How much is enough?

Review optimization methods to deliver best value from electronic monitoring of commercial fisheries

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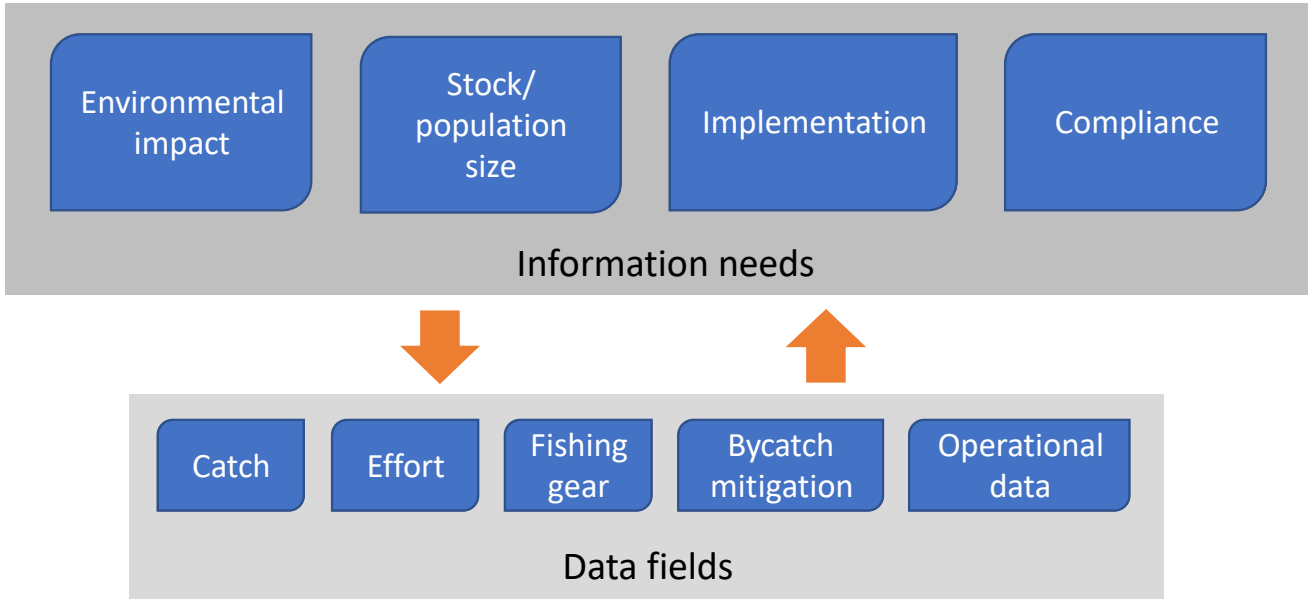
Marine research and data science

What did we do?

- Considered fisheries management data needs that EM can support
  - Review and case studies
- Developed *EMoptim,* a prototype simulation tool, to explore:
  - minimum EM review rates for single monitoring objectives
  - optimised EM review rates for more than one monitoring objective
  - effects of accuracy criteria on review rates
  - review costs
- Looked at other ways to reduce cost of EM review



Catch	Effort	Gear	Bycatch mitigation	Operational data
Catch composition: Target species, fish bycatch, ETP, megafauna • Landed • Discarded • Released • Life status	Start/end of set Start/end of haul Hooks per set Net length per set Searching time	Gear attributes, e.g., hooks/basket, floats, light sticks Use of FADs FAD type Net characteristics	Bycatch mitigation: • Use of mitigation measures • Bycatch handling practices	Location of fishing FAD deployments, maintenance Compliance Misc. (e.g. offal discharge, waste disposal – may be opportunistic)

Case studies

Program	Mgmt body	Method	Main monitoring objectives										
			Target species		Non-target species		Life status	Discards	ETP	Bycatch handling	Mitigation	Compliance	FADs
			Catch	Length	Catch	Length							
WCPO	WCPFC + Pacific EEZs	Longline	✓		✓		✓	✓	✓				
AGAC Pacific Indian Atlantic	IOTC ICCAT WCPFC IATTC	Purse seine							✓	✓	✓	✓	✓
Chile	SERNAPESCA SUBPESCA	Trawl, purse seine, longline	✓		✓			✓	✓	✓	✓	✓	
Atlantic USA	ICCAT	Longline	✓	✓	✓	✓	✓	✓	✓			✓	
Alaska USA	NPFMC	Longline, pots	✓		✓			✓				✓	

