Design of an eastern tropical Pacific (ETP) dolphin survey

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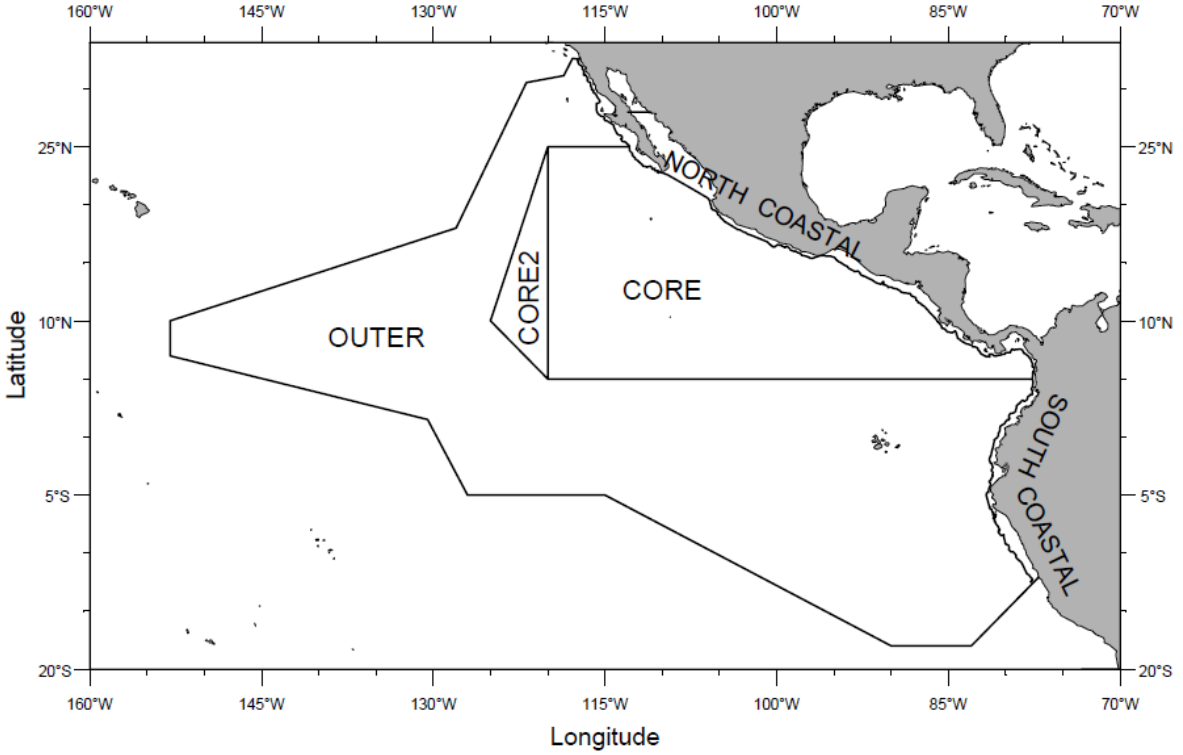
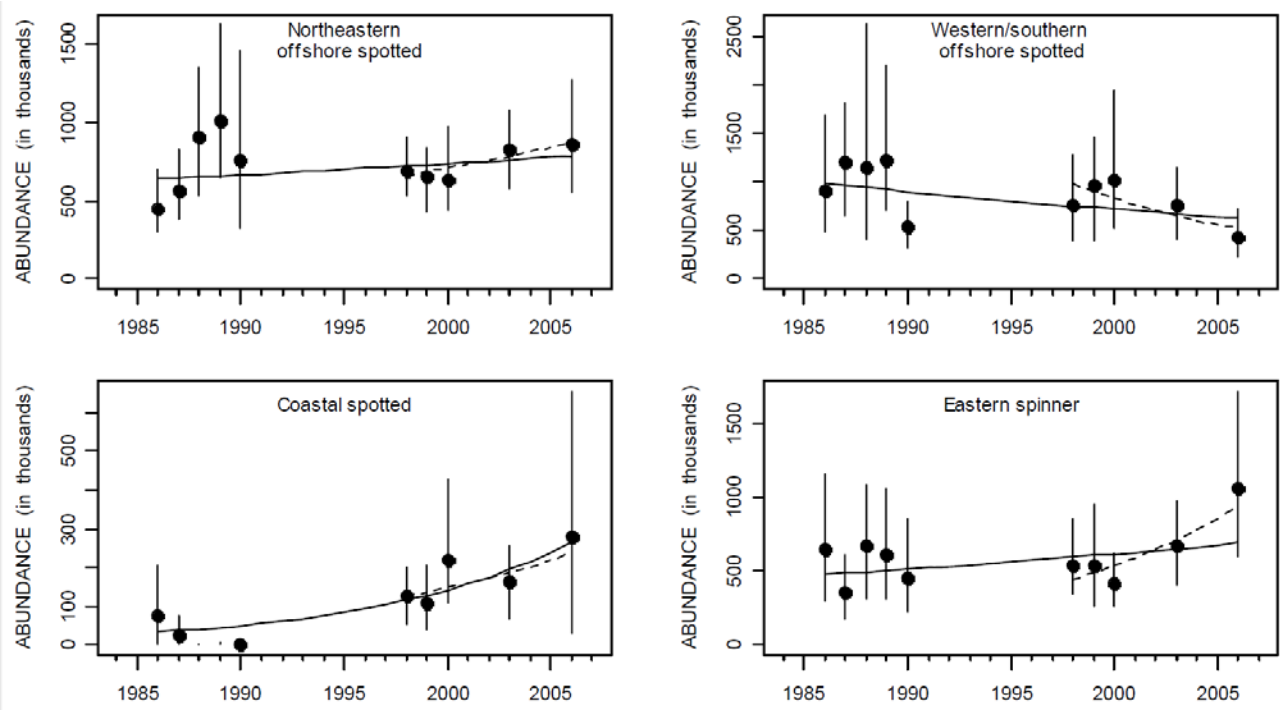
Previous NMFS surveys for ETP dolphin stocks

- Recent survey strata and abundance estimates





Strata for the STAR06 cruise (Gerrodette et al. 2008).

Abundance estimates and 95% confidence intervals (Gerrodette et al. 2008).

Issues for next survey

- Potential use of tuna vessels
  - Comparable to previous surveys?

- Barlow (2015): trackline detection probability g(0) < 1 for Beaufort > 0
  - Biased estimates?

Estimated trackline detection probability g(0) relative to Beaufort 0 (Barlow 2015).

	Number of Sightings used for estimates	Beaufort Sea State						
Species		0	1	2	3	4	5	6
Spotted dolphin (*S. attenuata*)	1,653	1	0.73	0.53	0.39	0.28	0.21	0.15
CV			*0.03*	*0.06*	*0.09*	*0.12*	*0.15*	*0.18*

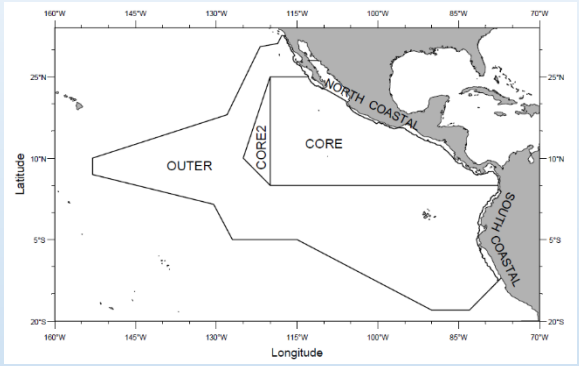
Objectives for next ETP survey

1. Estimate *relative* abundance of priority stocks
    - Provides trend estimates
    - Needs comparability with past surveys
2. Estimate *absolute* abundance of the priority stocks
    - Stock mortality limits
    - Stock status
    - Needs g(0) estimation

