Bycatch

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Bycatch

i. What is bycatch?
ii. How big is the problem?
iii. What are the solutions?
iv. The “Tuna-Dolphin Issue”
i. What is bycatch?

- Any unintended capture
- Also referred to as “incidental capture/mortality”
- Bycaught species may be utilized but are often discarded
- Bycaught species may be killed, seriously injured, or released unharmed
- Bycaught species include marine mammals, seabirds, sea turtles, fishes, and invertebrates
Fishing Gear 101

• Gillnets
  – Vertical panels of netting normally set in a straight line
  – Fish caught in 3 ways:
    • (1) wedged – held by the mesh around the body
    • (2) gilled – held by mesh slipping behind the opercula
    • (3) tangled – held by teeth, spines, maxillaries, or other protrusions without the body penetrating the mesh
  – Widely used by commercial and artisanal (subsistence) fishers
  – Target fish and invertebrates of a wide range of sizes
  – The widely publicized “driftnet” is a type of gillnet
Fishing Gear 101

• Longlines
  – Used by commercial fishers
  – A long line ("main line") with baited hooks attached at intervals by means of branch lines
  – Hundreds to thousands of baited hooks per line
  – Placed at the surface or bottom, set with an anchor, or left to drift
  – Used by commercial fishers
  – Commonly target swordfish, tuna, halibut, sablefish and other large-bodied species
ii. How big is the problem?

- Most species of marine mammal that occur in places that are heavily fished have been recorded caught in some type of fishing gear.
- Most types of fishing gear have been reported to ensnare marine mammals.
- Data are difficult to come by and problematic.
  - Best data come from observer programs (vs. self-reporting).
  - Observer programs are expensive.
  - Cheating, harassment, falsified records may (do) occur.
  - Extrapolation of observer data to entire fishery is fraught with difficulties.

- “Incidental capture in fishing operations is the major threat to whales, dolphins and porpoises worldwide. Several species and many populations will be lost in the next few decades if nothing is done.” (Read & Rosenberg 2002)
Bycatch* in US Fisheries: 1990-1999

*Non-targeted species killed or seriously injured

- Data source: U.S. Stock Assessment Reports
- Mean bycatch = 6215 (SE 448) animals/yr
- Mean annual cetacean bycatch (3029 ± 316) ~ mean annual pinniped bycatch (3187 ± 341)
- Cetacean bycatch primarily Delphinidae and Phocoenidae (mean annual lg. whale bycatch = 20.1 ± 2.9)
- Gillnet bycatch dwarfs other fisheries (84% and 98% of all cetacean and pinniped bycatch, respectively)

Read et al. 2006
An estimate of global bycatch, 1990-1994

<table>
<thead>
<tr>
<th>Fishery type and year</th>
<th>No. of U.S. vessels</th>
<th>Total no. of vessels</th>
<th>Global cetacean bycatch</th>
<th>Global pinniped bycatch</th>
<th>Global marine mammal bycatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gill net</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>1990</td>
<td>2,140</td>
<td>203,598</td>
<td>466,392</td>
<td>182,763</td>
<td>649,154</td>
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<tr>
<td>1991</td>
<td>2,140</td>
<td>217,585</td>
<td>320,633</td>
<td>336,748</td>
<td>657,381</td>
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<tr>
<td>1992</td>
<td>2,160</td>
<td>218,272</td>
<td>239,766</td>
<td>568,518</td>
<td>808,283</td>
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<tr>
<td>1993</td>
<td>2,500</td>
<td>219,461</td>
<td>218,513</td>
<td>313,654</td>
<td>532,167</td>
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<tr>
<td>1994</td>
<td>2,500</td>
<td>220,500</td>
<td>258,250</td>
<td>312,228</td>
<td>570,478</td>
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<tr>
<td>Trawl</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1990</td>
<td>7,446</td>
<td>129,403</td>
<td>3,389</td>
<td>330</td>
<td>3,719</td>
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<tr>
<td>1991</td>
<td>7,440</td>
<td>130,128</td>
<td>5,198</td>
<td>630</td>
<td>5,828</td>
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<tr>
<td>1992</td>
<td>8,150</td>
<td>132,957</td>
<td>3,790</td>
<td>555</td>
<td>4,344</td>
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<tr>
<td>1993</td>
<td>8,290</td>
<td>137,720</td>
<td>2,213</td>
<td>166</td>
<td>2,379</td>
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<tr>
<td>1994</td>
<td>8,030</td>
<td>137,479</td>
<td>3,407</td>
<td>496</td>
<td>3,904</td>
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<tr>
<td>Other</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>3,220</td>
<td>77,640</td>
<td>72</td>
<td>3,645</td>
<td>3,717</td>
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<tr>
<td>1991</td>
<td>3,180</td>
<td>79,045</td>
<td>222</td>
<td>3,708</td>
<td>3,930</td>
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<td>1992</td>
<td>3,230</td>
<td>80,606</td>
<td>6,382</td>
<td>3,698</td>
<td>10,079</td>
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<tr>
<td>1993</td>
<td>3,495</td>
<td>80,366</td>
<td>1,377</td>
<td>235</td>
<td>1,612</td>
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<tr>
<td>1994</td>
<td>3,430</td>
<td>80,991</td>
<td>9,164</td>
<td>685</td>
<td>9,849</td>
</tr>
</tbody>
</table>

