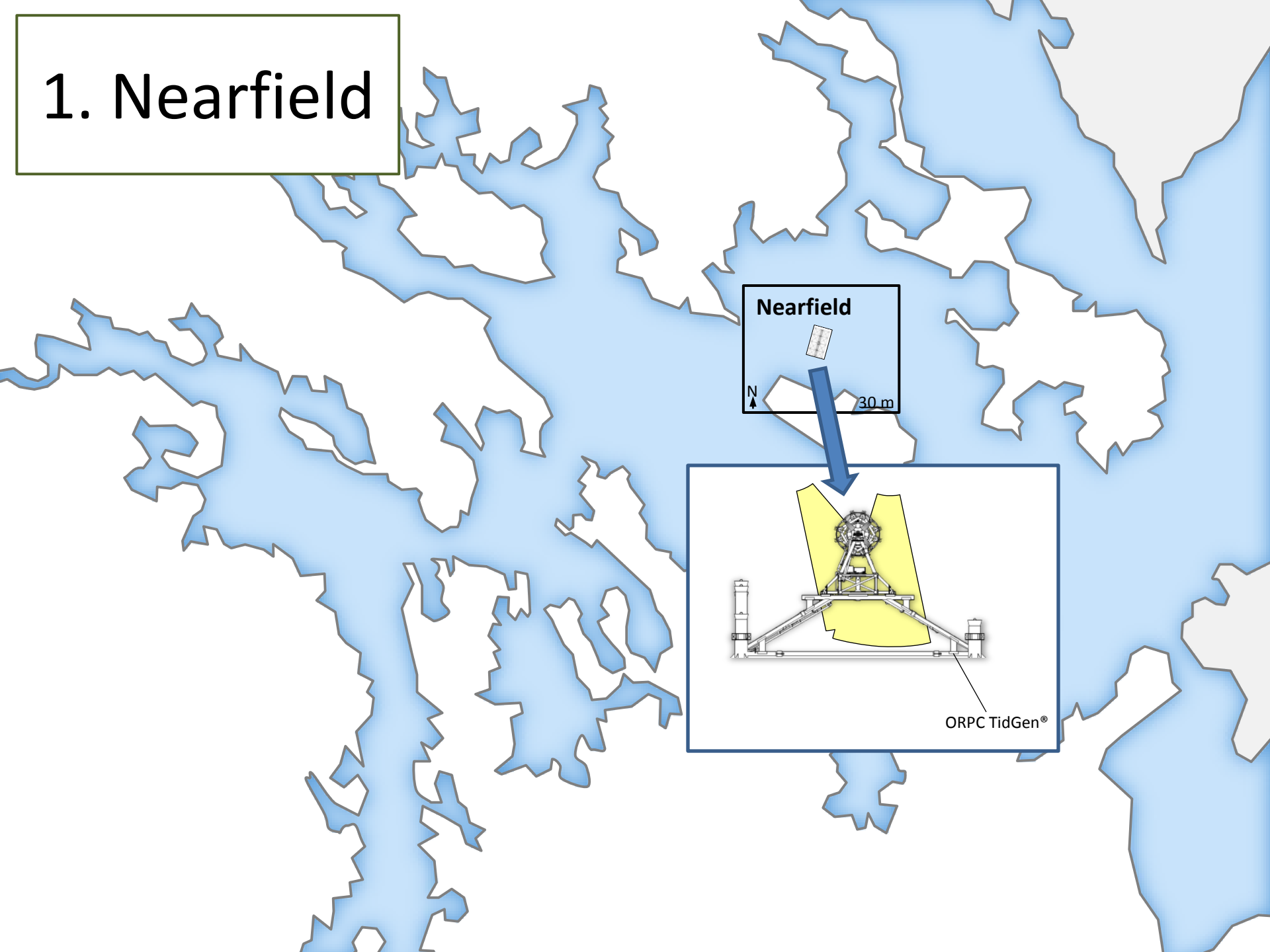
What is the probability that a fish will encounter an MHK device?

1. **Near-field** – within 5 m of a blade
   - DIDSON (Viehman and Zydlewski 2014)
2. **Far-field** –no expected effects of the device
   - Abundance & distribution (Viehman et al. 2014)
3. **Mid-field** – within the hydrodynamic effects, 100s m
   - Proportion of fish at the depth of the device

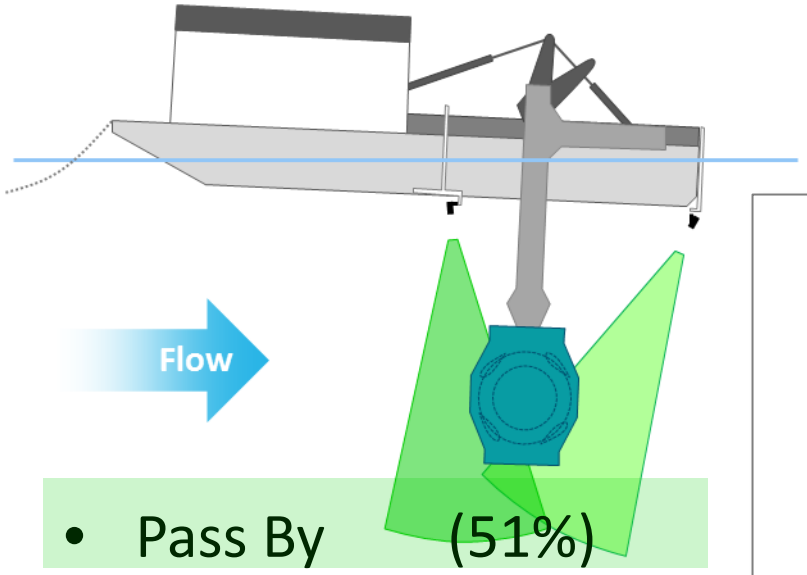


Why consider multiple space and time scales?