Survey area and priority stocks

Survey area:

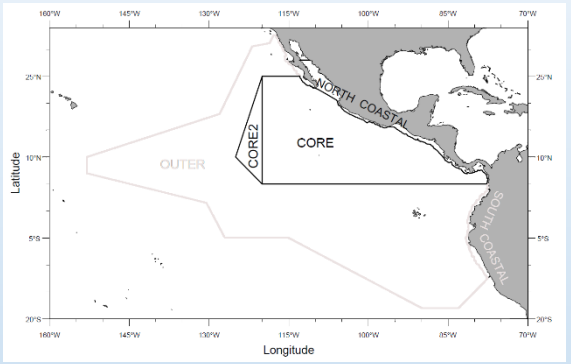
STAR06 area and strata



Survey area:

CORE, CORE2 and N. COASTAL strata

(just the strata where these stocks occur)



A. 10 stocks from Gerrodette et al. (2008)

Species	Scientific Name	Stock
Spotted dolphin	*Stenella attenuata*	northeastern offshore
Spotted dolphin	*S. attenuata*	western/southern offshore
Spotted dolphin	*S. attenuata graffmani*	coastal
Spinner dolphin	*S. longirostris orientalis*	eastern
Spinner dolphin	*S. longirostris*	whitebelly
Striped dolphin	*S. coeruleoalba*	
Rough-toothed dolphin	*Steno bredanensis*	
Short-beaked common dolphin	*Delphinus delphis*	northern, central and southern combined
Bottlenose dolphin	*Tursiops truncatus*	
Risso's dolphin	*Grampus griseus*	

B. Main stocks listed as 'depleted' by the MMPA (www.mmc.gov)

Species	Scientific Name	Stock
Spotted dolphin	*Stenella attenuata*	northeastern offshore
Spinner dolphin	*S. longirostris orientalis*	eastern

Drones for the next ETP survey

Address the g(0) issue and vessel calibration

- Monitor the area in front of the vessel for mark-recapture distance sampling methods (Borchers 2012)

School size calibration

- High resolution imagery

Alternatives to drones

- Fixed-wing aircraft
- Helicopters

Advantages of drones

- Safer
- Less detectable by dolphins and observers
- Potentially higher Beaufort sea states
- Longer hours of operation
- Fixed-wing aircraft is limited to operating near the coast

Flexrotor operated by Precision Aviation www.flyprecision.com

Sequence of events

- Trial survey in July - September 2019
- Main survey in July - December 2020

Trial survey

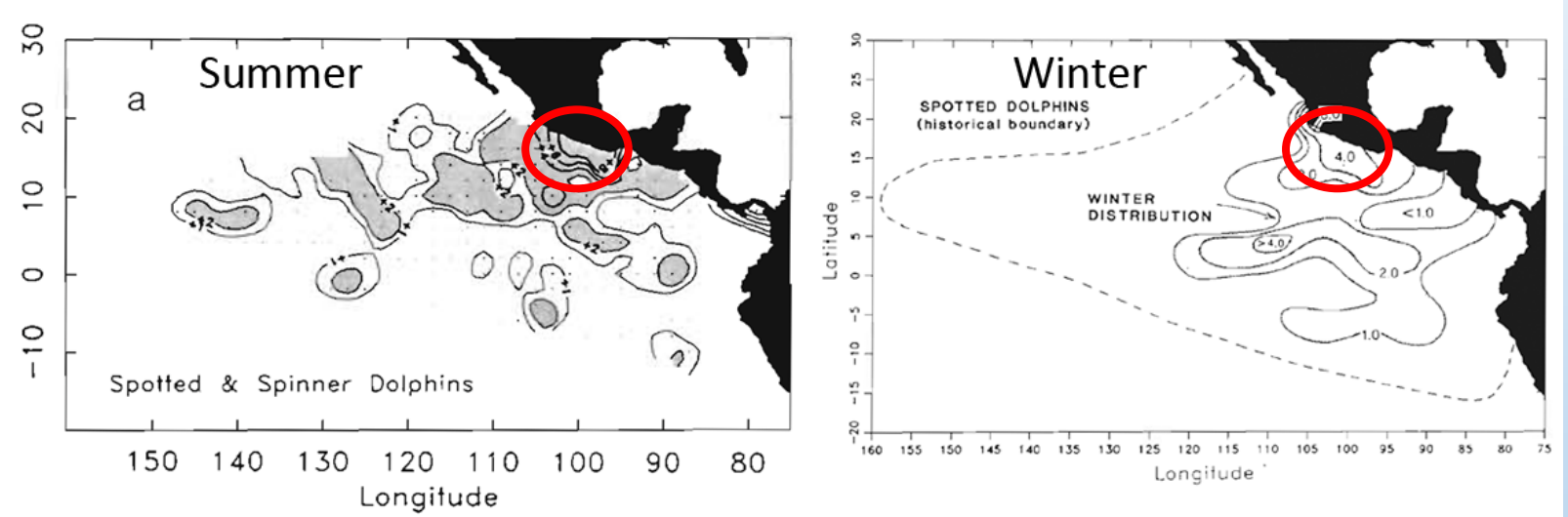
Rationale

- Pilot survey
- Vessel calibration[1]
- Testing utility of drones for
  - Assessing g(0) issue[2]
  - School size calibration

Length[3]

- 30 days if vessel calibration
  - 1 tuna + 1 research vessel
- 14 days if no vessel calibration
  - 1 research vessel

Area: highest expected encounter rates



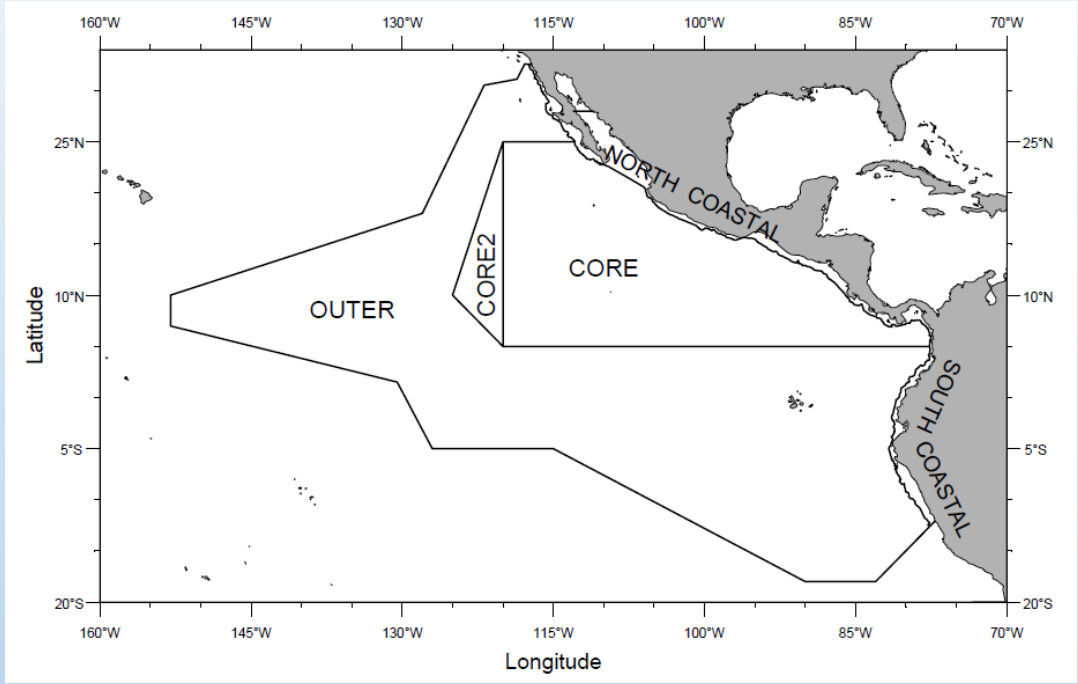
Summer and winter distributions of spotted and spinner dolphins in the ETP (Reilly 1990).

