Progress report on development of an index of relative abundance for dolphins from purse-seine observer data

SAC-05-11d

Background

- Under the Antigua Convention the IATTC has the responsibility to monitor the status of all species involved in the purse-seine fishery in the EPO, including dolphins.
- Historically, population dynamics modelling has been the primary means of monitoring stock status for dolphins.
- Populations dynamics models require information on population trends, typically inferred from indices of relative or absolute abundance.

Background

- Historically, EPO dolphin indices have been computed from:
  - Fishery-dependent data (purse-seine observer data)
    - Based on line-transect methodology, 1975-2000
    - Index not computed since 2000 due to concerns about trends in biases caused by changes bearing data quality and changes in fishing behavior
  - Fishery-independent data (NMFS surveys)
    - Conducted intermittently, 1979-2006 (1986-2006 used for recent modelling)
- With hiatus in NMFS surveys, purse-seine observer data are the only source of information with which to try to monitor EPO dolphin population status.
- The present work focuses on the northeastern stock of offshore spotted dolphins because of its historical involvement with the fishery.

Outline of presentation

- Data
  - What is available
  - What was excluded
- Search effort
- Search behavior
- Current state of trends model development
  - modeling considerations
  - preliminary results
  - insights provided by comparison of preliminary results to other indices
- Conclusions
- What’s next

Data

- Observer data for large purse-seiners
  - Vessel activities (e.g., running, searching, drifting, setting)
  - Operational information (e.g., location, date, time)
  - Dolphin sightings (e.g., herd size, species composition)

- Information specific to searching
  - Sighting methods used by vessel crew:
    - Binoculars
    - Helicopter
    - Radar
  - When a sighting is made, the sighting method is recorded.
  - Positions and times during searching are available for the purse-seiner.
  - However, the following are not available:
    - Times of use of each sighting method.
    - Distance covered by the helicopter during search.

Data

- To try to standardize searching practices, data were limited to:
  - Years 1990-2012
  - Trips with at least than 5% sets on dolphins
  - Trips with at least one sighting by each sighting method
  - Days when the vessel was below 90% full capacity
  - Beaufort sea state ≤ 4

- And, finally, any search between a set-sighting and the set itself was excluded.

Data

- Dolphin sightings
  - Dolphin sightings are made by vessel crew
  - Up to three estimates of herd size and species composition
    - Crew initial
    - Observer initial
    - Observer best
  - Distance and bearing to sighting; sighting cue
  - Did not use:
    - sightings with only a crew initial estimate
    - sightings of “other” origin
    - sightings behind the vessel
    - cue information

Computing search effort

INFORME DIARIO
DAILY ACTIVITY RECORD

No. DEL CRUCERO / CRUISE NO. 08 00

PAGINA/PAGE 4

FECHA / DATE	SUCESO / EVENT	¿DE TURNO? / ON EFFORT?	HORA DEL SUCESO / TIME OF EVENT	LATITUDE N/S	LONGITUDE E/W	OBSERVADO POR / OBSERVED BY (NO X 20)	ORIENTACION DESDE BARCO / BEARING FROM SHIP	DISTANCIA / DISTANCE	NO. OBSERVACION / SIGHT NO.	VELOCIDAD / VESSEL SPEED	TEMP DEL AGUA / WATER TEMP	NUBOSIDAD / CLOUD COVER	NO. BEAU	VISIBILIDAD / VISIBILITY	¿AYUDA AEREA? / AERIAL ASSIST?	NO. LANCE / SET NO.	AA / YF	BA / SJ	OTRAS / OTHERS	CODIGO OTRAS / OTHER SP. CODE	BODEGAS / WELLS
3/30	DERIVA		1813																		
3/31	BUSCAR	S	0801	2056 N	11157 W	P3				12.2	64.3	3	3	8							
	PAJAROS		0940			X20	325	05.0	3												
	MAMIF		0945	2049 N	11156 W				3												
	BUSCAR	S	0947			P1				13.5		4	3	7							
	CAZA		1002						3						5						
	LANMAM		1030	2044 N	11153 W				3		64.5				5	4	052				E7
	TERLAN		1302																		
	BUSCAR	N	1303			P1				12.0		6	3	6							
	BUSCAR	S	1308	2043 N	11152 W	P3				12.0		6	4	6							
	MAMIF		1310	2043 N	11152 W	HA	045	05.9	4												
	BUSCAR	S	1311			P1				13.5		6	4	6							
	CAZA		1325						4						5						
	LANMAM		1357	2040 N	11150 W				4		64.3				5	5	0				
	TERLAN		1645																		