- Mean of 653,365 bycaught marine mammals/yr
  - 307,753 cetaceans/yr; 345,611 pinnipeds/yr
- Most bycatch in the world is likely due to gillnets

Read et al. 2006
What does this mean to a population or species?
Vaquita: the most critically endangered cetacean

- First described in 1958
- Endemic to the northern Gulf of California, Mexico

Rojas-Brachot et al. 2006
Bycatch is a problem for vaquita.

- Documented since 1950s
- 1993-1995: Bycatch quantified through interviews with fishers from 1066 trips and data from observers aboard 47 trips

Table 4. Estimates of total annual mortalities of vaquita, calculated with different mortality rates, and the corresponding percentage of the estimated population size of 224 (Barlow et al. 1997).

<table>
<thead>
<tr>
<th>Data used</th>
<th>Mortality</th>
<th>Population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed mortality</td>
<td>14</td>
<td>6.25</td>
</tr>
<tr>
<td>EGSC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGSC all data</td>
<td>39</td>
<td>17.41</td>
</tr>
<tr>
<td>EGSC observer data only</td>
<td>84</td>
<td>37.50</td>
</tr>
<tr>
<td>EGSC + SF(^b) all data</td>
<td>~78</td>
<td>~34.82</td>
</tr>
<tr>
<td>EGSC + SF observer data only</td>
<td>~168</td>
<td>~75.00</td>
</tr>
</tbody>
</table>

\(^a\)EGSC, El Golfo de Santa Clara, Sonora; SF, San Felipe, Baja California.
\(^b\)We have assumed, based on the number of boats fishing, that the SF pangas conducted the same number of trips between January 1993 and January 1994 as the pangas in EGSC. Thus, the total estimated incidental mortality for both EGSC and SF is twice the estimate for EGSC.
• 39 – 84 bycaught animals/yr (from 1 of 3 fishing villages)

• 78 – 168 bycaught animals/yr (from 2 of 3 fishing villages)

• 17% - 75% of 1997 global population estimate

• Maximum population growth rate < 4%/yr (Rojas-Bracho et al. 2006)

“We strongly recommend a complete and permanent ban on gillnets in the area.”

D’Agrosa et al. 2000
Rare events can be significant.