[1] If tuna vessels are involved in main survey
[2] If objective 2 and/or if tuna vessels are involved in main survey
[3] + 5-day transits to and from San Diego

Main survey: Design 1

- Address objectives 1 and 2
  1. Comparable estimates of *relative* abundance
  2. Estimates of *absolute* abundance

- Priority stocks A
  - 10 stocks from Gerrodette et al. (2008)



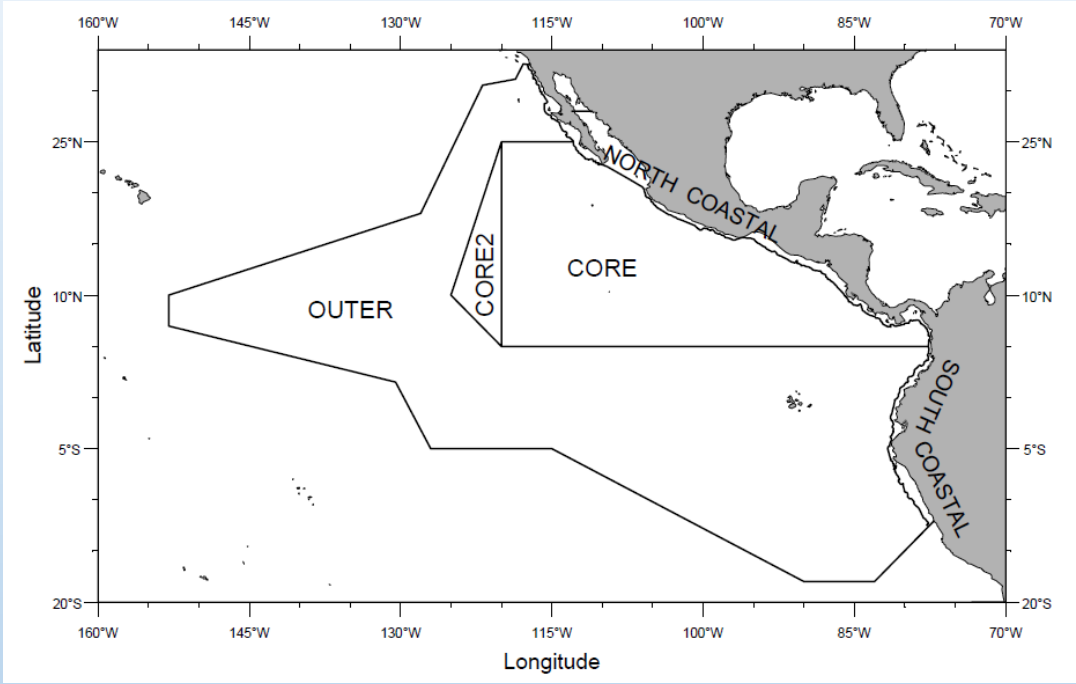
Study area and strata as in STAR06

- Two vessels, 120 sea-days each
- One or two drones
- Same strata with proportional effort allocation as STAR06

Main survey: Design 2

- Address objective 1
  1. Comparable estimates of *relative* abundance
  2. ~~Estimates of *absolute* abundance~~

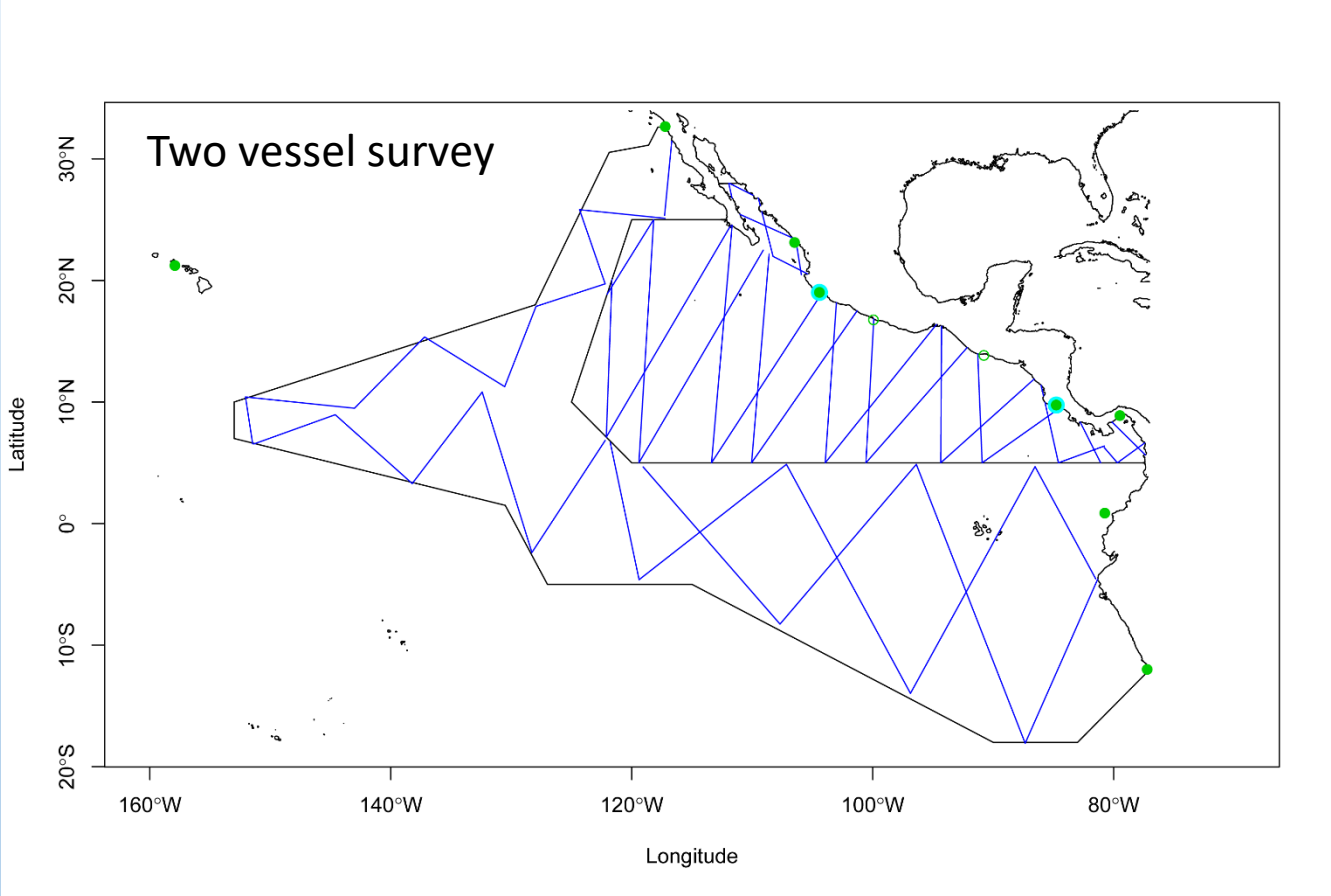
- Priority stocks A
  - 10 stocks from Gerrodette et al. (2008)



Study area and strata as in STAR06

- Two vessels, 120 sea-days each
- One or two drones for school size calibration
- Same strata with proportional effort allocation as STAR06

Example for main survey: Design 1 and Design 2



Realised total transect length is ~61,000km (including night time transits).
Potential ports in green.