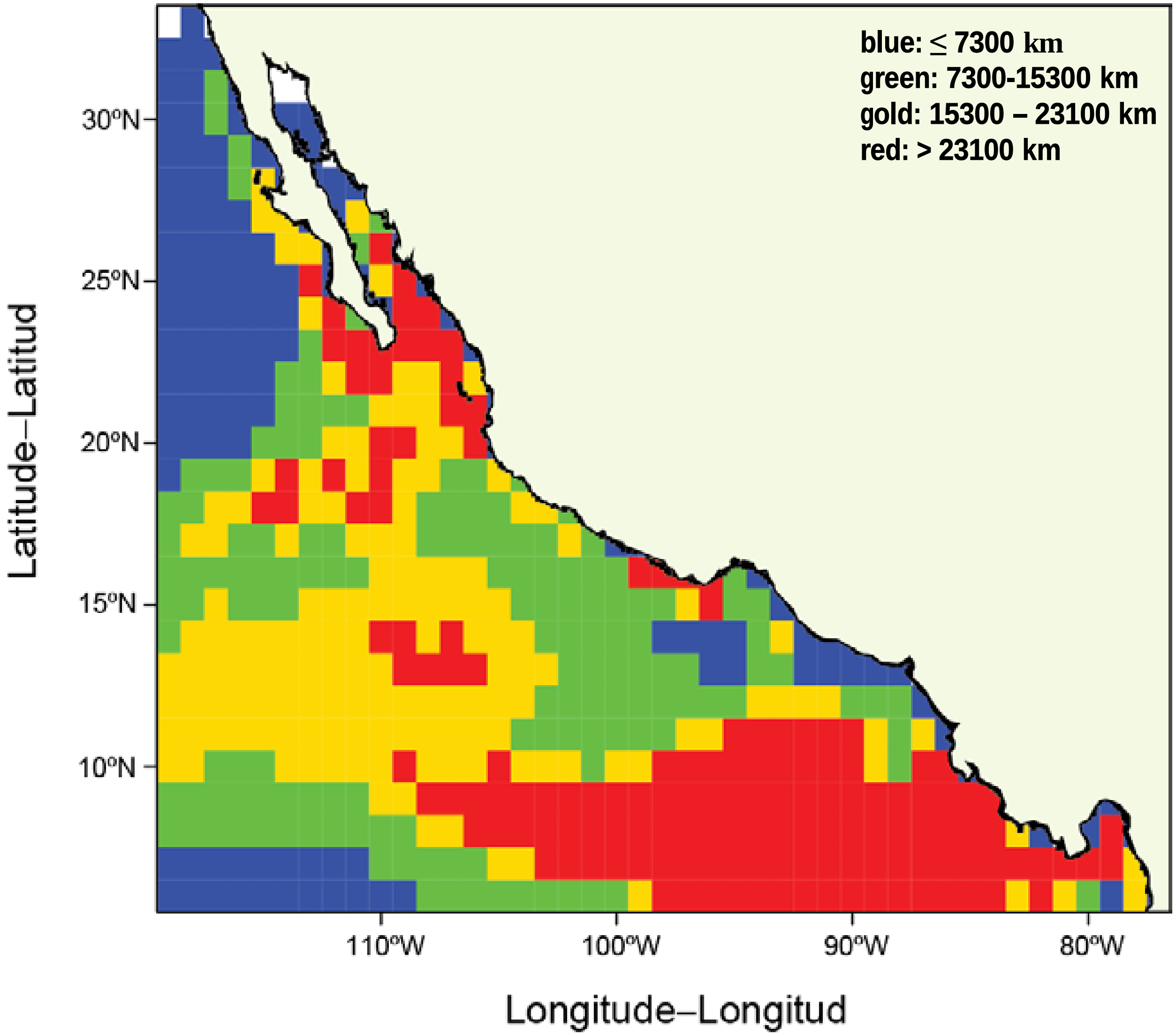
DATOS REVISADOS
DATA REVIEWED

CIAT ATUN-DELFIN
IATTC TUNA DOLPHIN
I.D./DAR 8/89

Computing search effort

- Distance travelled while searching is based on movement of the purse-seiner.
- Search effort was computed for each pair of daily events (“a segment”) when:
  - Observer on duty
  - Vessel crew actively searching
  - At least two positions available for the day
- Segment start and end positions were estimated when not available.
- Search effort, in km, was computed from start/end positions using the great circle distance formula.
- Search effort was summed across segments for each trip-day-1°area.