1. Nearfield



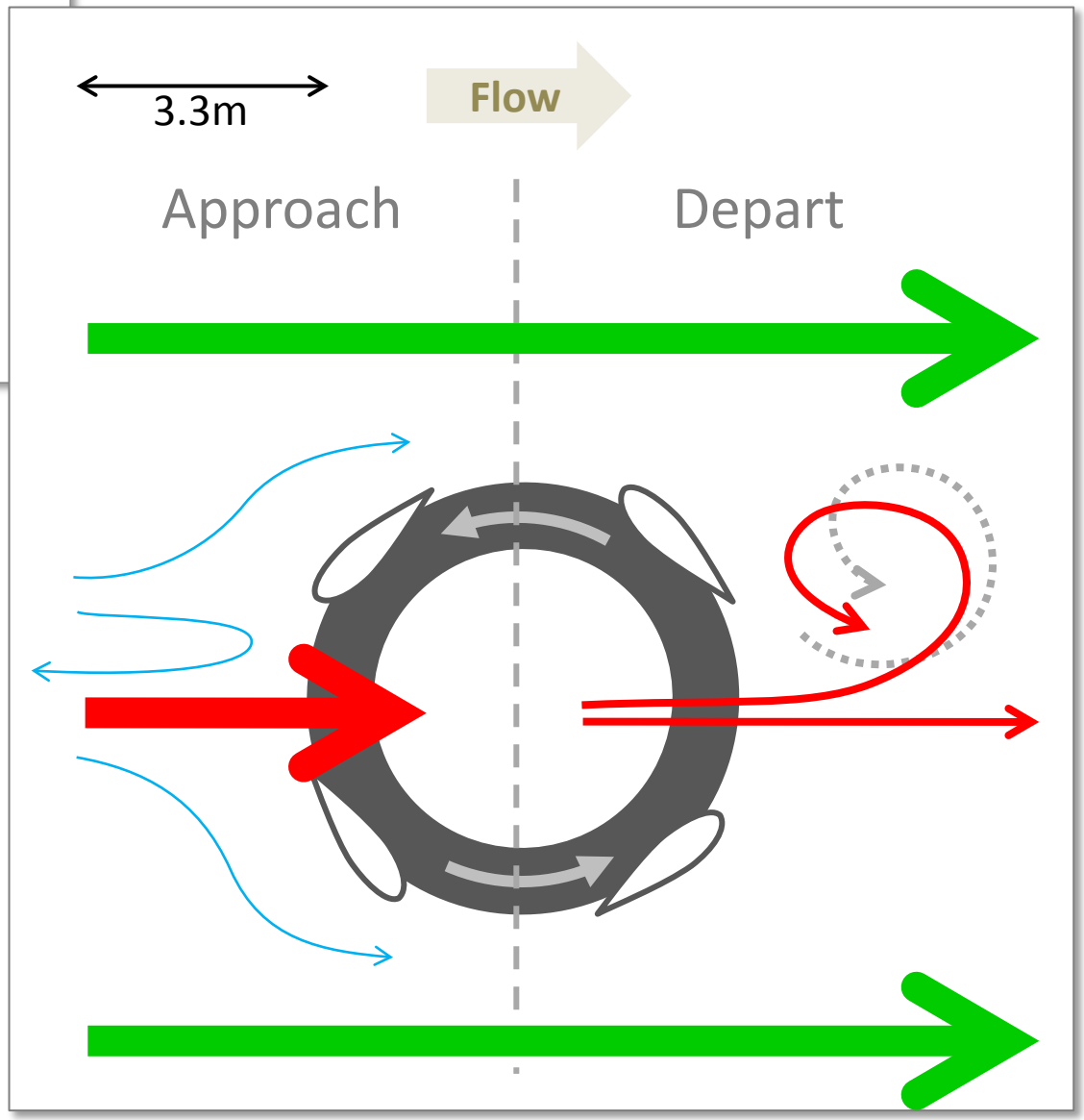
Spatial Scale: within 5 m



- Pass By (51%)