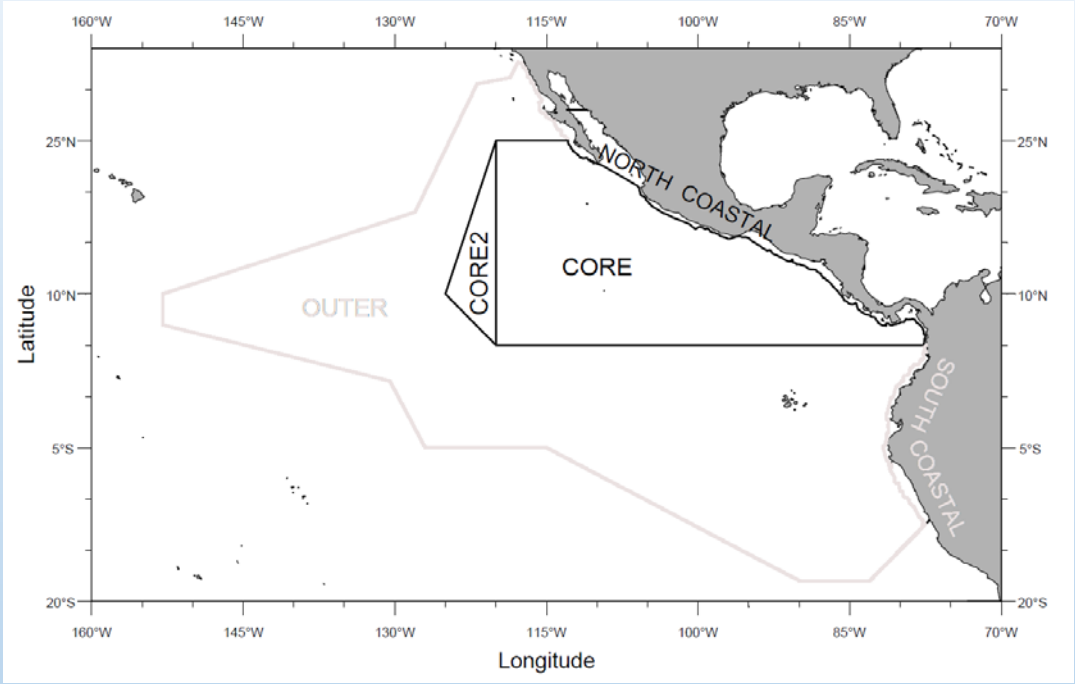
- The ratio effort / area is ~3 × higher in CORE, CORE2 and N. COASTAL compared to OUTER and S. COASTAL.

Main survey: Design 3

- Address objectives 1 and 2
  1. Comparable estimates of *relative* abundance
  2. Estimates of *absolute* abundance

- Priority stocks B
  - 2 main stocks

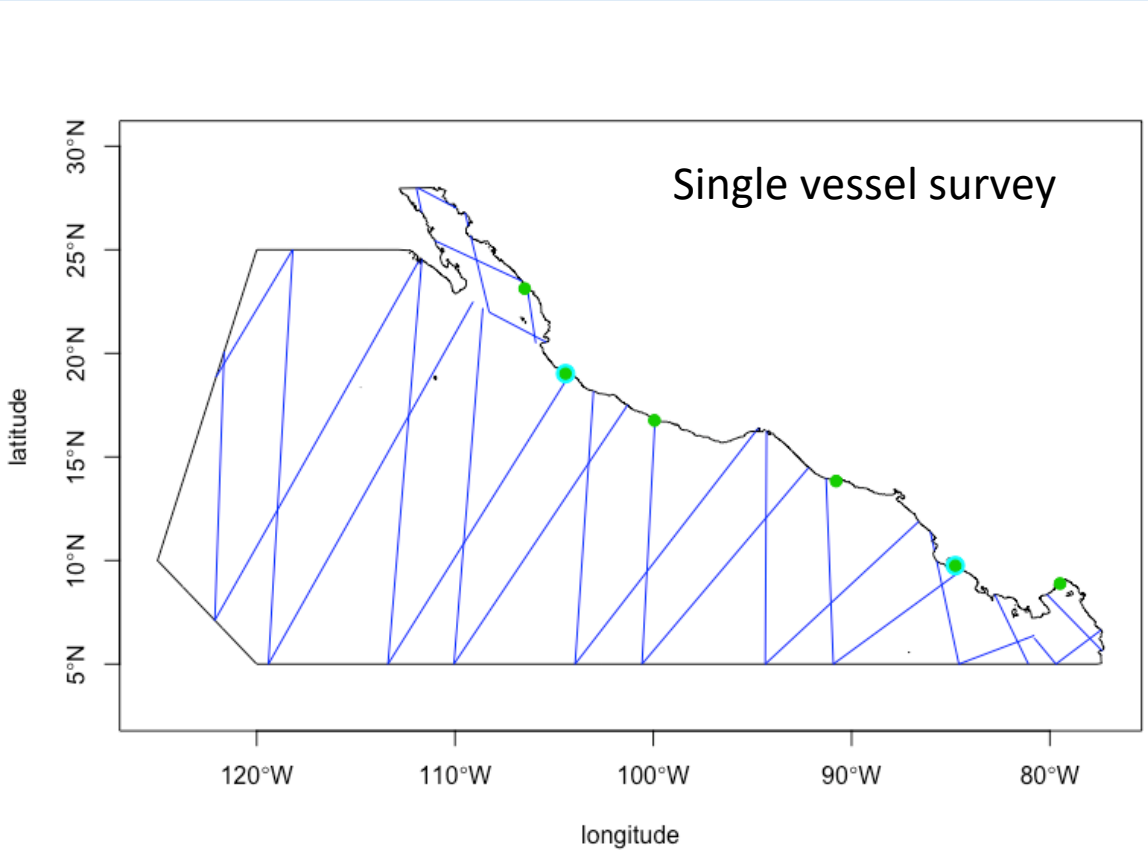
- One or two vessels, 120 sea-days each
- One or two drones
- Only CORE, CORE2 and N. COASTAL strata