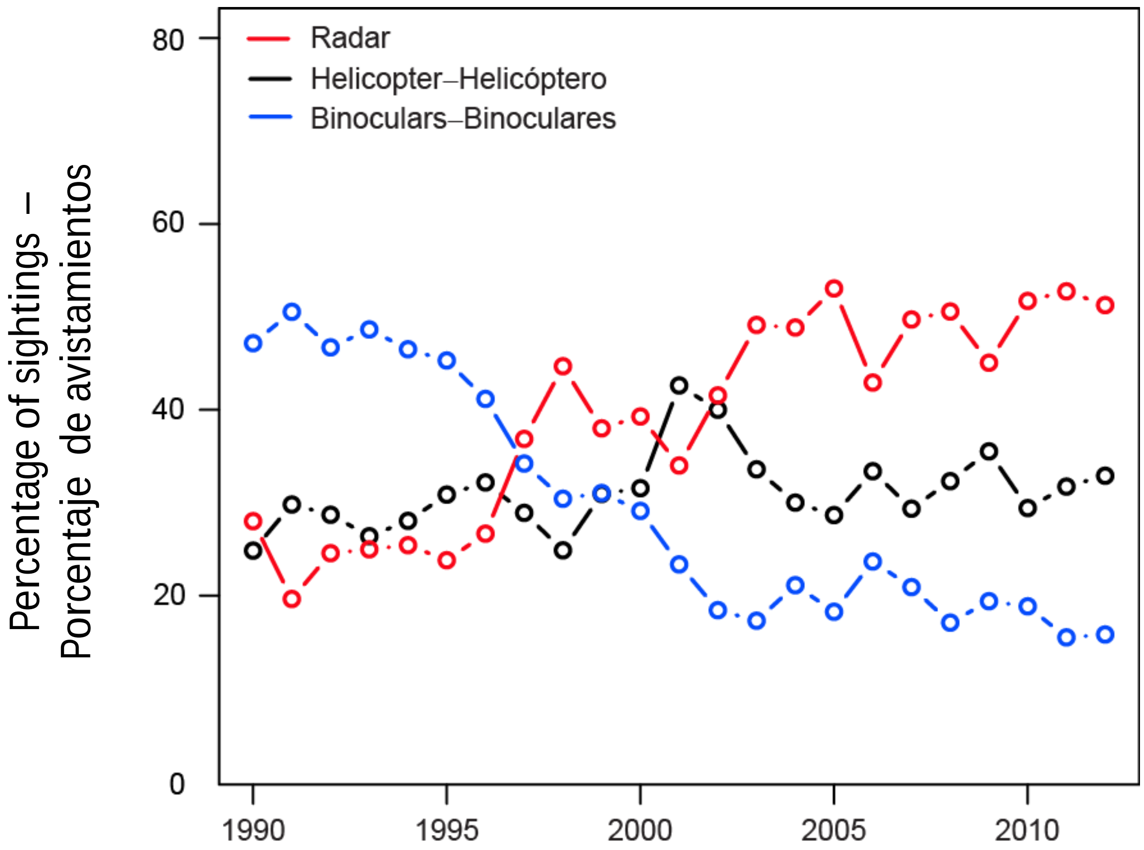
Search effort, 1990-2012



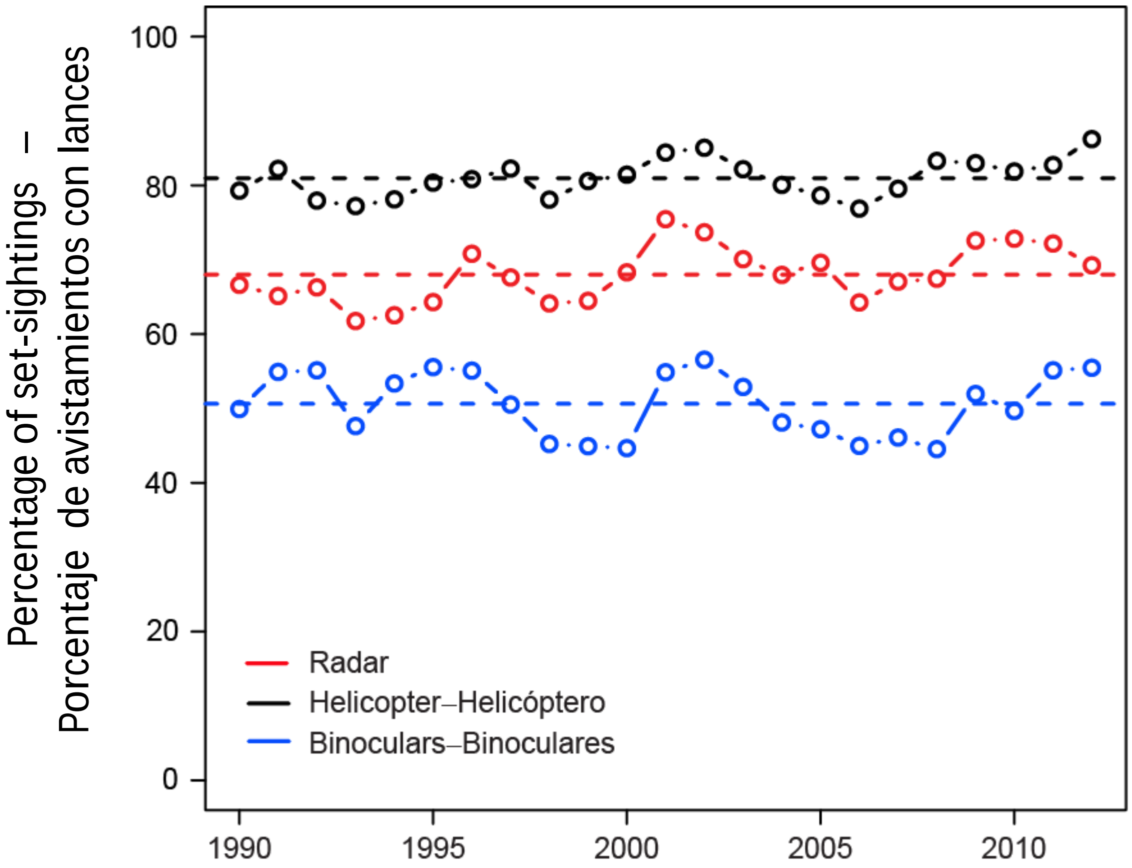
Search behavior

- Even with data restrictions, heterogeneity in search behavior remains:
    - There are changes over the years in the relative use of the three sighting methods.
    - There are changes within a trip in search tactics, depending on whether a vessel is in transit between fishing areas or at a fishing area.

