California Fish and Game 94(1):33-43 2008

OBSERVATIONS AND PREY OF WHITE SHARKS, *CARCHARODON CARCHARIAS,* AT POINT REYES NATIONAL SEASHORE: 1982 – 2004

Scot D. Anderson, Benjamin H. Becker, and Sarah G. Allen
Pacific Coast Science and Learning Center
Point Reyes National Seashore
Point Reyes Station, CA 94956
E-mail: sharkman1137@mac.com

We compiled a 23-year record of 71 incidental sightings and 11 years of decoy surveys (with 45 encounters) of white sharks, *Carcharodon carcharias,* at Point Reyes National Seashore, California. Sharks were generally sighted in rocky, nearshore habitats (5 – 30 m water depth), and appeared to be more likely to prey on California sea lions and harbor seals than on northern elephant seals, which are their primary prey at other areas in California. Decoy surveys suggest somewhat low densities of white sharks at Tomales Point averaging only one sighting every 6 h from 1994 – 2003, while similar surveys at the Farallon Islands reported observations every 1.9 h. However, these observations at Tomales Point increased to one every 1.9 h in 2004. Sex ratios (M:F = 4:9) were also inverse to those found at the Farallon Islands in recent studies (M:F: = 14:8).

INTRODUCTION

White shark, *Carcharodon carcharias*, ecology, distribution, behavior, and prey selection have been investigated in California for at least 40 years (Miller and Collier 1980, Ainley et al. 1985, McCosker 1985, Klimley et al. 2001, Kelly and Klimley 2003). These large, apex predators have primarily been studied at the South Farallon Islands (SFI) and Año Nuevo Island (ANI), where they prey almost entirely on pinnipeds (Ainley et al. 1981, Ainley et al. 1985). However, few studies have been done at Point Reyes National Seashore (PRNS) (Kelly and Klimley 2003) where five species of pinnipeds utilize local habitats to feed, haul out, and/or breed, providing an ideal foraging habitat for the white shark (Ainley et al. 1981, Sydeman and Allen 1999). These five pinniped species are California sea lion, *Zalophus californius*, Steller sea lion, *Eumetopias jubatus*, harbor seal, *Phoca vitulina*, northern elephant seal, *Mirounga angustirostris,* and northern fur seal, *Callorhinus ursinus* (Sydeman and Allen 1999). Pinniped presence at Point Reyes includes the highest concentration of harbor seals on mainland California, representing around 20% of the population, and the northern-most breeding colony of northern elephant seals, which continues to grow at > 8% per year[1] (Sydeman and Allen 1999). Similarly, because of the persistent nearshore eddies

[1] Allen S., S. Waber, W. Holter, and D. Press. 2004. Long-term monitoring of harbor seals at Point Reyes, California: five year annual report 1997-2001, National Park Service Technical Report.

in the region, white sharks also have a good chance of finding and scavenging upon marine mammal carcasses that have been advected into the region (Wing et al. 1998).

Previous white shark studies in California have focused primarily on rocky island habitats, such as SFI (Ainley et al. 1981, Klimley et al. 1992). These studies suggest that the white shark's preferred prey are elephant seals at SFI and were harbor seals at Point Reyes' Double Point prior to elephant seal colonization at the nearby Point Reyes Headlands during the 1970's (Ainley et al. 1981). The Point Reyes peninsula, comprising 190 kilometers of sandy and rocky shoreline, differs from SFI in being a mainland site with few adjacent island haul-out sites, the largest of which is Bird Rock, near Tomales Point (Fig. 1). PRNS also differs from SFI in that northern elephant seals are found in only part of the study area at the Point Reyes Headlands and adjacent beaches (Fig. 1). Thus, PRNS, with its spatial distribution and segregation of five species of pinniped, and both sandy and rocky habitats, presents an ideal location for investigating the prey preferences of white sharks. Here, we provide observational and experimental data describing the similarities and differences in shark presence, habitat utilization, prey selection, and behavior between previous studies at SFI and ANI and long-term data collected at PRNS over the past quarter century.