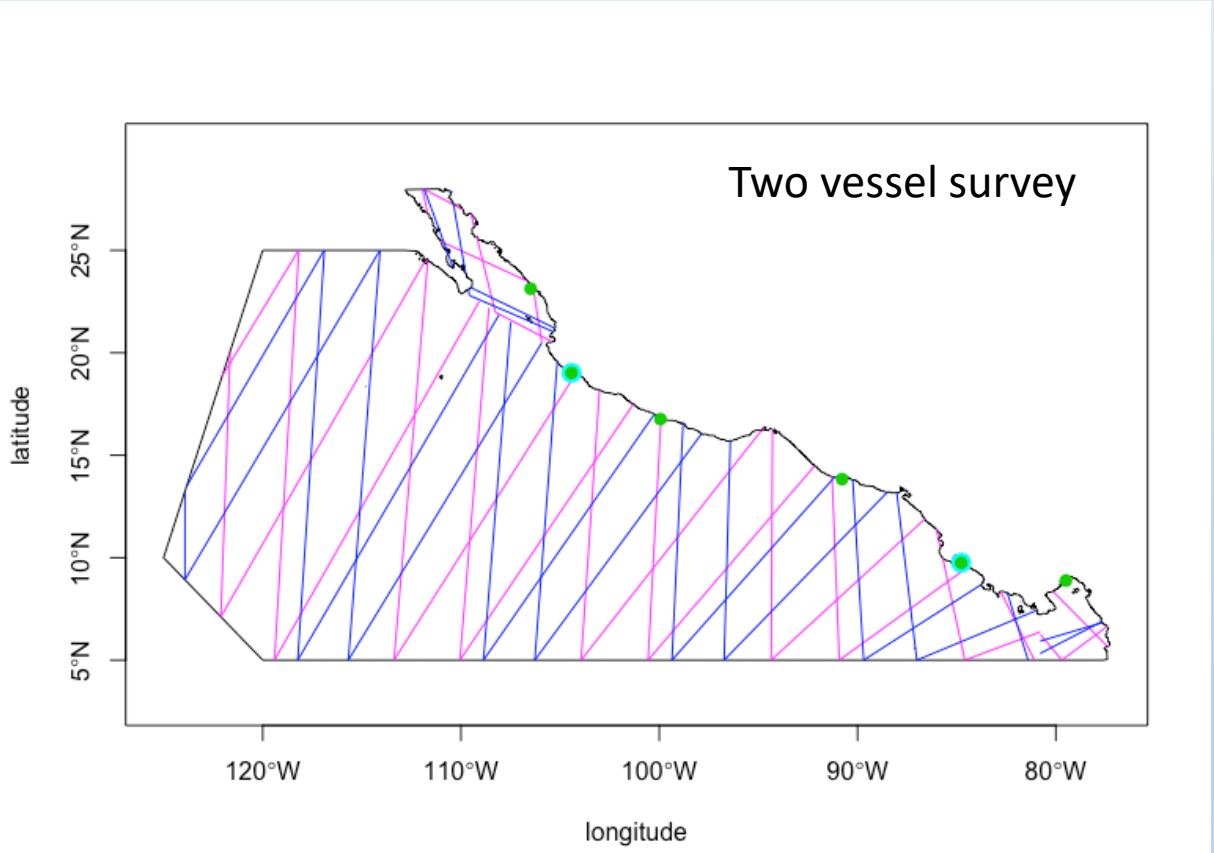


Study area restricted to CORE, CORE2 and N. COASTAL strata.

Examples for main survey: Design 3

Surveys in the CORE, CORE2 & N. COASTAL strata using a 500km equal spaced zigzag design





Realised total transect length, **including night time transits,** is ~31,000km (single vessel) or ~62,000km (two vessels).
Potential ports in green.

Design 1 or Design 2?

Absolute abundance

Estimated g(0) relative to Beaufort 0 (Barlow 2015) and STAR06 effort (Jackson et al. 2008).

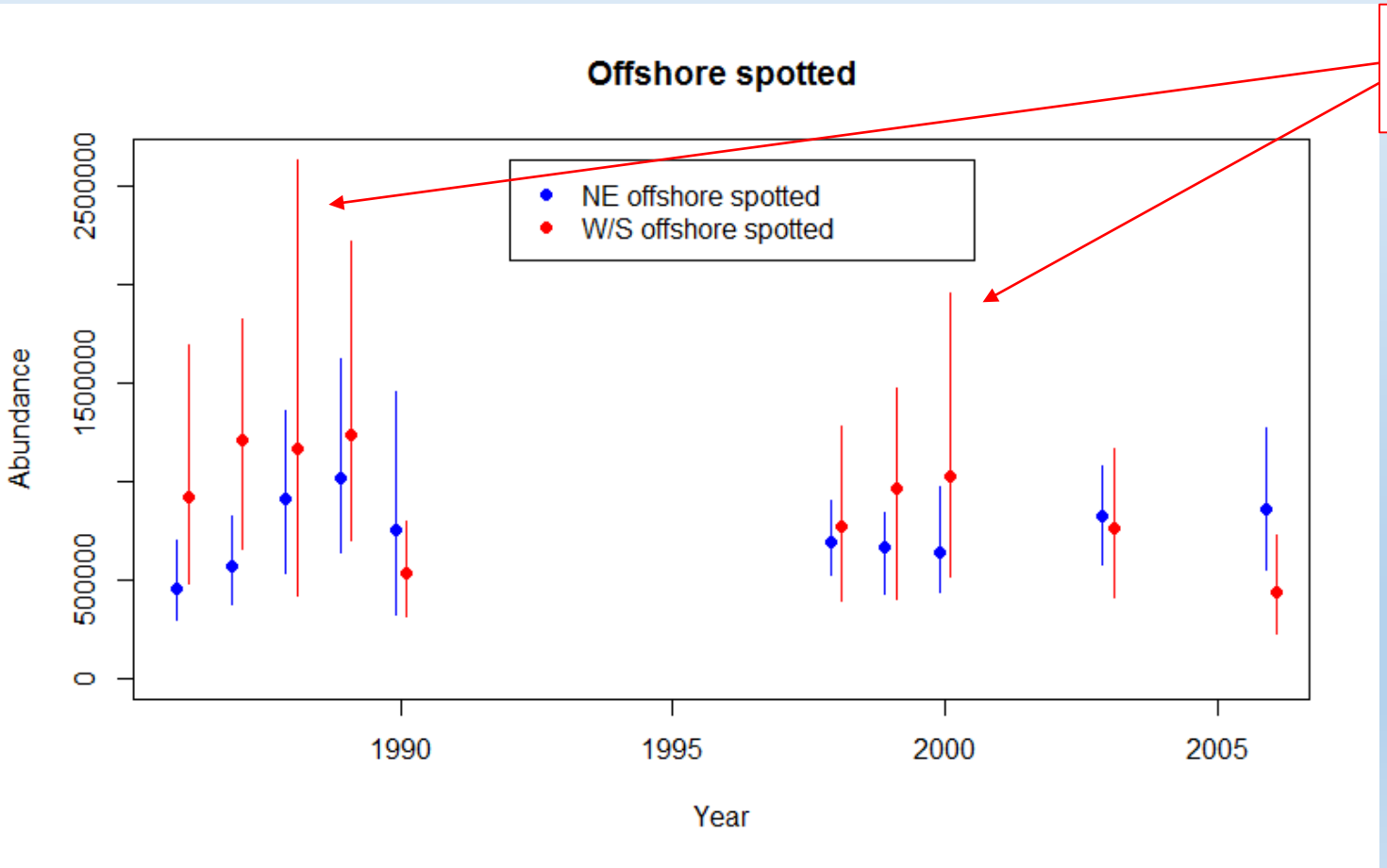
Beaufort	g(0) *S. attenuata*	Effort (km) STAR06
0	1	100.1
1	0.73	375.4
2	0.53	1,729.8
3	0.39	3,212.2
4	0.28	9,375.5
5	0.21	6,952.1
6	0.15	492.1
Weighted average	0.30	
Adjustment factor for STAR06	1/0.30 = 3.32	

- Most effort during sea states 3 – 5 where Barlow's g(0) << 1
- Effect on abundance estimate ~ 3.3 times higher
- We need to verify the g(0) estimates with a field study.

← Approximation!!!