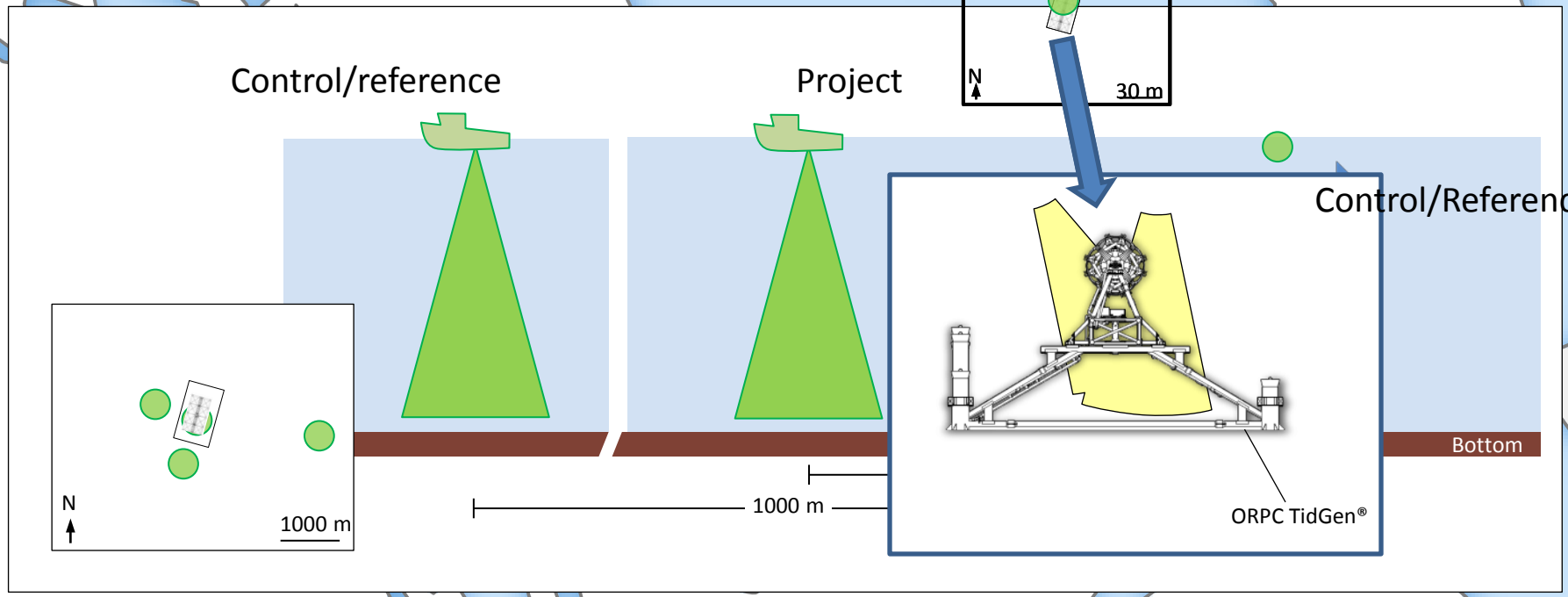
- Through Turbine (48%):
  - Into Turbine
  - Out of turbine

- Active Avoidance (1%):
  - Above
  - Reverse
  - Below

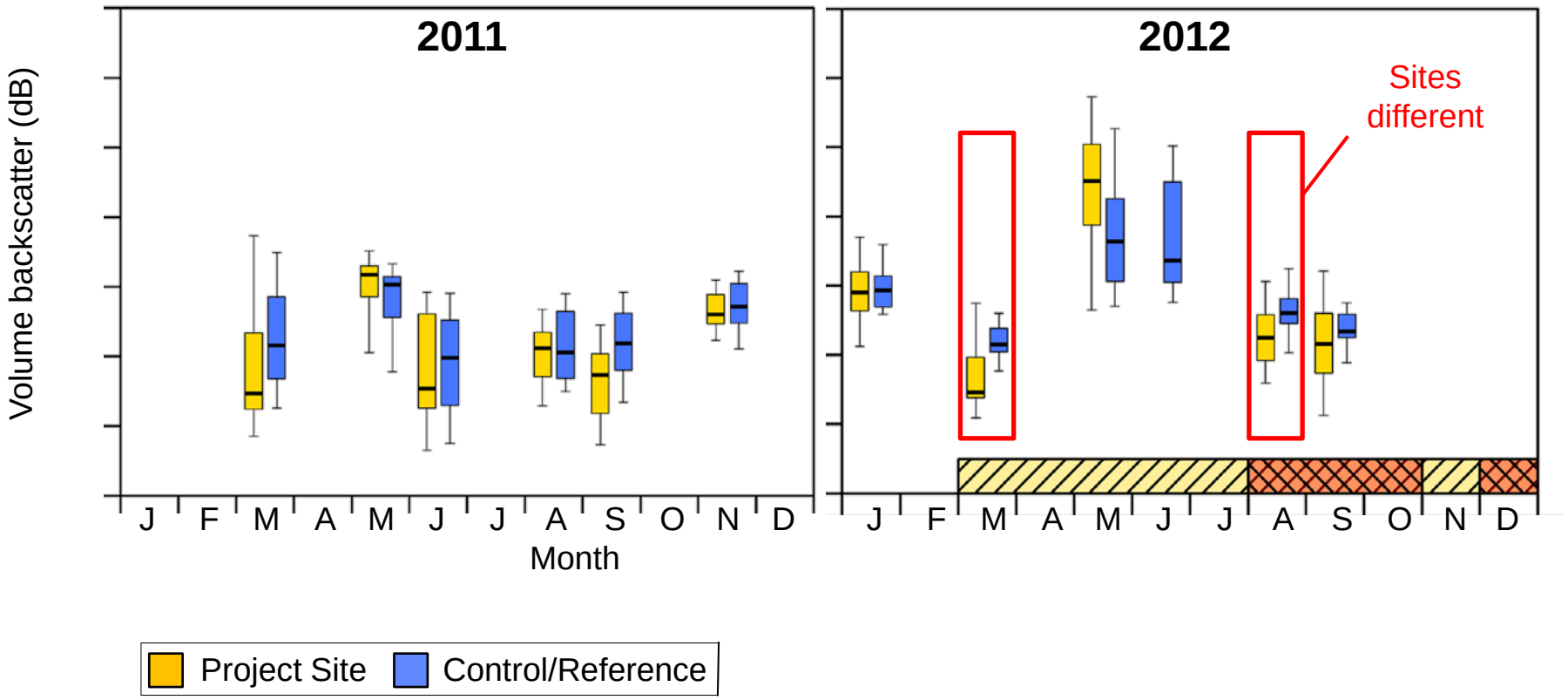


Viehman and Zydlewski. 2014. *Estuaries and Coasts*.