- The average fisher may never catch a vaquita.
- Yet this bycatch was estimated to kill 17-75% of the population in a single year.
Population abundance and trends

- 1986-’88 (boat surveys) = 503 (95% CI: 163-1551)
- 1988-’89 (aerial surveys) = 855 (340-2149)
- 1991 (aerial survey) = 572 (73-4512)
- 1993 (ship survey) = 224 (106-470)

Decline of 17.7% per year (-43.2% - +19.3%)

But not statistically significant due to wide CIs

Barlow et al. 1997
More population abundance and trends

- 1997 (boat survey) = 567 (95% CI: 177-1073)
- 2008 (ship and acoustic survey) = 245 (68-884)
- 2008 estimate is 57% lower than the 1997 estimate (but not statistically different due to large CI values)

Bayesian methods indicate that the probability of decline during this period is 89%

Gerrodette et al. 2011
We further conclude that more surveys or estimates of bycatch mortality will not provide useful information needed for the conservation of this critically endangered species. Instead, resources would be better invested in a comprehensive program to eliminate entangling nets from the range of the vaquita through a buyout program or other system of compensation to affected fishing communities.”*

Jaramillo-Legorreta et al. 2007

*Remember for later
Baiji: first human-caused extinction of a cetacean species

Family Lipotidae
Lipotes vexillifer
• Population declines documented since late 1970s
• Threats included boat collisions, dam construction, pollution
• Bycatch was the primary known cause of mortality
  – Responsible for >50% of deaths in ‘70s - ‘80s (rolling hooks and other fishing gear)
  – ~40% of deaths in ‘90s (electrofishing – illegal throughout the river)

Turvey et al. 2007 and references therein
• Last confirmed sighting in 2002

• 2006: Intensive six-week, multi-vessel, visual and acoustic survey of entire known range failed to find any evidence of Baiji

“We are forced to conclude that the baiji is now likely to be extinct, probably due to unsustainable by-catch in local fisheries.”

Turvey et al. 2007
• The baiji represents the fourth disappearance of an entire mammal family since 1500, and the first global extinction of a megafaunal (>100 kg) vertebrate in 50 yrs (since extinction of the Caribbean Monk Seal).

• It’s decreasing population was recognized for more than two decades and was the focus of international attention.

• It was not actively targeted, but the victim of incidental mortality resulting from massive-scale human environmental impacts, primarily uncontrolled and unselective fishing.

• This fishing pressure was entirely small-scale, local, and mainly subsistence fisheries as opposed to large-scale, commercial ones.*

*Remember for later
Bycatch in artisanal fishing is now recognized as the single most significant threat to coastal cetaceans worldwide.
iii. What are the solutions?

a) Modify fishing gear
b) Close areas or times to fishing
c) Provide alternative livelihoods
a) Modify Fishing Gear

- **Circle Hooks**
  - Reduce likelihood of swallowing
- **Escape devices/release practices**
  - “Back-down” procedure in purse seine fishery
- **Pingers**
  - A device that emits a noise that most fish cannot hear but that appears to repel marine mammals
  - Attached at regular intervals along a net
  - Mandatory in many US fisheries
  - Can reduce bycatch greatly
  - But...
    - Effectiveness relies on fishers to use and maintain
    - Can be expensive
A pinger success story

- California Current Drift Gillnet Fishery – nets ~1800m long and 65m deep; fished from dusk to dawn
- Partial observer coverage to obtain bycatch data
- 1990-95: 33 beaked whale entanglements (3303 observed sets)
- 1996: pinger use begins
  - pingers every 91m and w/in 9 m of the top and 11 m of the bottom
  - typical net = 40 pingers
- 1996-2006: 0 beaked whale entanglements (4381 sets!)
  - but 260 other cetaceans from 12 species entangled

Carretta et al. 2008
Solution b) Close Areas or Times to Fishing*

- Gray whale refuges (Scammon’s Lagoon, 1971; San Ignacio Lagoon, 1979) – Mexico
- Hector’s dolphin Sanctuary (Banks Peninsula, 1988) – New Zealand – gillnet driven
- Small cetacean Sanctuary (Sylt & Amrum Islands North Sea 1999) – Germany – gillnet driven
- Humpback whale Sanctuary (Hawaiian Islands 1993) – USA
- National Marine Sanctuaries (e.g., Channel Islands, Gulf of the Farallones, Monterey Bay, Stellwagen Bank) – USA
- Antarctic and Sub-Antarctic sites/islands under various measures of protection – International Agreements