METHODS

For the first part of our study, we compiled observations of white sharks from PRNS recorded from 1982 to 2004 by National Park Service (NPS) biologists surveying seal colonies (5), NPS rangers (10), park visitors (7), fishing boat and whale watching skippers (9), McCosker and Lea (1996) (5) and the authors. Many of these records came from a daily logbook of events and unusual sightings maintained at the Point Reyes Headlands by NPS rangers. Other sightings were compiled from various sources including local newspapers. In every case, we interviewed the witnesses and were able to confirm the sightings as a white shark. None of these data sets were systematically collected. All sightings included information on time, date, location, and behavior. Two other species of shark in the study area could be mistaken by laypersons for the white shark: the basking shark, *Cetorhinus maximus,* and the salmon shark, *Lamna ditropis*. The former is a very large filter feeder, and the latter is smaller and feeds on fishes rather than marine mammals (Castro 1983). Thus, we believe errors of identity were unlikely and any record which could not be verified as a white shark was omitted from the data set. We only used actual observations; anecdotal information such as recent bites by white sharks on seals, sea lions, and dead whales were omitted since these wounds or bite marks could have occurred anywhere before beaching, and therefore, did not indicate the location of the feeding shark (Long and Jones 1996). Observations were sorted into four categories: predation (shark attacks, kills prey, and then feeds - P), scavenging (shark seen feeding on carcass, such as a dead baleen whale - SC), sighting (shark seen, behavior unknown - S) and attack (shark bites human or dog - A). We also examined the data for environmental patterns in water depth, distance from shore, annual variation in sighting frequency, month of the year, tidal state, and substrate type. We compared whether sharks were over rocky or sandy substrates by identifying

