Social and Mating among Core Groups

Ecology of Mammal-Hunting ("Transient") Killer Whales in Monterey Bay, California: A 22-Year Study

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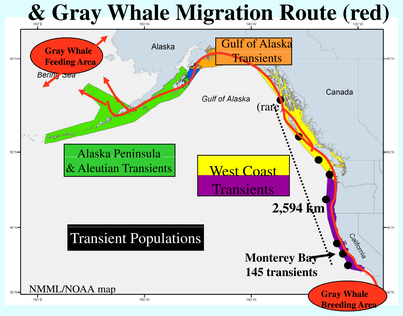
ABSTRACT

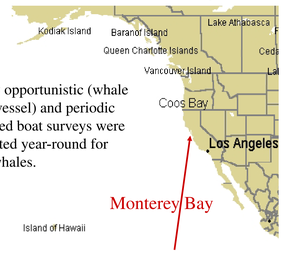
Since 1987 we photo-identified whales, recorded location, prey type, behaviors and collected biopsy samples on year-round boat surveys to determine population parameters, ecological patterns, and contaminant levels of killer whales. Transients were sighted on 545 days, and 154 individuals were identified (from 1 to 80 times each) over 20 years with a current population of 112 whales (22% reproductive females, 11% post reproductive females, 20% adult males). Whales frequented the canyon edge in Monterey Bay and were re-sighted from southern California to Southeast Alaska. The population consisted of core groups comprised of 1-3 adult females and their offspring. Calving interval ranged from 5 to 10 years. These whales (n=9) were highly contaminated with POPs, which could contribute to a low reproductive rate and higher mortality level. Mean values were ∑PCBs: 87,888ng/g; ∑DDTs: 507,148; ∑PBDEs: 15,000 which is among the highest levels recorded for cetaceans. Krahn (2007) reported on our sampled males (n=4); ∑PCBs: 630,000; ∑DDTs: 3,700,000; ∑PBDEs: 12,600. We observed 123 predation events on nine species of mammals. Whales occurred year-round but were most frequent with largest group sizes (mean=12) occurring during spring, corresponding to the migration of mother/calf gray whales. Fifty-four predation events on gray whale calves were recorded, 1 to 5 core groups were involved, just 2-3 females were most active in the attack, and some whales killed and fed on 6 gray whales over 21 days. The number of attacks (0-11/yr) corresponded to the number of gray whale calves born each year (87 to 559; per W. Perryman/NMFS). Cultural transmission of spatial/temporal timing is evident and the bathymetric features of the canyon appear advantageous to foraging killer whales.

Transient Killer Whale Populations and Ranges & Gray Whale Migration Route (red)



- Black dots indicate sighting locations as an example for one killer whale core group identified in Monterey Bay and other locations along west coast with Southeast Alaska most likely the extreme limit of range. More re-sights have occurred within California, and up to B.C. Attacks on gray whales are reported near Aleutians (C. Matkin), with sporadic reports along west coast, but occur consistently in Monterey Bay.

Study Area: Monterey Bay And Submarine Canyon

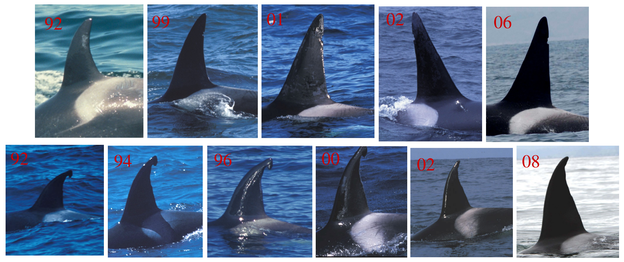


- Daily opportunistic (whale watch vessel) and periodic dedicated boat surveys were conducted year-round for killer whales.

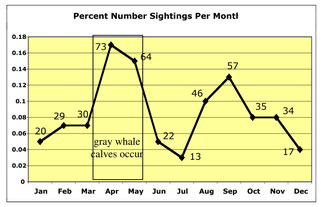
Sighting Locations of Killer Whales

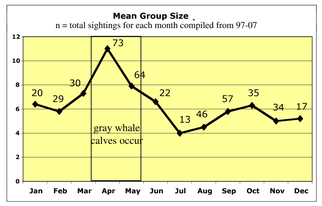
- Killer whales were frequently sighting near the edge of the canyon (200-400 m depth; 1987-2007).

Growth of Male Killer Whales Over 16 Years



Percent Number of Sightings and Mean Group Size of Killer Whales by Month (1997-2007)





- Killer whales were frequently sighted and occurred in the largest groups during spring, corresponding to the migration period for mother/calf pairs of gray whales.