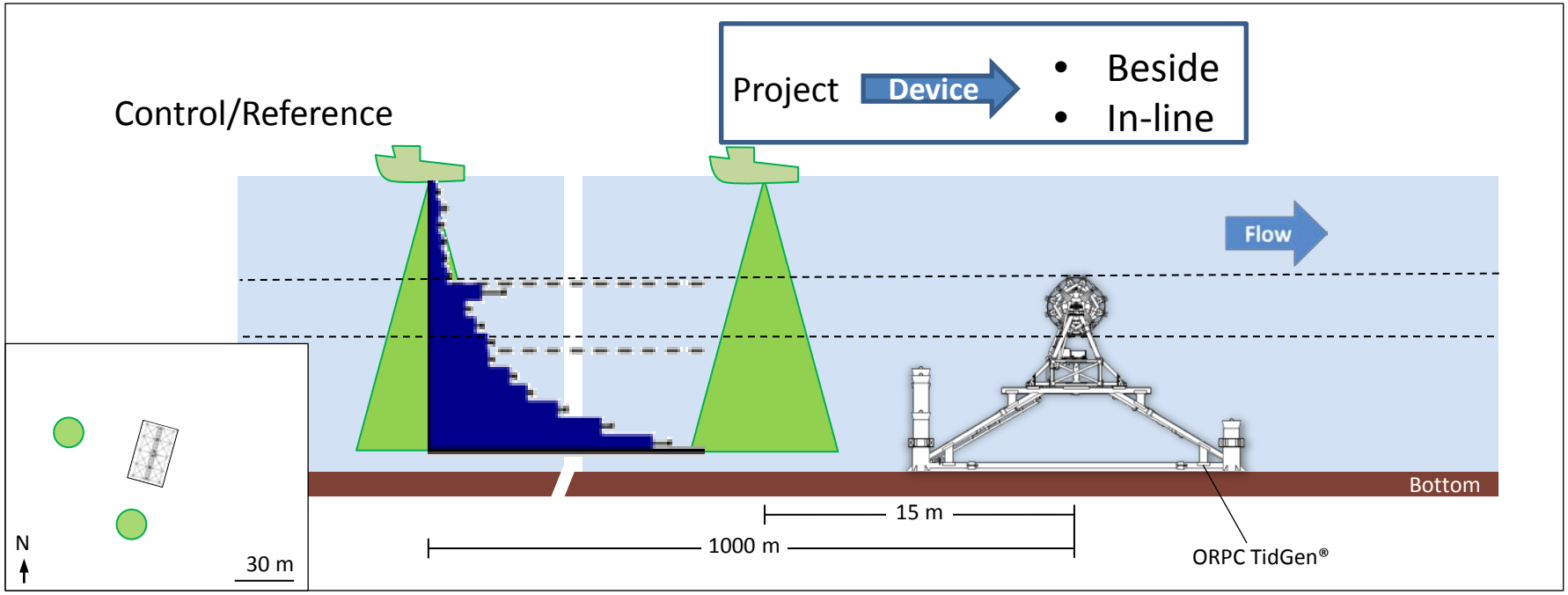
2. Farfield

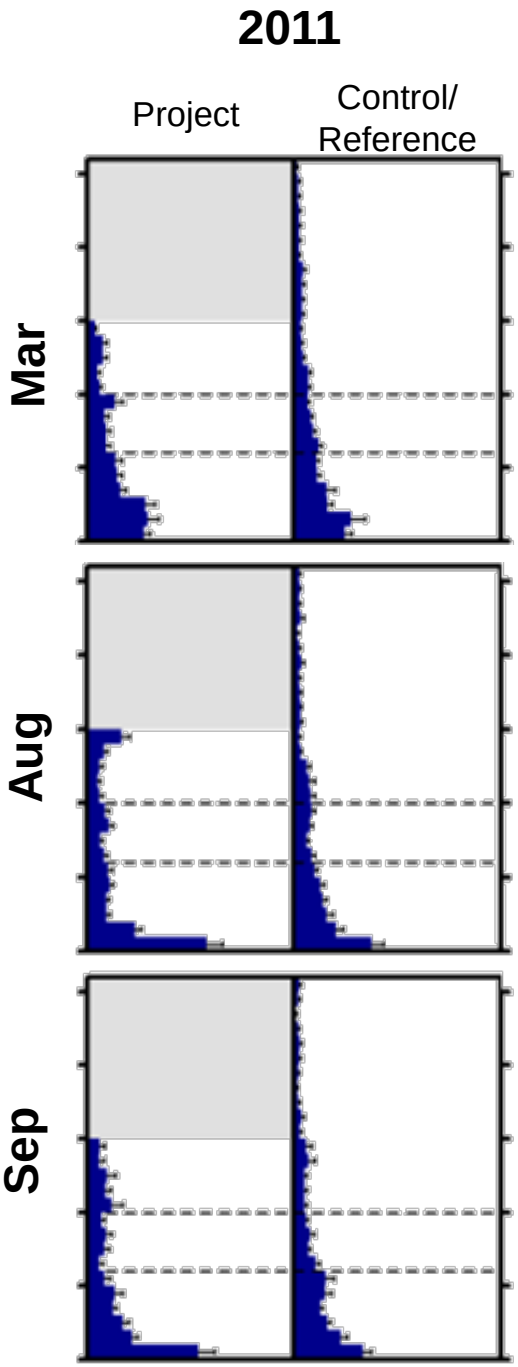

Nearfield Project
N
30 m
Control/reference
Project
Control/Reference
Bottom
N
1000 m
1000 m
ORPC TidGen®