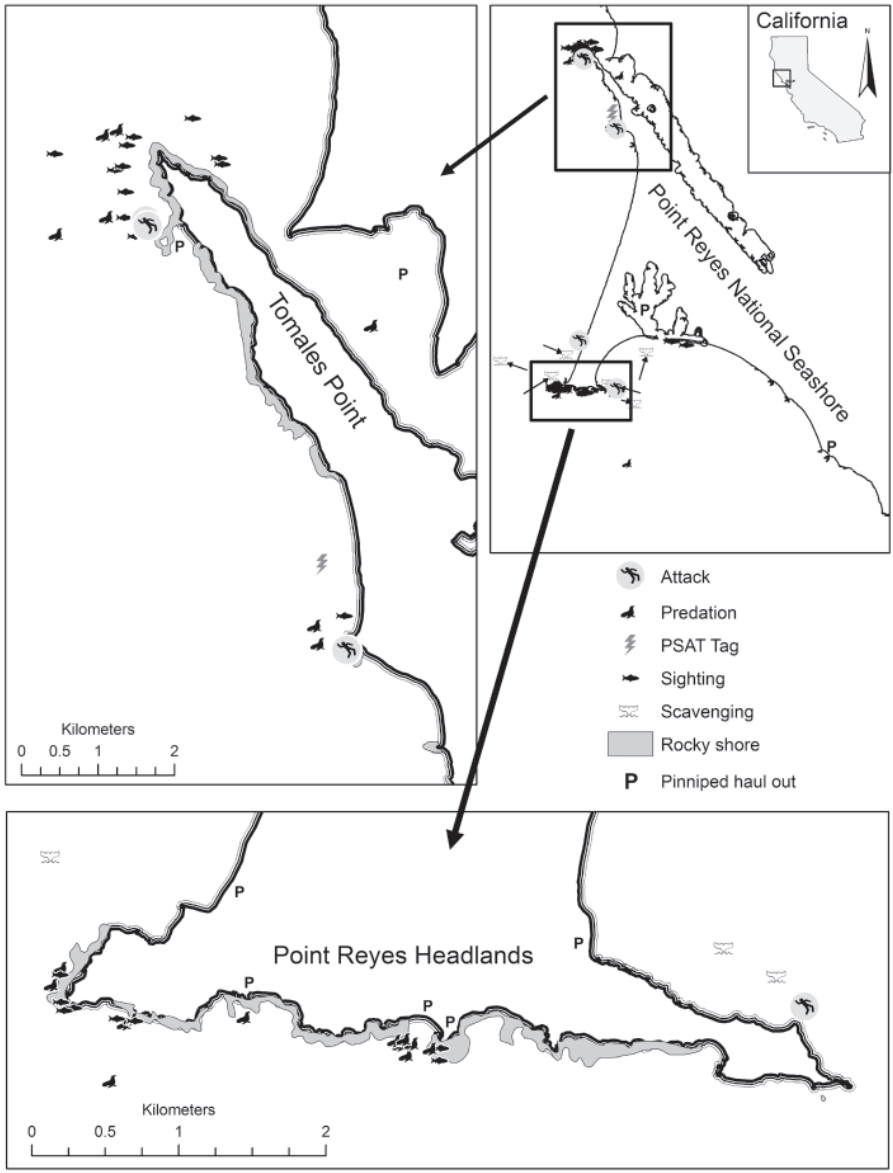

Figure 1. Study area. Small arrows adjacent to scavenging events indicate approximate path of carcass and associated shark(s). Those sightings that were not specific in location are not shown.

the nearest intertidal habitat for all shark observations. The rocky habitat is concentrated around points and headlands: Point Reyes Headlands, McClures Rock, and Bird Rock to Tomales Point (Fig. 1). We also looked for trends by year over the study period,

omitting all observations by the senior author (SDA) from Tomales Point since they were only performed during the Fall of each year.

For the second part of our study, we conducted systematic surveys using decoys as lures from September to December 1994 – 2004. These surveys, in the area from Tomales Point to Bird Rock and between 500 and 1,600 m from shore (Fig. 1), were generally done by drifting with the current from north to south. Since white sharks are so rarely sighted, we only surveyed where we had previously found sharks and not in areas of poor success. So these sightings show presence, but not absence, of sharks. The purpose of the surveys was to: 1) identify individual sharks, 2) determine sex of individuals, and 3) calculate the frequency of shark investigations of decoys compared to similar studies at ANI and SFI (Anderson and Goldman 1996). Photographs and video were used to identify individual sharks by natural and acquired markings and the shape and notches on the dorsal fin (see Klimley and Anderson 1993, Anderson and Goldman 1995).

Decoys of a 1.5 – 2.0 m seal silhouette made of black carpet or a blue surfboard were used to lure sharks to the surface in an attempt to photograph or videotape individuals (Anderson et al. 1996a). Individual white sharks were cataloged, sexed, and then compared with known individuals from SFI, the closest study site (Anderson and Goldman 1996). Time, location, and date of deployment were compared for trends. We recorded other shark behavior, such as breaching or predation events, as well. We also collected information from one white shark upon which we had attached a PSAT (pop-off satellite archival tag) at Point Reyes as part of a larger study (Boustany et al. 2002).

We analyzed the observational and decoy data separately. Observational data (P, S, SC, A, and PSAT) were analyzed together for location, depth, distance from shore, bottom type, time of year, and prey type. The decoy surveys were analyzed for frequency of shark sightings with effort (time), individual identification, movement and sex.

RESULTS

Over 23 years, a total of 116 observations was recorded: 45 decoy encounters, 30 predation events, 27 sightings, 7 scavenging events, 6 shark attacks (5 human and 1 dog) and 1 PSAT. Twenty positions were taken from GPS points with the remainder estimated based on detailed descriptions (Fig. 1). Spatially, most observations were clustered in three areas of the PRNS: the Point Reyes Headlands, McClures Rock and Tomales Point. Shark observations increased in frequency in later years of the study (Fig. 2A). The fewest white sharks were observed in the spring from March to June, with no records for April and June. A pulse of observations occurred in the late winter during January and February. Despite thousands of hours of harbor seal monitoring observations at Double Point (Fig. 1) over the study period, no white sharks were observed at that site.