Design 1 or Design 3? *Priority stocks A or B*

- Low effort in OUTER and S. COASTAL strata gives worse precision



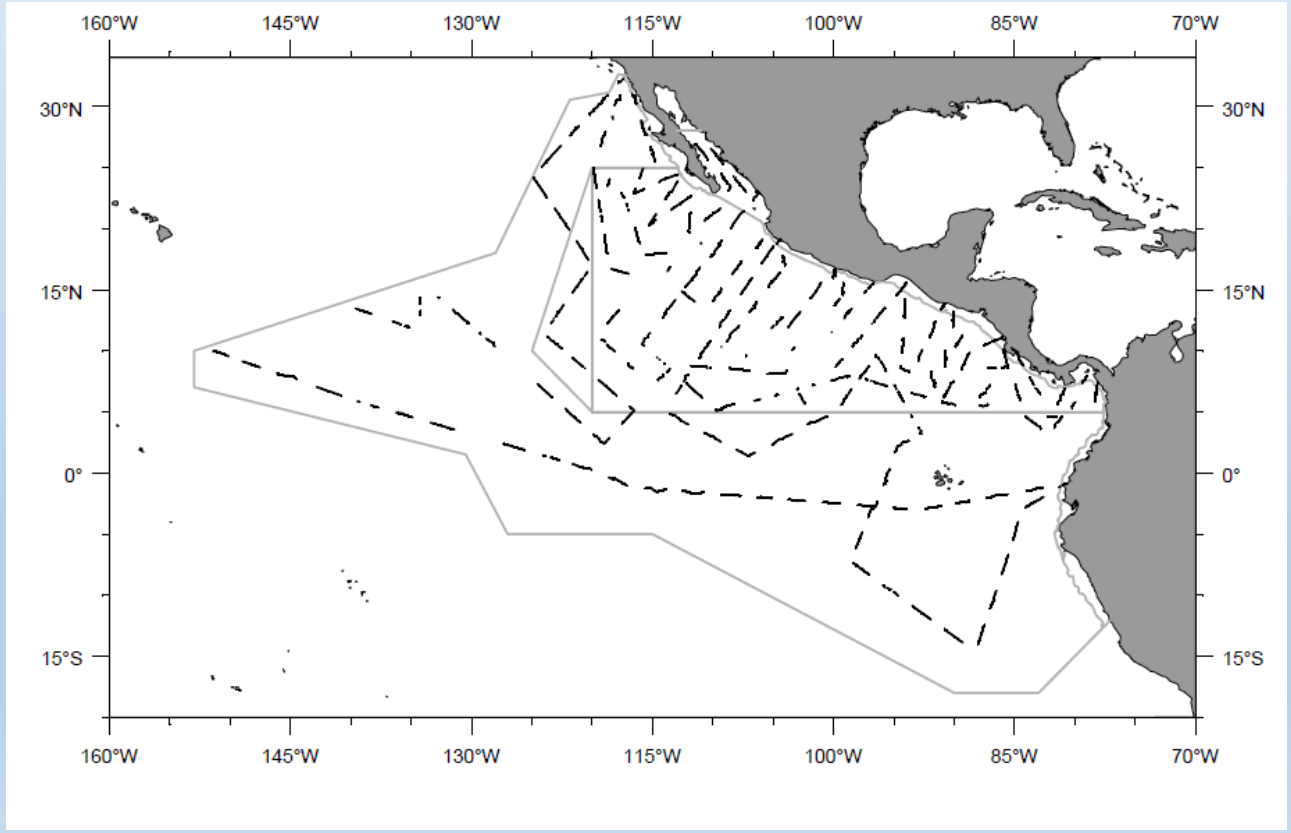
Generally wider confidence intervals for W/S offshore spotted

Abundance estimates and 95% confidence intervals (Gerrodette et al. 2008).

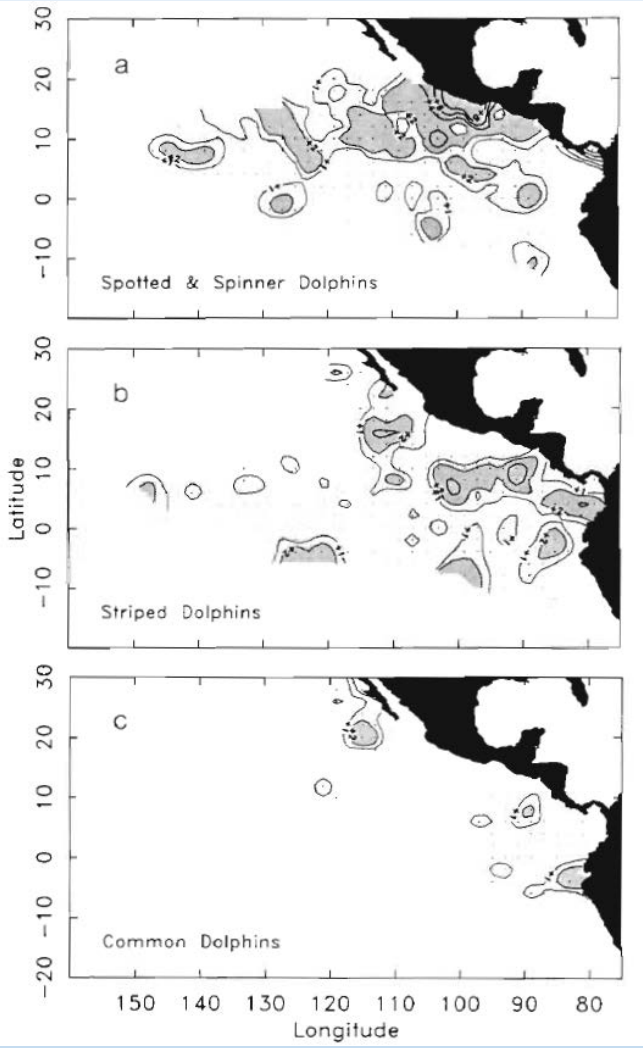
Design 1 or Design 3?

Priority stocks A or B

- Poor coverage in OUTER and S. COASTAL strata may cause bias in abundance estimates



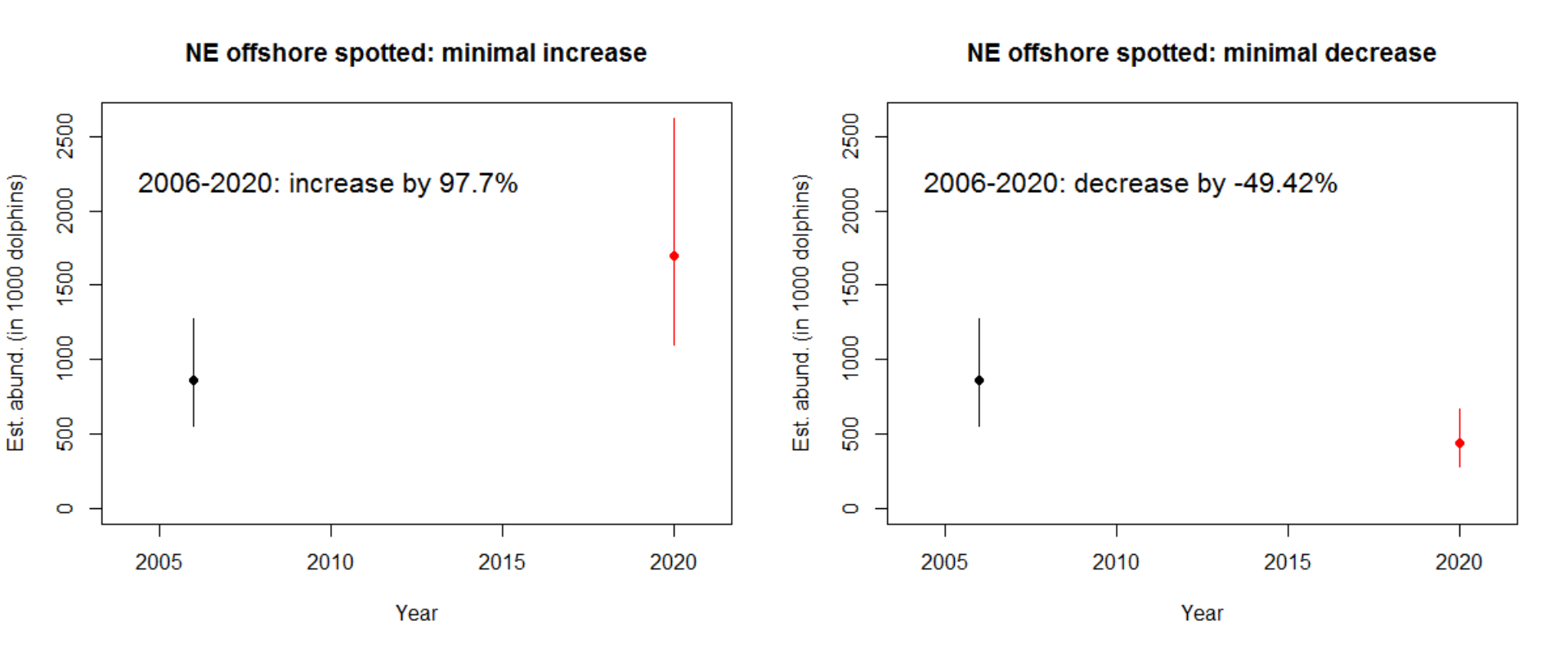
Line-transect effort (broken dark lines) for STAR06 (Gerrodette et al. 2008).