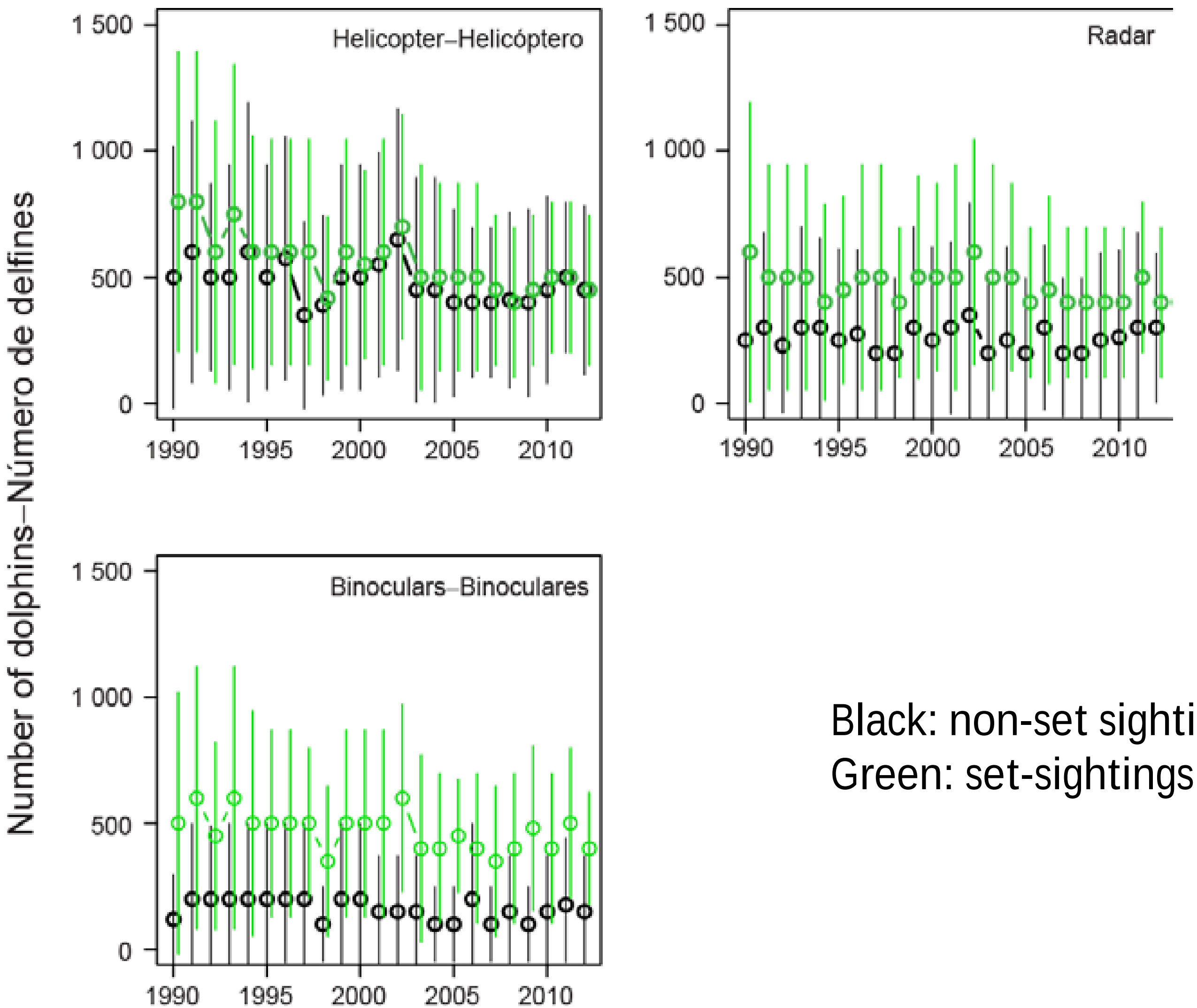
Search behavior: changes across years



Search behavior: changes across years

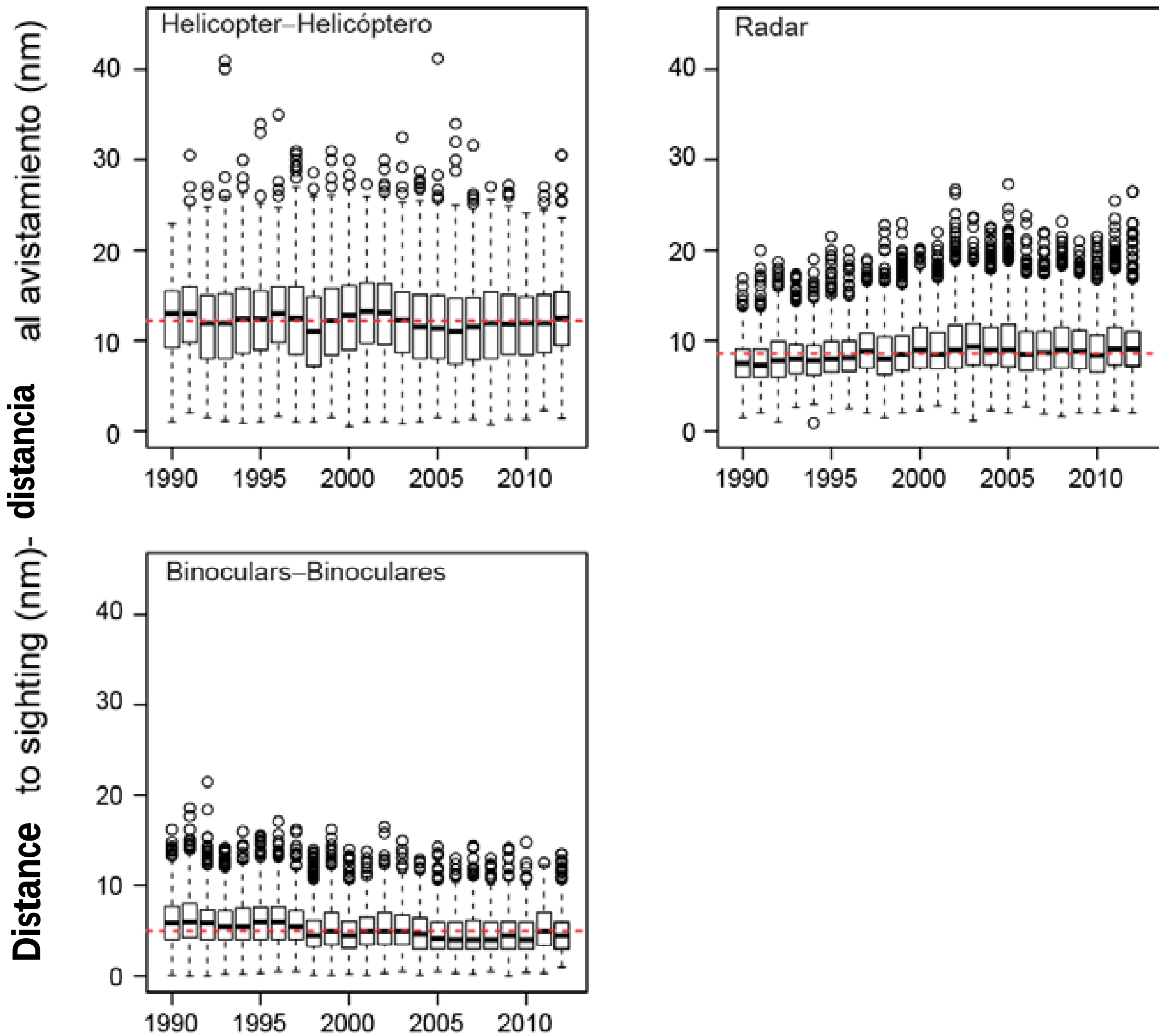


Search behavior: herd size

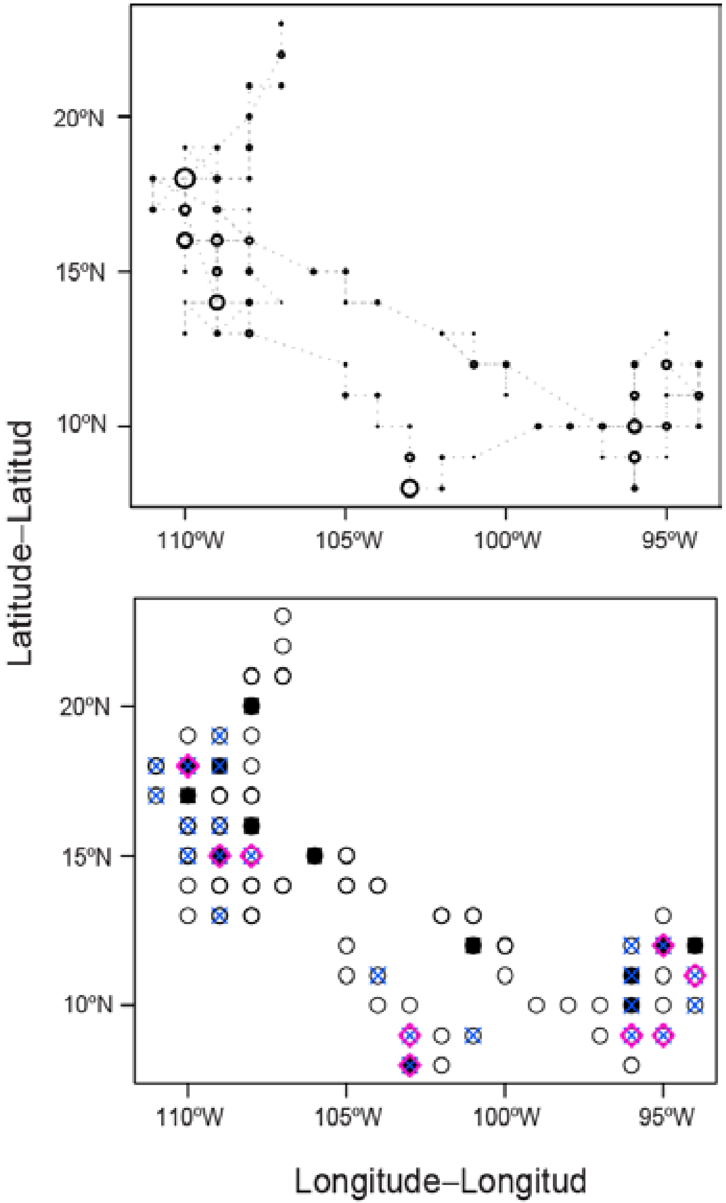


Black: non-set sightings
Green: set-sightings

Search behavior: sighting distance



Search behavior: changes within a trip



Top panel

black open circles: 1° areas with effort, size proportional to amount

gray dotted line: connects 1° areas through time.

Bottom panel

solid black circles: non-set sightings

blue crosses: set-sightings

pink diamonds: helicopter sightings.

Trends model development

- Would like an index of relative abundance of dolphins, taking into consideration effects of variables such as area, season, and herd-specific covariates.
- In addition, would like to account for changes in search behavior across years and within trips in the standardization model.
- A model of this form is still work in progress…
- Thus, as a start, we used a simplified approach to estimating standardized trends, and compared those results to other indices in order to obtain insights for further model development.

Trends model

- Take a CPUE-type approach to trend estimation, instead of using line-transect methods.
- Data unit of analysis: trip-day-1°area
- Most trip-day-1°areas had no sightings (69%), 22% had one sighting, and few had more than three sightings.
- Dolphin herd size was right-skewed, with considerable rounding, particularly to multiples of 50 and 100 animals.