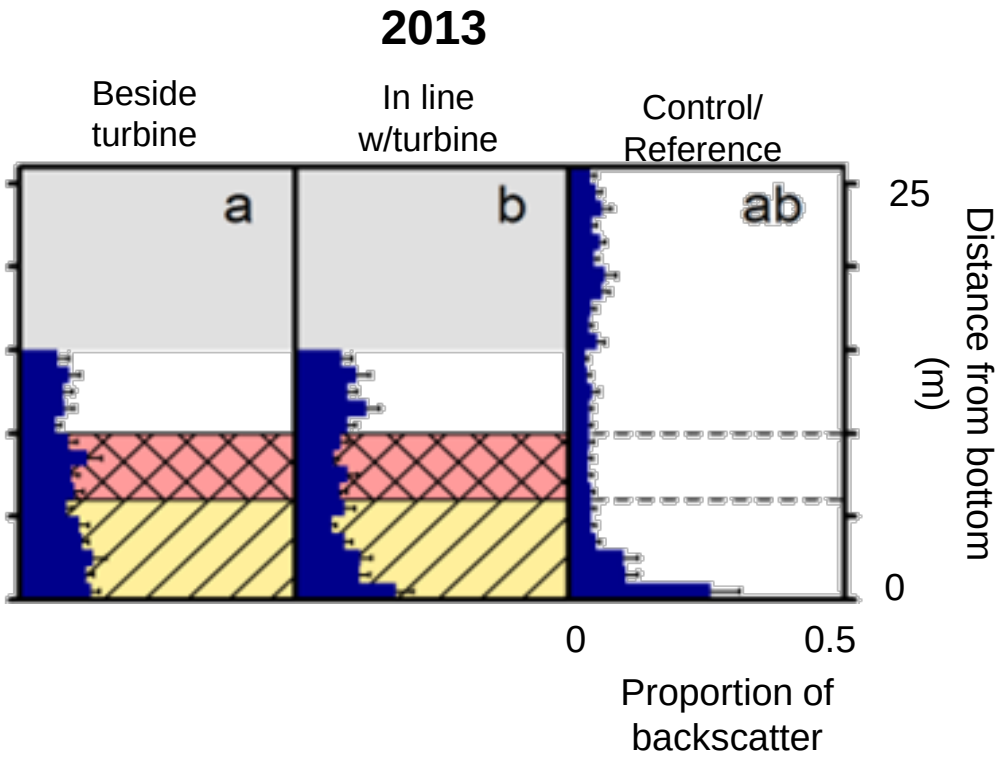
Seasonal patterns of relative abundance



Proportion of fish at different depths



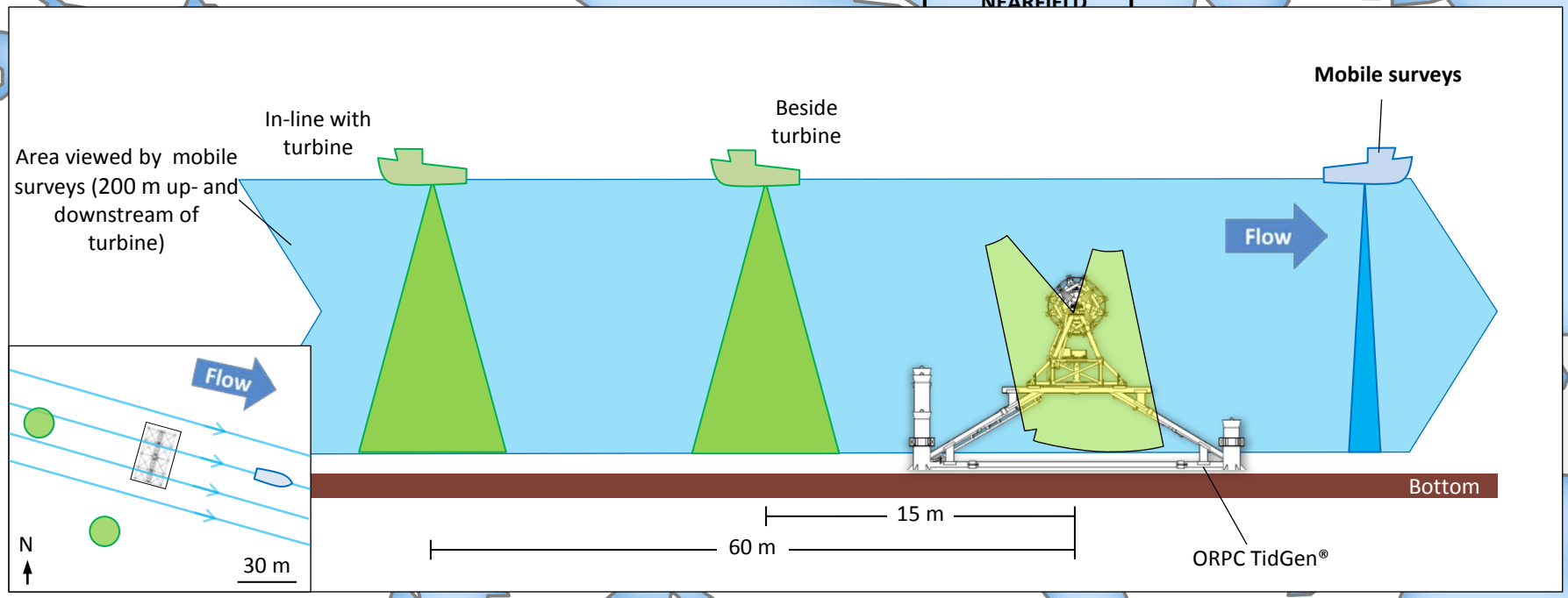




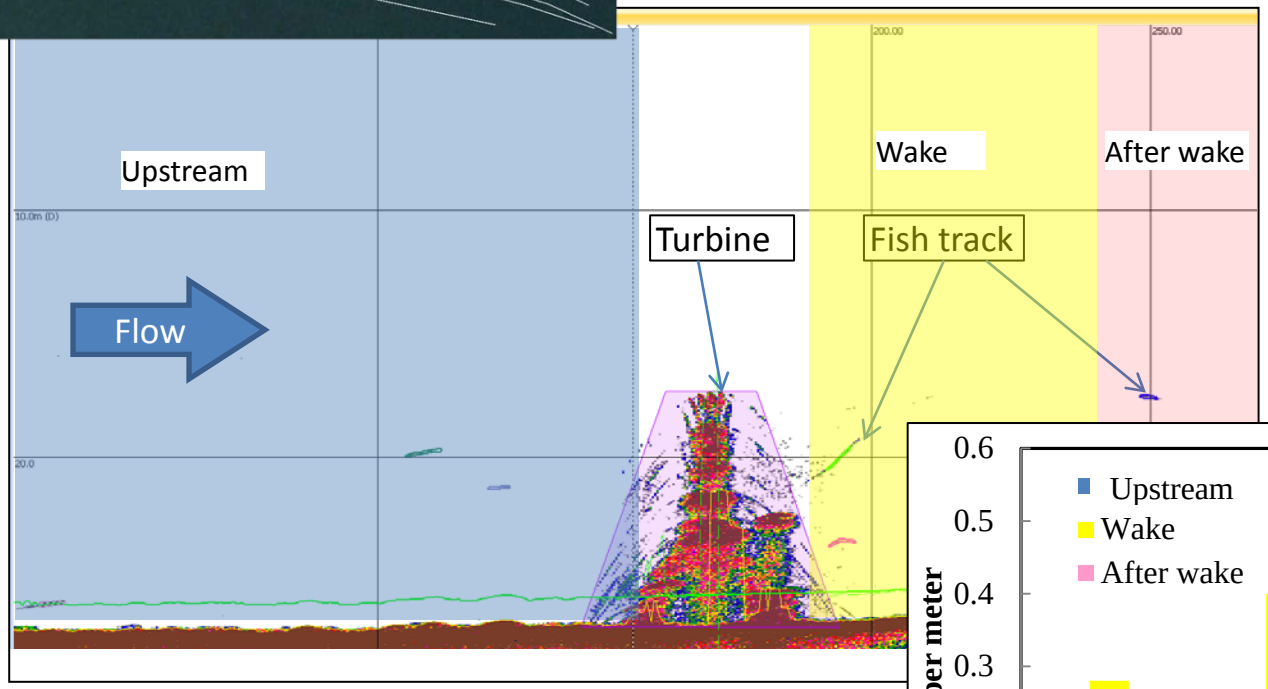
- ***Evidence of avoidance (?)***
  - Beside and in-line
- ***Possible avoidance during construction***
  - Decreased density at project site
- 3 surveys while deployed (not enough!)