Summer dolphin distributions (Reilly 1990).

Design 1 or Design 3? *Priority stocks A or B*

- Even in CORE stratum only large changes in abundances can be detected

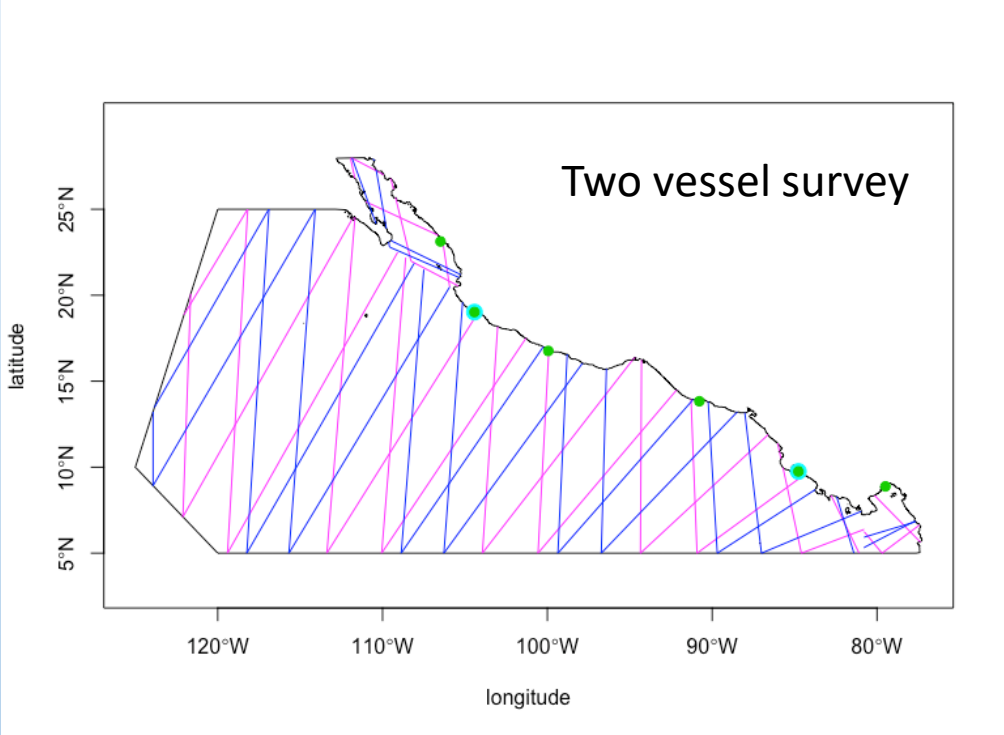


Black: Abundance estimates (Gerrodette et al. 2008).

Red: abundance estimate for a 2020 survey for which a minimal increase or decrease in comparison to 2006 can be detected

Design 1 or Design 3?

Priority stocks A or B



Example for a survey in the CORE, CORE2 and N. COASTAL strata using a 500km equal spaced zigzag design.

Option to improve precision for priority stocks B in a one-off survey:

- More effort in CORE, CORE2 and N. COASTAL strata (Design 3 with 2 vessels)

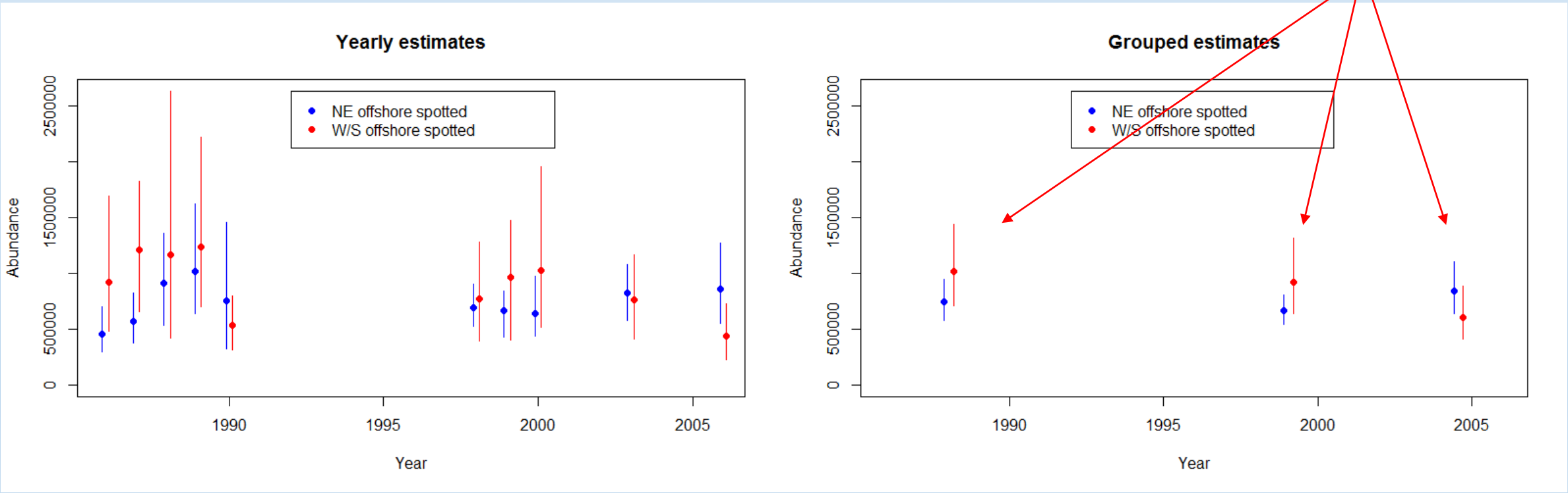
Design 1 or Design 3?