Number Of Whales In Each Age Class

Age Class	# of Whales
reproductive females	27
non/post reproductive fem	11
adult males	23
female type/juv	33
calves	18
Total	112

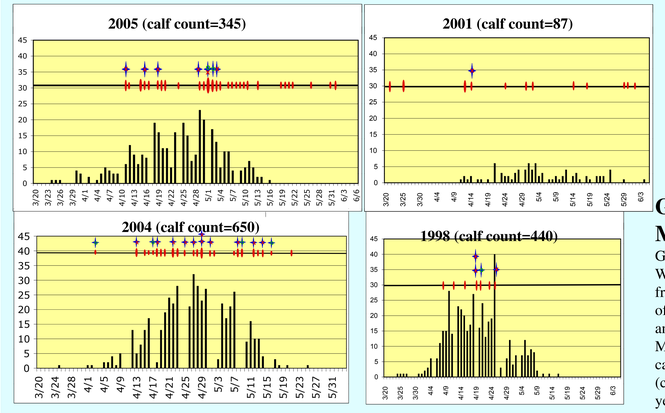
Number of Surviving Calves, Calving Interval, and Number of Sighting Years For Females

Whale #	Surviving Calves	$\bar{X}$ Calving Interval	# Years Sighted
1	2	8.0	22
2	1	---	23
3	3	6.5	21
4*	2	8.0	18
5	1	---	18
6*	2	9.0	19
7	1	9.0	17
8*	2	6.5	17
9	1	---	18
10	3	6.0	18
11	2	10	16
12*	2	9.0	14
13	2	9.0	14
14*	1	---	12
15	2	7.0	09

- Years between the birth of calves for each female ranged from 6 to 10 years over a period of 7 to 21 years. During this time each female had from 1 to 3 surviving calves. The * indicates a known calf death for that female.

- Killer whales off California contain some of the highest levels of PCBs and DDTs for any cetacean population. High levels are likely due to residual chemicals that were once dumped or drained into the ocean before they were banned, plus some atmospheric input from other regions.

Counts of Migrating Gray Whale Calves (from W. Perryman/NMFS) per Day (bar graph) Over-layed by Killer Whale Sighting Dates (red) and Attack Dates (blue) by Year (select examples)



- **Legend:**
  Bars = number of calves/day
  = killer whale sightings, size of oval relative to group size (5, 10,15, 20, 25)
  = predation events by killer whales on gray whale calves (X in center is attack) (O in center is escape)

Gray Whale Mother/Calf Migration

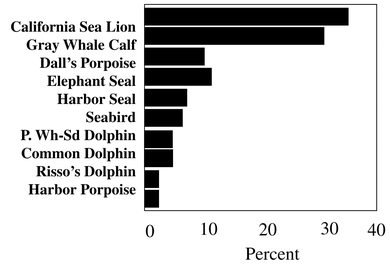
Gray whale calves were counted by Wayne Perryman's group (NMFS) from Pt. Piedras Blancas (64 km south of Monterey). Killer whale sightings and attacks were documented in Monterey Bay. Number of gray whale calves and timing of migration (clumped, dispersed) varied among years.

Killer Whale Sightings and Attacks

- Concentrated killer whale sightings corresponded to migration period for mother/calf gray whales. Attacks were most frequent around peak of mother/calf migration past Monterey.
- 2004 was exceptional as gray whale calf numbers were high, killer whale sightings were frequent, and coincided with the most predation events ever recorded since this study began.

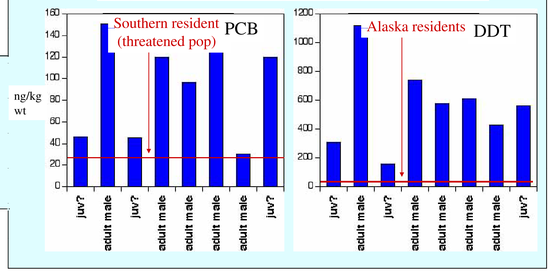
Killer Whale Prey Items (n=132)

- Predation on Gray Whales is very conspicuous and lasts for several hours, whereas predation on smaller mammals may occur in several minutes so this may bias our prey proportions.