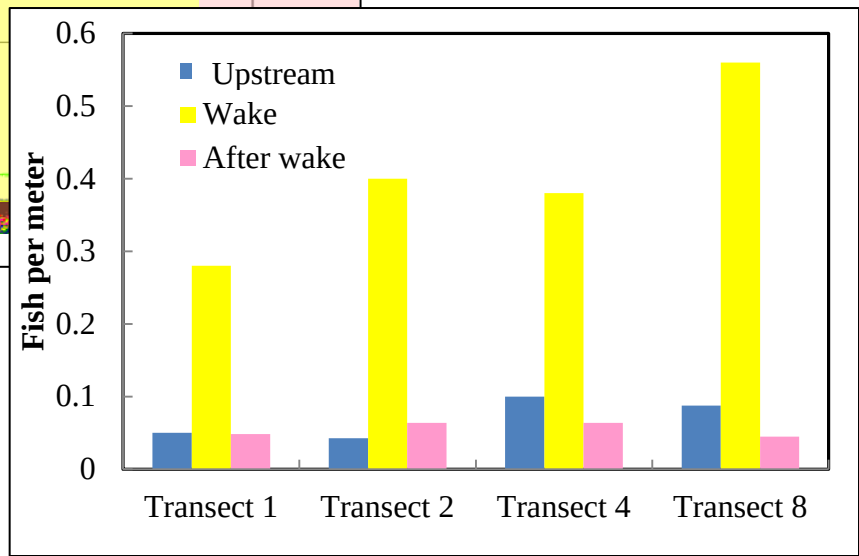
Viehman et al. 2014

3. Midfield: 100s m



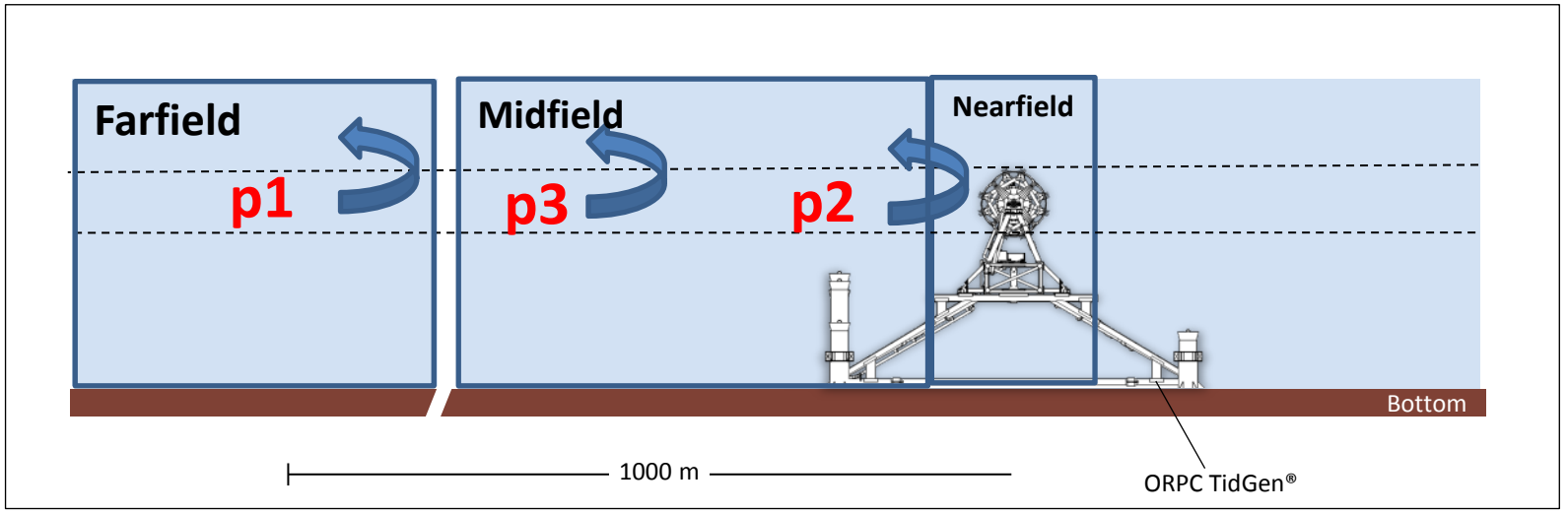
Spatial scale: 200 m





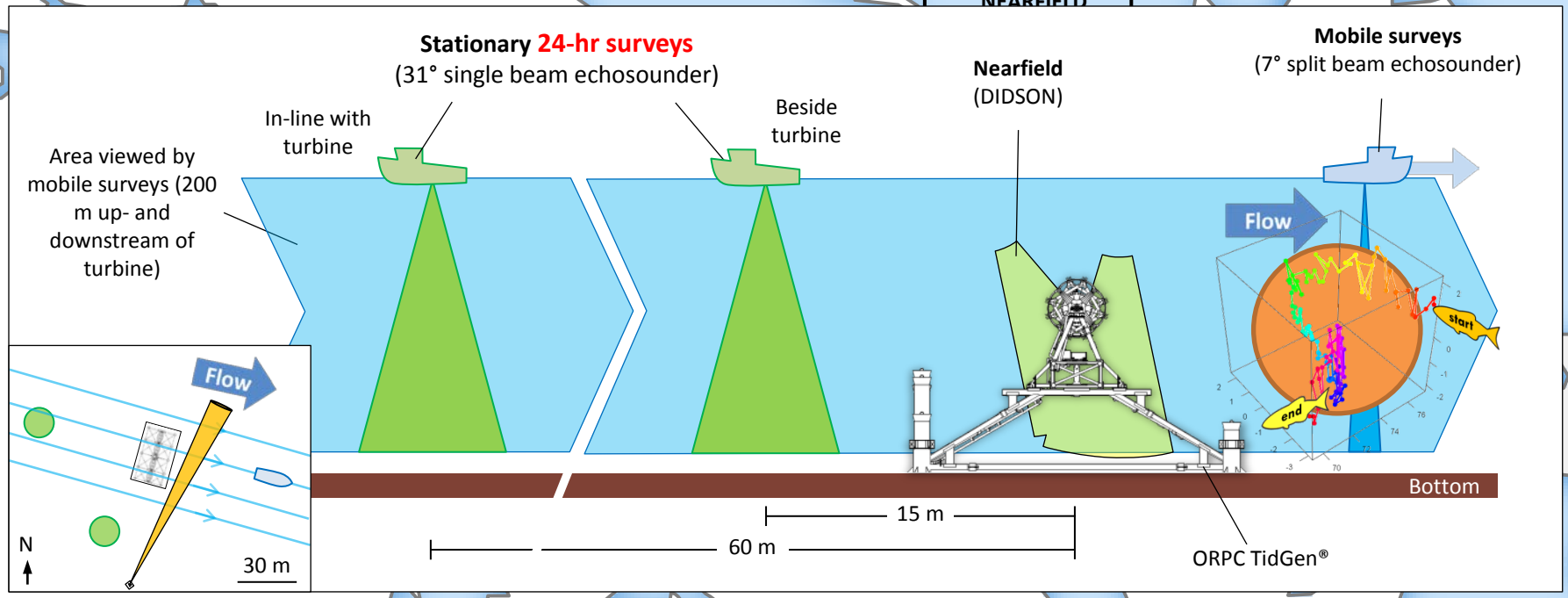
Project integration–Probability of encounter (P)

1. **Near-field** - DIDSON (Viehman and Zydlewski 2014)
   - Within 3.3m, only 1% of fish at turbine level avoided
2. **Far-field** - Abundance & distribution (Viehman et al. 2014)
   - Proportion of fish at turbine depth, without the turbine (p_1, p_2)
   - Proportion of fish at turbine depth, with turbine (p_2)
3. **Mid-field** - Mobile transects
   - Proportion of fish at turbine depth, with turbine (p_3)



p_x = f(time of day, tide, month, year)

Most of the picture…
What about temporal resolution?