Priority stocks A or B

Options to improve precision for priority stocks A

- Design 1 with **3** vessels: 2 in OUTER stratum
- Design 1 with 2 vessels *and repeat surveys*

Smaller confidence intervals for grouped estimates



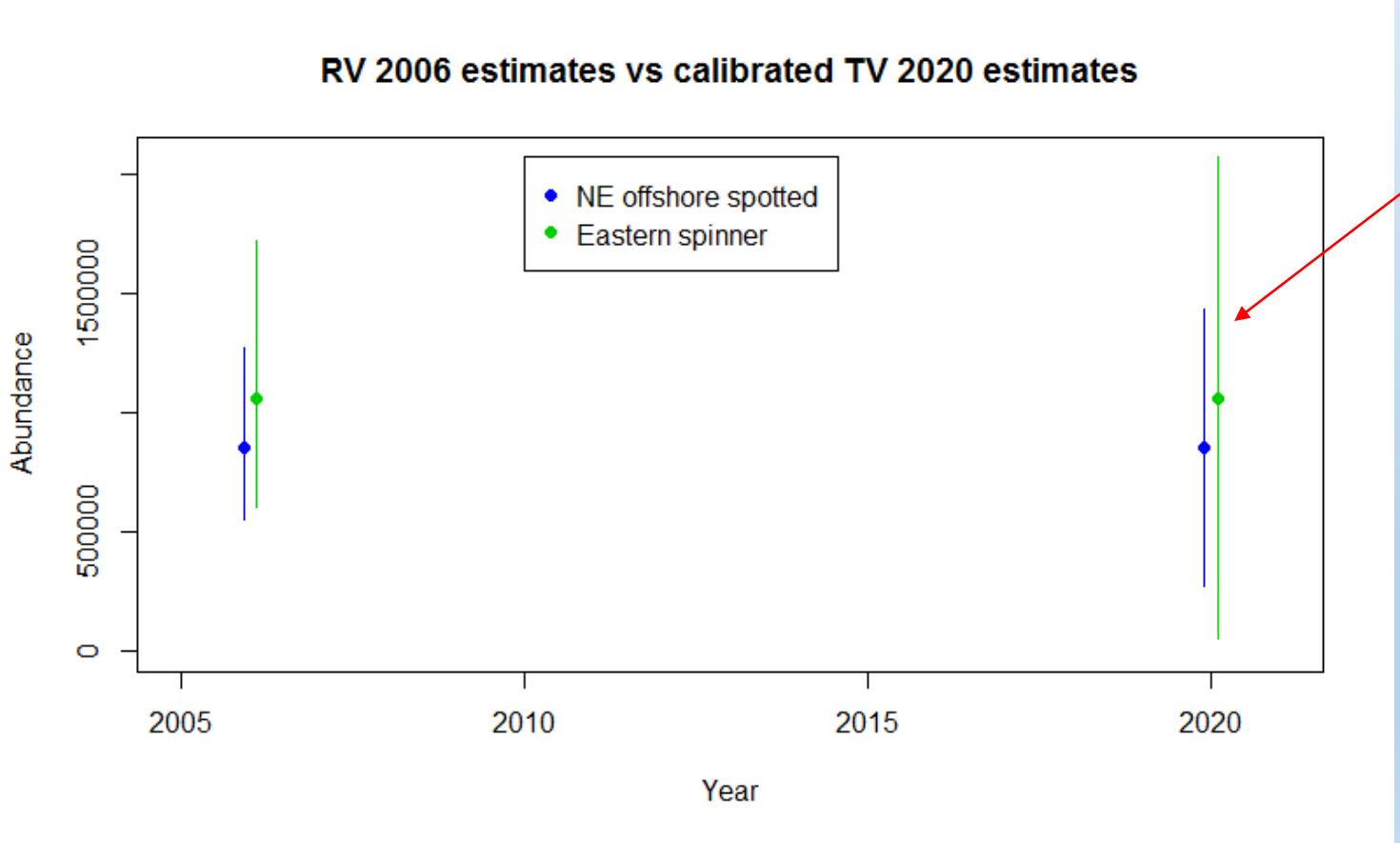
Estimates for individual survey years (Gerrodette et al. 2008)

Estimates for survey blocks 1986-1990, 1998-2000, 2003+2006.

Tuna vessel?

Vessel calibration

- Poorer precision due to uncertainty in the estimated calibration factor



Wider confidence intervals

Abundance estimates from research vessels (RV) from STAR06 and example of calibrated abundance estimates from tuna vessels (TV) for 2020.

Tuna vessel?

Budget

	14-day trial Ocean Starr	30-day trial Ocean Starr + tuna vessel
	(US$ 1000)	(US$ 1000)
Cetacean abundance		
	359.62	731.37
Vessels and associated costs		
	740.57	1,187.34
Foreign observers		
	2.00	8.00
Drones		
	452.96	1,490.24
School size calibration		
	71.83	98.97
Trackline detection probability		
	59.07	98.01
Equipment		
	158.84	320.30
IATTC headquarters-based contractors		
	242.58	242.58
Ship loading	3.00	6.00
Contingency	67.35	150.01
Total	**2,157.82**	**4,332.82**

- Trial survey costs more because of tuna vessel calibration
- Costs of tuna vessel not included

Summary

1. Use of a tuna vessel increases the complexity of the survey (vessel calibration).
2. Both trial and main surveys should be conducted during the historical survey season; however, in consecutive years.
3. The trial survey is essential, even for objective (1) [*relative* abundance], to test all equipment.
4. Use of drones is essential for objective (2) [*absolute* abundance].
5. If the drones are not (or cannot be) used, objective 2 may need to be dropped.
6. Limiting the drones to the trial would be unsatisfactory because:
   - If $g(0) < 1$, it likely varies by location, as animals respond differently in different parts of the ETP
   - Estimation of $g(0)$ from only the trial will add substantial imprecision to an abundance estimate

Summary *Objectives and priority stocks*

7. Design 1 allows Objectives 1 and 2 to be addressed for priority stocks A.
   However:
   - Precision of estimates for the OUTER stratum will be poor, as has been the case in previous surveys.
   - Poor survey coverage in the OUTER stratum, such as that achieved in previous surveys, can lead to bias

8. As an alternative, Design 3 was proposed:
   - If northeastern offshore spotted and eastern spinner dolphin stocks are the only stocks of interest
   - Having two survey vessels operating in the CORE + CORE2 + NORTH COASTAL strata should give better precision
   - However, movement of animals across boundaries may be an issue

9. The level of precision achieved in previous surveys only allows for detection of large changes in abundance.
   - Mitigating this would require an increase in survey effort and/or conducting a sequence of surveys over multiple years

Recommendations

1. Use research vessels only

2. Obtain estimates of absolute abundance

3. Select the survey design based on the choice of priority stocks:
   - If all stocks are a priority, use Design 1
   - If only the northeastern offshore spotted and eastern spinner stocks are a priority, use Design 3 with 2 vessels

4. As a future consideration, we strongly recommend that a series of surveys be planned to improve precision.

References

- Barlow J (2015) Inferring trackline detection probabilities, g(0), for cetaceans from apparent densities in different survey conditions. Marine Mammal Sciences. 31(3):923-943.
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- Reilly SB (1990) Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific. Marine Ecology Progress Series 66:1-11.

Summary of Designs: main survey

	Design 1	Design 2	Design 3 option 1	Design 3 option 2
Vessels (both research)	2	2	1	2
Drones	Yes	Yes	Yes	Yes
Study area	All STAR06 strata	All STAR06 strata	CORE, CORE2, N. COASTAL	CORE, CORE2, N. COASTAL
Priority stocks	10 stocks	10 stocks	The 2 depleted stocks	The 2 depleted stocks
Absolute abundance	Yes	No	Yes	Yes
Coverage in CORE, CORE2, N. COASTAL	Same as previous surveys	Same as previous surveys	Same as previous surveys	Better than previous surveys
Coverage in OUTER and S. COASTAL	Poor Unless increase in effort	Poor Unless increase in effort	Nil	Nil
Expected precision	Same as previous surveys	Same as previous surveys	Same as previous surveys	Better than previous surveys
Possible to detect movement between strata	Small chance	Very small chance	No chance	No chance
Potential for bias	Minor for 2 depleted stocks Considerable for others	Considerable for all 10 stocks	Minor for 2 depleted stocks	Minor for 2 depleted stocks
Total main survey (in US$ 1,000) **No in-kind vessels** **With one in-kind vessel**	 **15,380.76** **10,611.06**	[needs to be assessed]	 **7,079.31** **4,280.18**	 **15,380.75** **10,611.06**