EMoptim: A prototype simulation tool

- Operating model:
  - Spatially explicit
  - Customizable: region, fishery, fleet, etc.
- Evaluation model:
  - Explores P(event detection), uncertainty, bias
  - Calculates relative cost
- Optimization framework:
  - 2+ monitoring objectives
  - Provides review rate for best dataset
    - Specified confidence requirements, minimum review cost

- Inputs: fishery data, published information, expert opinion, etc.
- Stratified random sampling structures review effort

McElderry et al. 2010

What does *EMoptim* produce?

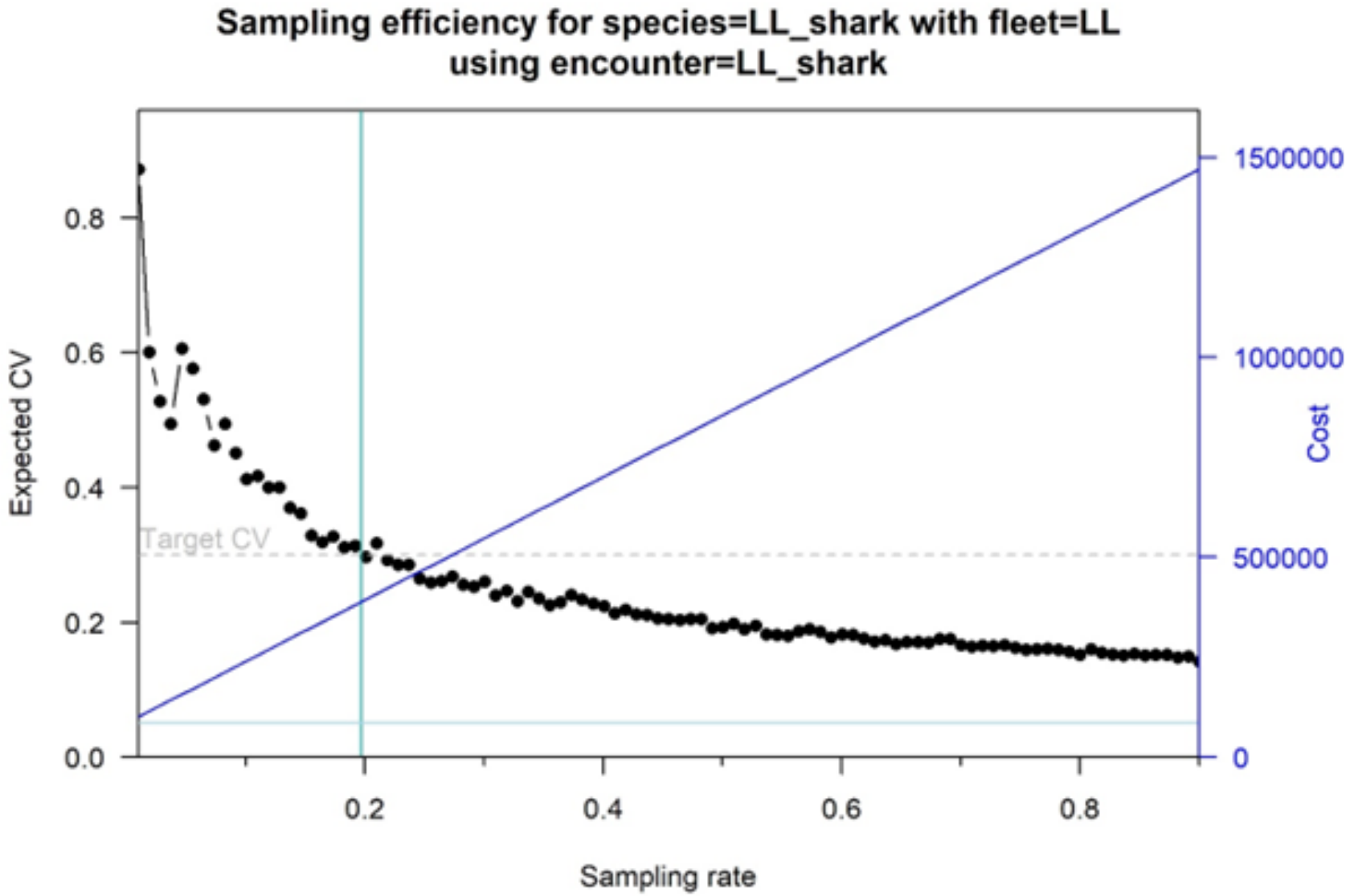


Photo: Jeff Muir

What did we find?