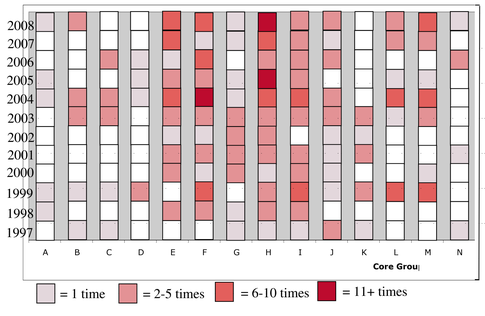
Levels of POPs in Monterey Bay Transients

- Blue bar indicates levels of PCBs and DDTs found in Monterey Bay whales with red line as a comparison for mean levels of Southern resident (fish-eaters) and Alaska resident killer whales (Samples analyzed by G. Ylitalo/NOAA). Samples collected by skin biopsy with air gun.



Predation on Gray Whale Calf

Sighting Frequency by Year of Core Groups During Spring (Gray Whale Migration Period)

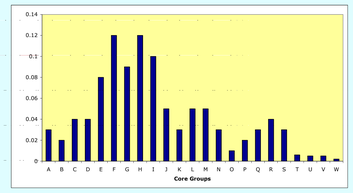


- Killer whales are most frequently sighted during the mother/calf gray whale migration period. At this time, core groups of whales gather together to hunt gray whales in groups up to 25 whales. Core groups are often sighted multiple times throughout the spring period each year and participate in multiple gray whale attacks within a month's time, suggesting the whales may be binge feeding.

Predation on Risso's Dolphin

Sighting Frequency of Core Groups

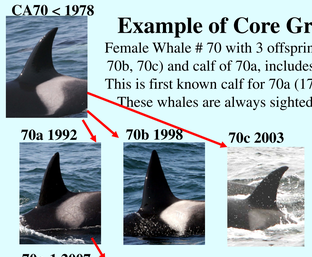
- Five Core Groups occurred most often and often gathered together to hunt gray whales.



CA70 < 1978

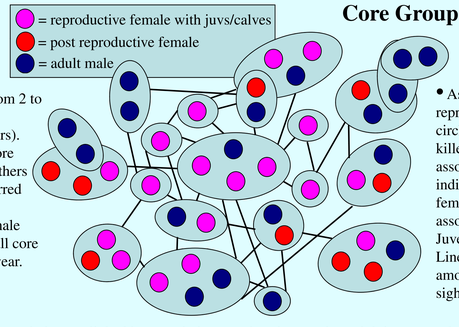
Example of Core Group F

Female Whale # 70 with 3 offspring and (70a, 70b, 70c) and calf of 70a, includes year born. This is first known calf for 70a (17 years old). These whales are always sighted together.



- CA70's group is frequently sighted and CA70 has been involved in many gray whale attacks over at least 17 years.

Core Group Associations



- Core groups contain from 2 to 8 whales that are highly associated over time (years). Some core groups are more frequently sighted than others and all groups have occurred during spring months corresponding to gray whale migration, although not all core groups are sighted each year.

- Associations among killer whales are represented by symbols: larger blue circles indicate core groups (groups of killer whales with a high coefficient of association > .8) and smaller circles indicate sex class. All reproductive females have one or more calves/juveniles associated with them in their core group. Juveniles and calves are not represented. Lines between circles represent linkages among groups; groups that have been sighted together.

- All transients in this population are linked by associations, such as in any given sighting, several core groups may be together and during another sighting one of these groups may be associated with a different group from previous sighting. Core groups with just one female also include their younger offspring. Females with small calves of similar age often travel together for periods of time, often several years. Female/offspring core groups will gather together during cooperative hunts for gray whales.

CONCLUSIONS

This long-term study provides valuable information on the ecology of killer whales off California:

- **Distribution**: Killer whales were highly associated with the edge of the Monterey Canyon, an area of higher productively and prey availability. Killer whales ranged from California to Southeast Alaska.
- **Occurrence**: Whales were sighted year round, with significantly more sightings with larger group sizes during spring corresponding to the mom/calf gray whale migration, a prime prey item.
- **Population**: Not all whales are sighted every year, while some are sighted regularly suggesting that Monterey Bay is a central home range for some whales and others occasionally occur. During the gray whale season, the greatest number of individual whales are sighted suggesting that whales that frequent other areas come to the Bay to hunt gray whale calves.
- **Predation**: Transient killer whales sighted in Monterey Bay were highly associated with the presence of gray whale calves and must have knowledge of the spatial and temporal patterns of calves; exhibiting characteristics of cultural transmission.
- **Association**: Core groups include one or more females with their offspring, from 2 to 8 whales with high coefficients of associations. These small groups are often sighted on their own but mix with other groups periodically especially when cooperatively hunting gray whale calves during spring.
- **Contaminants**: These whales have high concentrations of POP's which could contribute to their low reproductive rate.