Determine sampling periodicity to represent variability over a month

Acknowledgments

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- ORPC

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DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

NSF

MAINE EPSCoR

Award EPS-0904155

Maine Sea Grant Marine Science for Maine People

ORPC OCEAN RENEWABLE POWER COMPANY

Limitations

1. **Near-field** - DIDSON (Viehman and Zydlewski 2014)

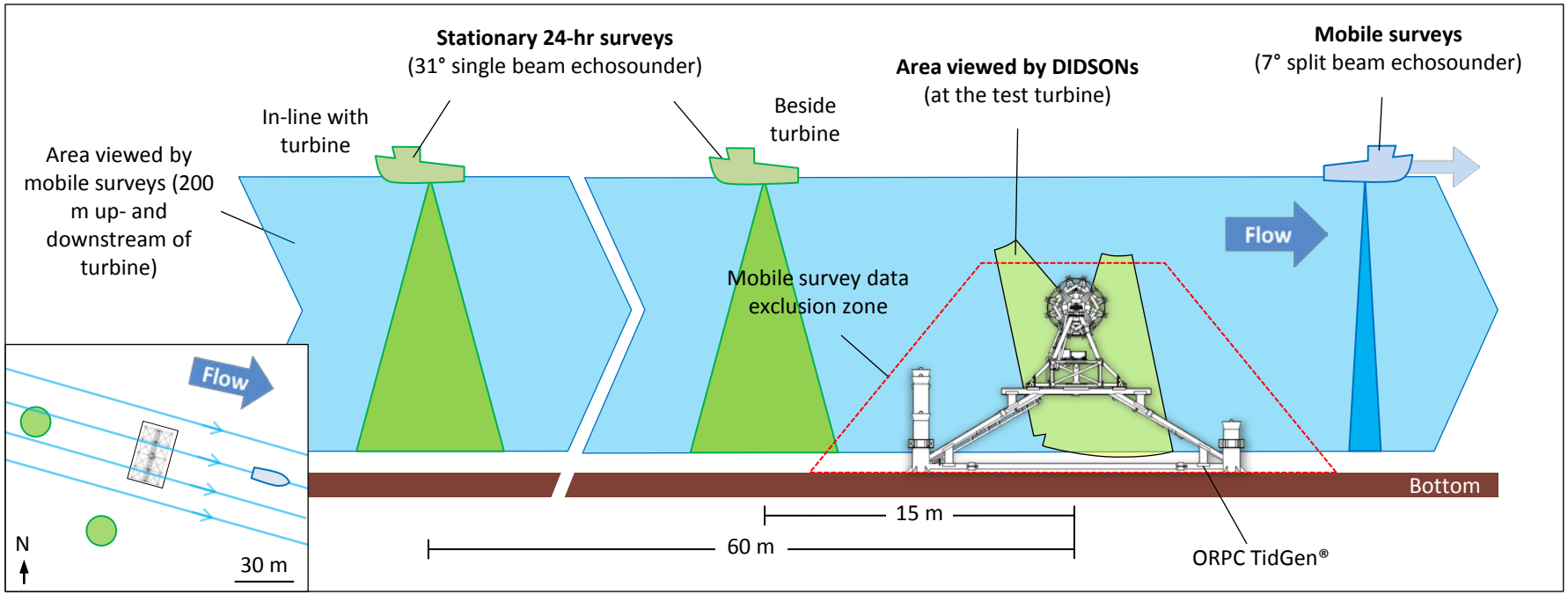
   Limitations: resolution and sampling volume, large amount of data, time required for data processing

2. **Far-field** - Abundance & distribution (Viehman et al. 2014)

   Limitations: 24 h surveys representing seasonal data, sampling close enough to device, inability to discriminate species

3. **Mid-field** - Mobile transects

   Limitations: low long-term temporal resolution, inability to discriminate species


Stationary 24-hr surveys
(31° single beam echosounder)
Area viewed by DIDSONs
(at the test turbine)
Mobile surveys
(7° split beam echosounder)
In-line with turbine
Beside turbine
Area viewed by mobile surveys (200 m up- and downstream of turbine)
Mobile survey data exclusion zone
Flow
Flow
Bottom
15 m
60 m
ORPC TidGen®
N
30 m

Natural variation: in Space and Time

	Subtidal Catch:	Inner	Central	Outer	Intertidal Catch:	Inner	Central	Outer
2011	Winter flounder Atlantic herring Longhorn sculpin Grubby Threespine stickleback White hake	10	67	21	Threespine stickleback Atlantic herring Mummichog Rainbow smelt Blackspotted stickleback Fourspine stickleback	48	23	47
	Average number of fish per bottom and midwater trawl →				Average number of fish per seine net pull →			
2012	Atlantic herring Winter flounder Silver hake Longhorn sculpin Rainbow smelt Grubby	91	82	58	Threespine stickleback Atlantic silverside Blackspotted stickleback Alewife Mummichog Atlantic herring	257	97	50
	Average number of fish per bottom and midwater trawl →				Average number of fish per seine net pull →			
2013	Atlantic herring Winter flounder Haddock Longhorn sculpin White hake Silver hake	336	648	341	Threespine stickleback Alewife Mummichog Atlantic silverside Blackspotted stickleback Tomcod	65	37	32
	Average number of fish per bottom and midwater trawl →				Average number of fish per seine net pull →			