- Western and Central Pacific Ocean (WCPFC Convention Area)
- Longline, purse seine fisheries

Catch element	Example species/group	Statistical characteristics of capture events	Target CV	Longline fishery review %		Purse seine fishery review %	
				No stratification	25°x30° stratification	No stratification	25°x30° stratification
Target species	Yellowfin tuna *Thunnus albacares*	Lognormal p0 = 0	0.3	7.8	~1.0	3.8	~1.0
			0.1	25.8	4.4	10.8	2.1
Other retained species	Porbeagle *Lamna nasus*	Zif Poisson p0 = 0.40 – 0.80	0.3	9.4 - 11.7	3.2 - 4.2		
			0.1	37.9 - 90.1	10.8 - 26.9		
ETP species	Oceanic whitetip shark *Carcharhinus longimanus*	Zif Poisson p0 = 0.75 – 0.90	0.3	11.1 – 47.4	3.8 – 18.3		
		Zif Poisson p0 = 0.75 – 0.90	0.1	12.3 – 73.0	4.8 – 44.6		
		Zif Poisson p0 = 0.99	0.3 0.1			~99.0	~99.0
	Silky shark *C. falciformis*	Zif Poisson p0 = 0.99	0.3			34.2	18.7
			0.1			95.1	32.4
	Black-footed albatross *Phoebastria nigripes*	Zif Poisson p0 = 0.99	0.3	~99.0	91.2		
			0.1	~99.0	95.1		
	Whale shark *Rhincodon typus*	Zif Poisson p0 = 0.99	0.3			~99.0	95.1
			0.1			~99.0	~99.0
ETP species groups	Seabirds	Zif Poisson p0 = 0.95	0.3	~99.0	18.4		
			0.1	~99.0	~99.0		
	Turtles	Zif Poisson p0 = 0.90 – 0.95	0.3	76.4 - ~99.0	9.3 - 95.1	95.1 - ~99.0	8.4 - 87.2
			0.1	95.1 - ~99.0	84.1 - ~99.0	~99.0	80.4 - 91.2
	Marine mammals	Zif Poisson p0 = 0.99	0.3	92.1	87.2	87.2	51.3
			0.1	~99.0	91.2	~99.0	~99.0

*p0=proportion of zero catch sets

Optimization

Species	Target CV	No stratification	Optimized stratification		No stratification	Optimized stratification
		% review	% review	Achieved CV	% review	% review
Longline						
Yellowfin p0 = 0	0.1	25.8	~1.0	0.05	25.8	~2.0
Porbeagle p0 = 0.4	0.3	9.5	~2.0	0.22		
Purse seine						
Yellowfin p0 = 0	0.1	9.7	~1.1	0.09	~99.0	~99.0
Oceanic whitetip shark p0 = 0.99	0.3	~99	~99	1.07		

*p0=proportion of zero catch sets

How much review is enough?

Very broadly generalising review rates at moderate CVs to estimate catch composition:

- Commonly caught species 5-10%
- Less commonly caught species 10-50%
- Rarely caught species 50-85%
- Very rarely caught species 85-100%

- Stratified review can reduce required review rates
  - Less effective for rare, geographically widespread capture events
- More review -> higher confidence
- Statistical characteristics of capture events are critical determinants of review rates
- Best to use set-level data