Trends model

- Delta-lognormal generalized additive models (GAMs)
  - Logistic regression model for presence/absence of dolphins in a trip-day-1°area
  - Lognormal model for the total number of dolphins per km in a trip-day-1°area
- Because we are modeling aggregated sightings, to try to control for heterogeneity in sightings characteristics, fit to two subsets of the data:
  - use only sightings that led to sets (herd size more similar across sighting methods);
  - use all sightings within 20nm of the vessel (attempt to include all sightings that would have been seen by binoculars if not reported by radar or helicopter).

Trends model

- In addition to fitting to two different subsets of the data, two different approaches to trend estimation were taken:
  - Data-weighted index
    - Fit full GAM:

$$\text{logit}(p) = \text{overall constant} + \text{year effect} + f_1(\text{month}) + f_2(1°\text{latitude}, 1°\text{longitude}) + f_3(\text{km})$$

$$\log(\text{CPUE}^+) = \text{overall constant} + \text{year effect} + f_4(\text{month}) + f_5(1°\text{ latitude}, 1°\text{ longitude})$$

    - Compute index from predicted overall CPUE by partial dependence
  - Area-weighted (equal-weighted) index
    - For each year, fit reduced GAM:

$$\text{logit}(p) = \text{overall constant} + f_2(1°\text{latitude}, 1°\text{longitude}) + f_3(\text{km})$$

$$\log(\text{CPUE}^+) = \text{overall constant} + f_5(1°\text{latitude}, 1°\text{longitude})$$

    - Predict overall CPUE on fixed 1° area grid
    - Sum predicted values over 1° area grid cells

Trends model: sample size by year

Year	Number of trip-day-1° areas with effort	Number of set-sightings	Number of sightings within 20 nm
1990	5,412	1,124	1,482
1991	5,736	1,347	1,726
1992	7,849	2,279	2,904
1993	7,551	1,590	2,198
1994	7,516	1,755	2,327
1995	7,343	2,107	2,680
1996	9,187	2,510	3,106
1997	9,882	2,364	2,987
1998	13,277	2,796	3,653
1999	12,765	2,456	3,155
2000	9,886	1,771	2,219
2001	7,057	1,678	1,947
2002	9,275	3,098	3,527
2003	10,620	2,679	3,229
2004	11,963	2,481	3,085
2005	14,018	2,985	3,707
2006	10,886	1,778	2,354
2007	9,699	1,748	2,219
2008	8,770	1,595	1,964
2009	8,348	1,836	2,208
2010	9,965	1,950	2,385
2011	8,192	1,740	2,076
2012	7,211	1,437	1,741
Total	212,408	47,104	58,879

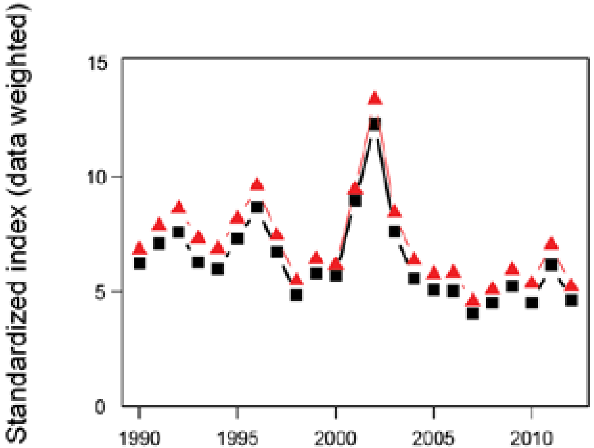
Preliminary results

- Model fit
    - All model terms were highly significant.
    - However, simple diagnostics suggest improvements need to be considered.

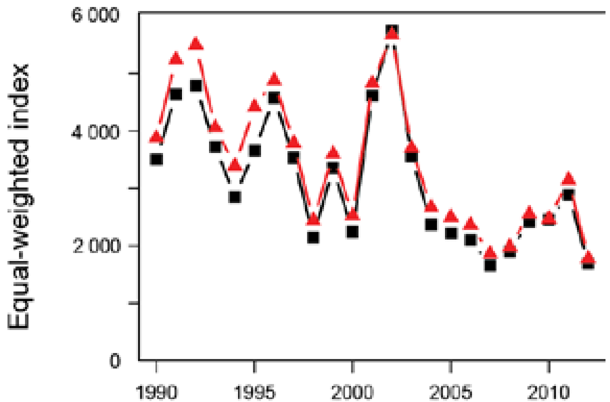
- Trends
    - All standardized indices show an overall decreasing trend over the 1990-2012 period.
    - There was little difference between the trends computed from set-sightings and those computed from all sightings within 20nm.
    - The trends based on equal weighting (area weighting) showed a greater decrease compared to those based on data-weighting.