- Challenges
  - Degree of protection varies widely (e.g., U.S. National Marine Sanctuaries have little to no regulation on fishing)
  - Enforcement (remember illegal electrofishing in the Yangtze?)
  - “Paper Parks” offer an illusion of protection (many Baiji reserves were designated in the Yangtze)

*and other anthropogenic perturbations
A chronology of area closure/fishing restriction management actions and vaquita status:

- 1942 – peak of totoaba fishery (presumably also bycatch of vaquita): 2261 tons landed
- 1975 – ban on totoaba fishing (landings down to 59 tons)
- 1978 – vaquita included on list of endangered and rare wildlife species of Mexico; classified as Vulnerable by IUCN
- 1979 – first proposal for a cetacean sanctuary to protect vaquita; vaquita listed in Appendix I of CITES (fully protected)
- 1985 – vaquita listed as Endangered under US Endangered Species Act
- 1990 – IUCN changes status to Endangered
- 1993 – Biosphere Reserve of the Upper Gulf of California and Colorado River Delta established
  - Gillnet fishing in the “nuclear” area (near river mouth) banned
- 1995 – Management plan for Biosphere Reserve published
- 1996 – IUCN changes status to Critically Endangered
- 2005 - Vaquita Refuge created (nested w/in Biosphere Reserve)
  - Gillnet fishing banned within
- 2008 – PACE (conservation action plan for vaquita) announced

Why an increase in concern with increasing protection? --Remember the challenges with closures/fishing restrictions?

Rojas-Bracho et al. 2006; Gerrodette and Rojas-Bracho 2012
PACE

- Eliminate vaquita bycatch by enforcing existing bans on gillnet fishing in the Biosphere Reserve
- Encourage methods of fishing that do not catch vaquita
- Provide economic compensation to fishers through a buyout plan/alternative livelihoods
- Possibly expand the gillnet fishing ban to a larger protected area
Which option(s) would reverse the population decrease due to bycatch?

<table>
<thead>
<tr>
<th>Vaquita protection area</th>
<th>PACE Vaquita conservation action plan</th>
<th>Biosphere reserve</th>
<th>Refuge area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median R*</td>
<td>0.73</td>
<td>0.30</td>
<td>0.75</td>
</tr>
<tr>
<td>P(success)</td>
<td>0.08</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Population increases when Median R* > 1

- Only Option 3 (gillnets banned throughout known range) results in a population increase

Gerrodette and Rojas-Bracho 2012
And a delay in implementation decreases the probability of reversing the decline.

- If implementation is delayed until 2015, the median $R$ becomes negative.

Population increases when $R > 1$

Gerrodette and Rojas-Bracho 2012
Solution c) Provide Alternative Livelihoods

“The people who live along the desert shores eke out a tenuous living by fishing in the same waters as the vaquita. They simply want to keep their families fed and improve their lot. ... We need to take care of this fisherman if we want to take care of the vaquita.”

Pitman and Rojas-Bracho 2007
Three relevant communities totaling ~ 61,000 people
Tourism a major component of two; fishing major for all three
Artisan fleet consists of 1771 vessels authorized to fish with nets
Total Profit + Labor for all fisheries occurring in vaquita range estimated at $78.50 million Pesos = $5.4 million U.S. dollars
Alternatives to fishing include aquaculture (esp. bivalves) and ecotourism
2011 workshop attempted to devise a socioeconomic strategy for creating alternative livelihoods
   – 21 projects identified; 8 selected for further investigation
Source of funds and mechanism to direct them to these communities remains problematic

If this sounds like it is beginning to diverge from biology, it’s because it is.
The solution to bycatch in artisanal fisheries lies with disciplines in addition to biology.

- Sociology
- Economics
- That’s why you are particularly important.
iv. The “Tuna-Dolphin Issue”

- Arguably the fishery with the largest bycatch of a single stock in the world
- Among the best examples of indirect effects
- Likely the single factor most responsible for enactment of the U.S. Marine Mammal Protection Act
- Stay tuned
Reading