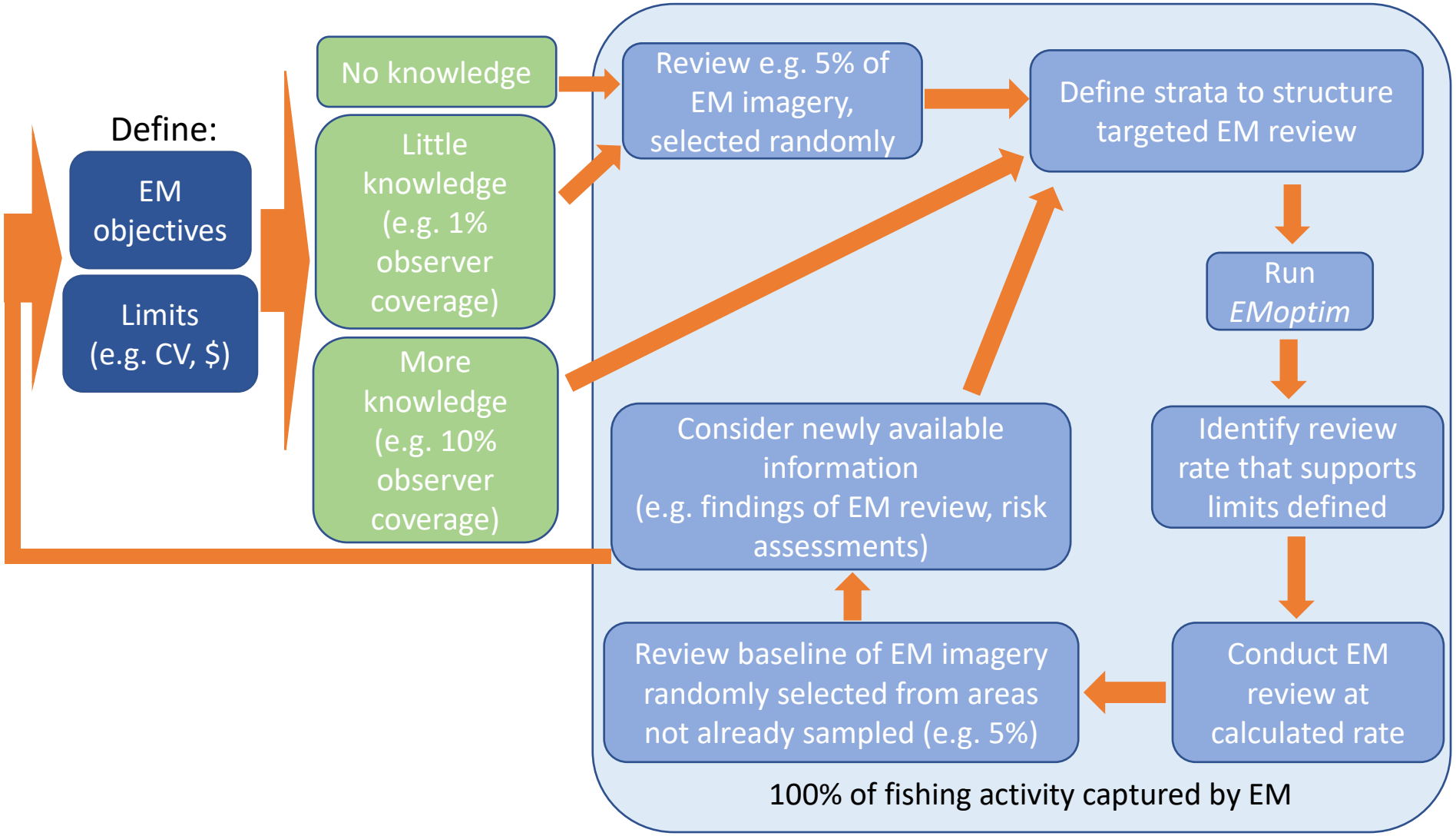
Above: AFMA 2018; Below: Piasante et al. 2012

Can review be optimized?

- The least commonly caught species drive optimized review rates
    - e.g. 1: Choose a review level and understand the accuracy associated with that.
    - e.g. 2: Accept that if the monitoring objectives include commonly and rarely caught species, commonly caught species will be oversampled if a single optimized review rate is used for all taxa.

http://www.seychellesnewsagency.com/articles/5768/Seychelles+takes+the+lead+with+electronic+monitoring+system+on+fishing+vessels

What if the budget for review is limited?



How to secure best value?

- Best practice remains 100% capture of fishing activity
  - Different levels of review are possible for different monitoring objectives (with scaling costs)
  - Closer management of ‘cost per datum’ is possible

- Support review efficiency through all EM program stages
  - Design phase (e.g. clear objectives, data definitions)
  - Onboard data capture (e.g. catch handling, camera views)
  - Review processes (e.g. hotkeys, AI assistance)

- Build on what others have already learned, to progress faster and at lower cost

https://mote.org/research/program/fisheries-ecology-and-enhancement/electronic-monitoring-project

Thank you

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