Preliminary results: trends

Data-weighted trends

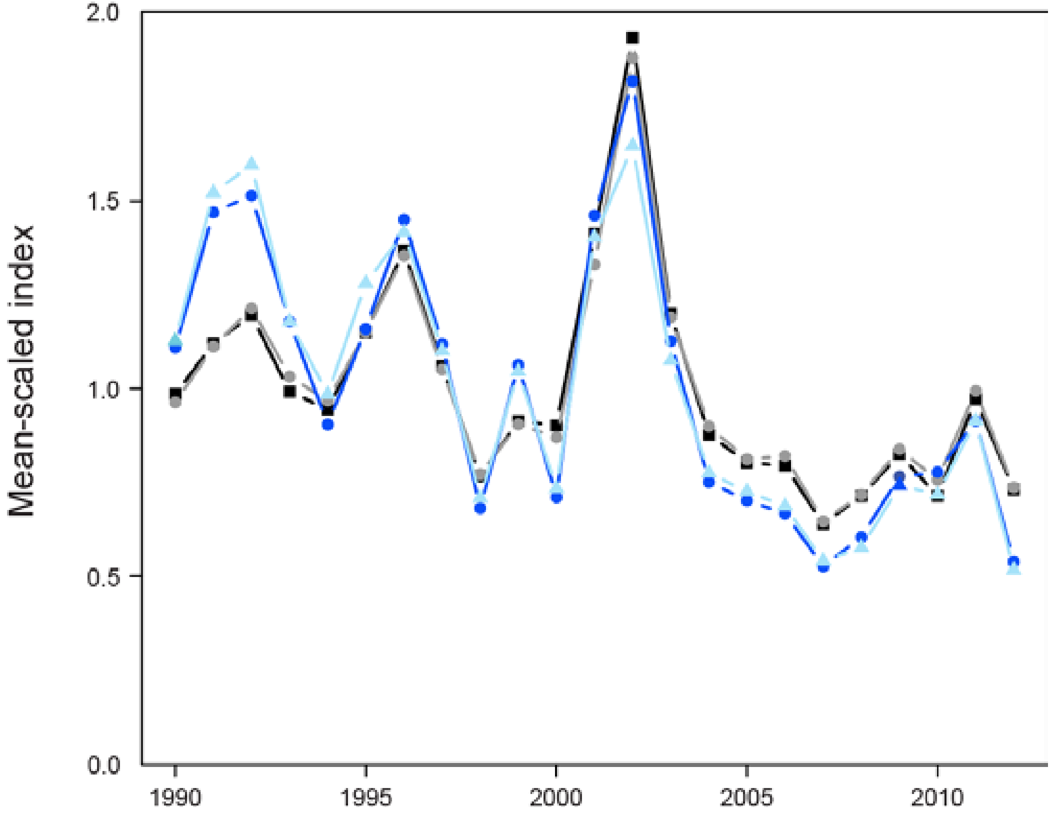


Area-weighted (equal weighted) trends



Black: set-sightings
Red: all sightings within 20nm

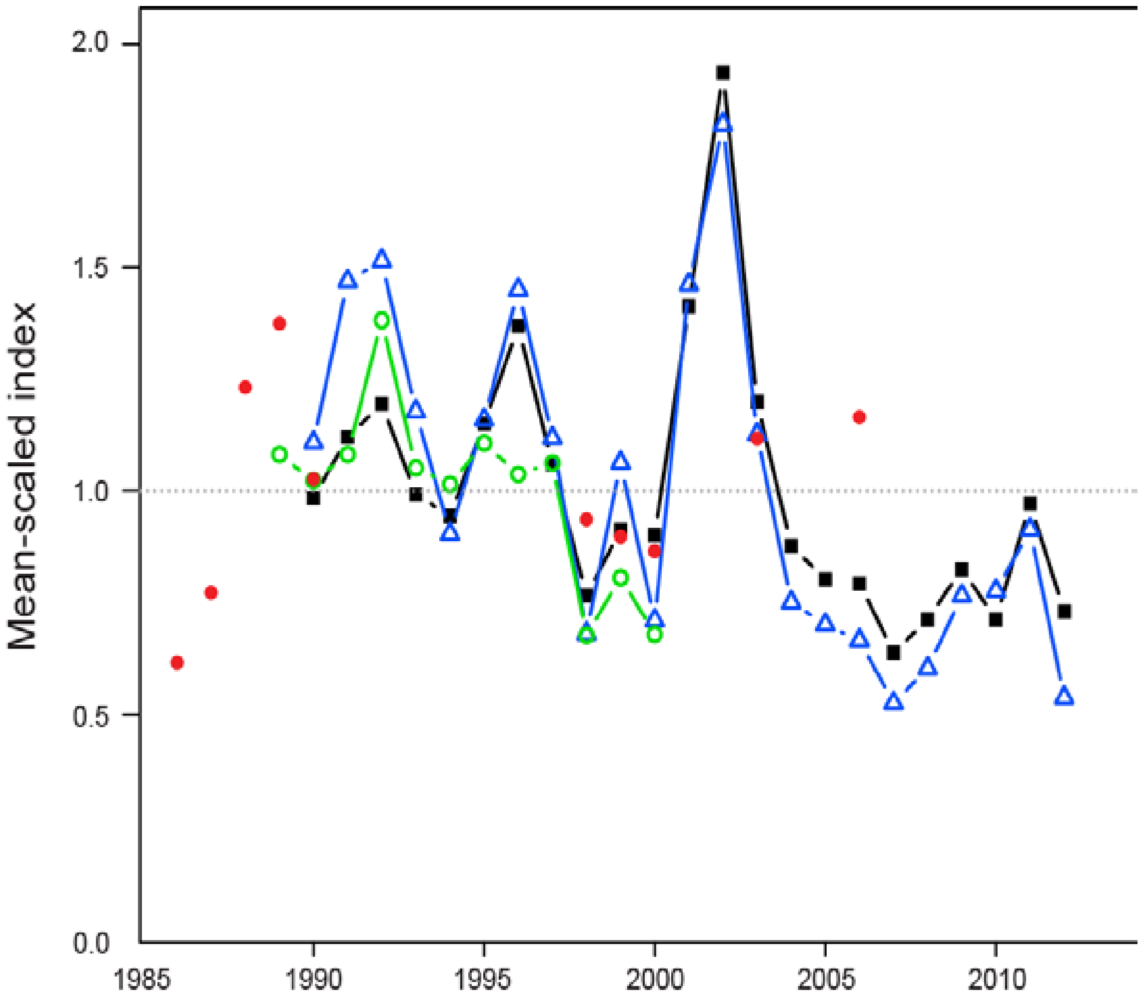
Preliminary results: trends



black:/gray: data-weighted

dark/light blue: equal-weighted

Discussion: comparison to other dolphin indices



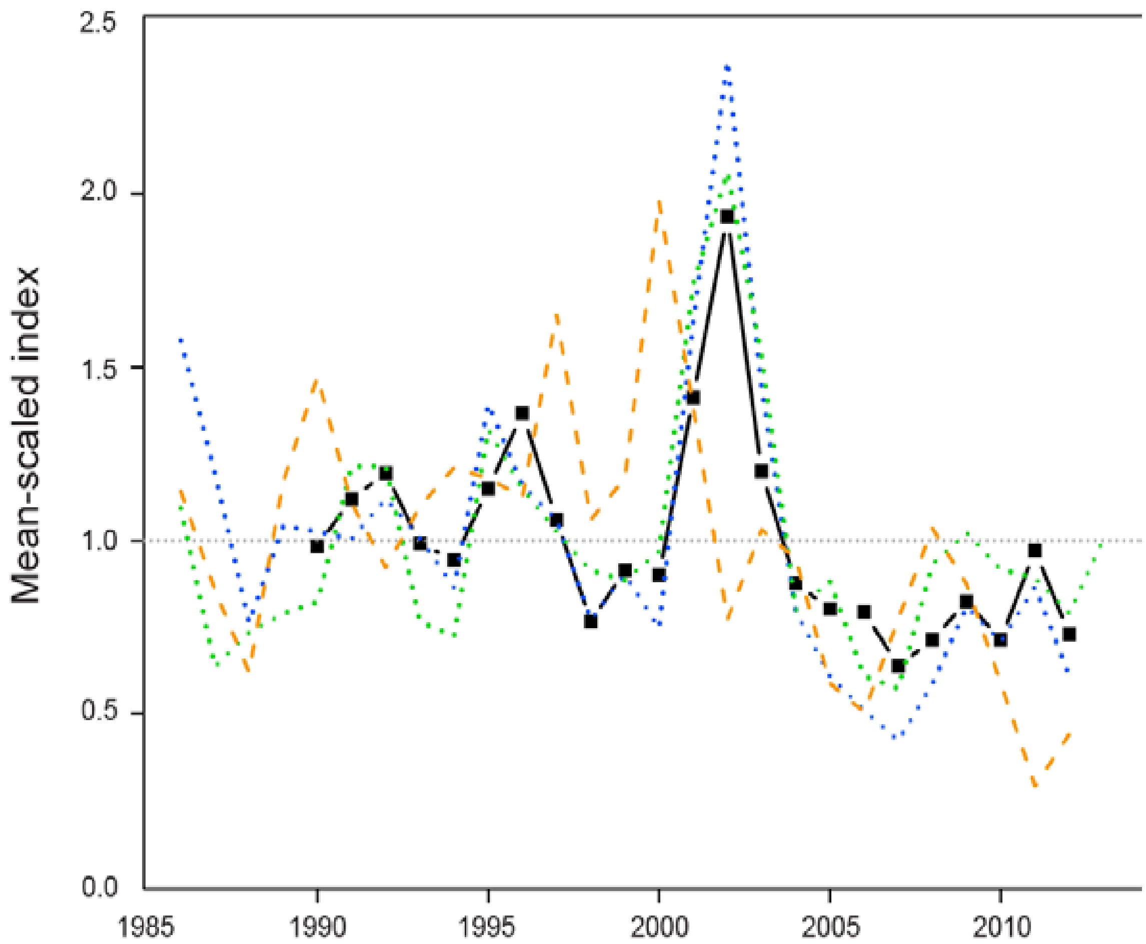
Black: data-weighted (set-sightings)

Blue: equal-weighted (set-sightings)

Green: Line-transect methodology (vessels with radar and helicopter)

Red dots: NMFS survey estimates

Discussion: comparison to yellowfin tuna indices



Black: data-weighted dolphin index (set-sightings)

Blue/Green: purse-seine yellowfin indices

Orange: longline yellowfin index

Conclusions

- Data collected by purse-seine observers represent an extensive data resource, with broad spatial-temporal coverage compared to survey data.
- It would be advantageous to be able to use these data to develop an index of relative abundance for dolphins.
- These data, however, do not represent random search and may contain time-varying biases due to temporal changes in fishing behavior.
- Preliminary dolphin trend estimates are very similar to yellowfin purse-seine indices, suggesting the non-random search may be problematic.
- At this point, it is unclear whether purse-seine observer data can be used to reliably track dolphin absolute abundance.

What is next…

- Occupancy-abundance mixture models are being developed that will allow for individual sightings and sighting-specific covariates.
- This occupancy/abundance model is being formulated in terms of:
  - a Poisson/zero-inflated Poisson regression model for the number of dolphin herds;
  - a negative binomial/lognormal/other regression model for the number of dolphins per herd.
- For these models, two additional covariates will be included:
  - a daily trip-specific indicator of ‘transit’ *versus* ‘area’ search;
  - a trip-specific sighting reporting rate indicator.
- Options to address the problem of non-random search will be explored.
- This work will be presented at the 2014 International Statistical Ecology Conference in July.
- If this work shows promise, other modeling options, sensitivities, and dolphin species/stock may be tackled…