Most observations occurred in water from 10 to 30 m deep (Fig. 2C): 63% in < 10 m, 22% in 10 - 20m and 9% in 20 - 30 m. Only one predation event was observed in water deeper than 40 m (at 3 km from shore; Fig. 1); however the deepest observations were

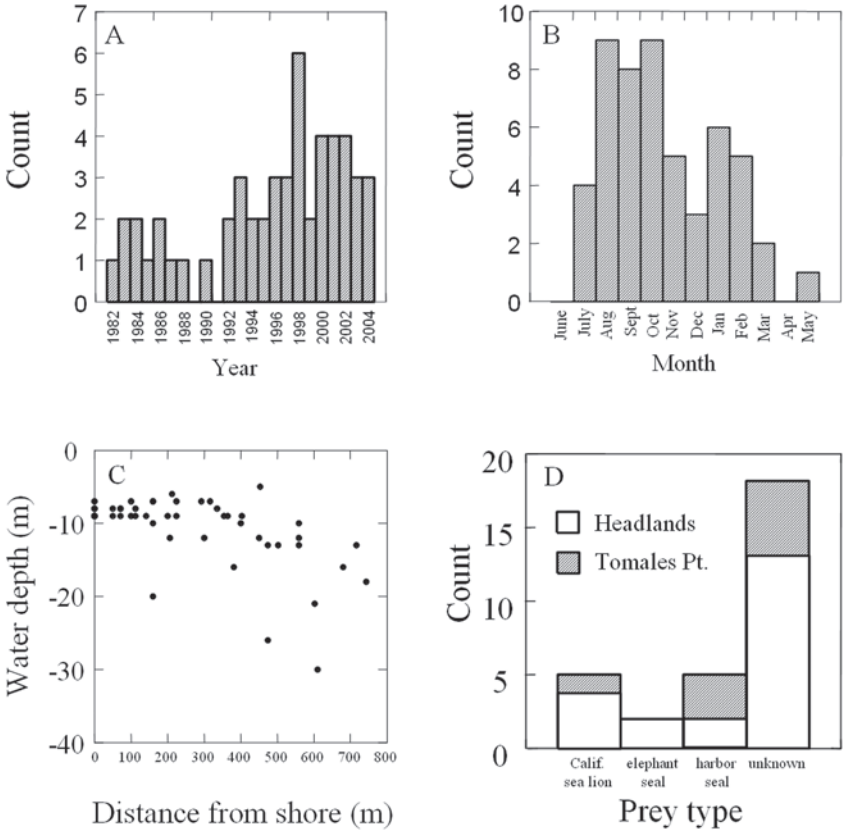

Figure 2. Frequency of incidental sightings (attacks, sightings, and scavenging events) (A) by year and (B) by month for years 1982 – 2004. N = 52. Histograms do not include sightings by the senior author (SDA), since his effort varied throughout the study period. (C) Depth and distance from shore of attacks, sightings, and scavenging events. Events greater than 800 m from shore are not shown. (D) Type of prey observed during incidental sightings and attacks (excluding scavenging events).

scavenging events in depths as deep as 80 m. Most observations (43) occurred over rocky habitat (80%) with only 11 over sandy areas (20%).

We were able to identify the prey in only 12 (40%) of the 30 predation events (2 northern elephant seals, 5 harbor seals, and 5 California sea lions) (Fig. 2D). The relative proportions of species taken appeared to differ among sites. At the Point Reyes Headlands, two northern elephant seals, two harbor seals, and four California sea lions were taken, while at Tomales Point, no northern elephant seals, four harbor seals, and one California sea lion were taken (Fig. 2D). Seven scavenging events were documented, and of these, two were northern elephant seals, and five were large whales including gray, *Eschrichtius robustus*, humpback, *Megaptera novaeangliae*, blue, *Balaenoptera musculus,* and sperm, *Physeter macrocephalus,* whales.

There were six records of attacks on five people and one dog, all of whom survived. Of these attacks, three were on abalone or spear divers, two were on surfers, and one was on a dog swimming off a boat. All attacks were near-shore in water <10 m deep, and occurred between August and November. The divers and the dog were over rocky bottom and the surfers were over sand.

During decoy surveys, we were able to identify 19 individual white sharks. Of these, one was previously identified at SFI on 5 October 1991, then resighted 3 years later at Tomales Point at PRNS on 28 September 1994 (Anderson and Goldman 1996). A second individual, a female, was photographed feeding on a dead gray whale carcass on 8 August 1999 off the Point Reyes Headlands and then reidentified 73 days later at SFI on 19 October 1999. A third shark, a male, was tagged by the first author (SDA) at SFI with a pop-off satellite archival tag on 30 October 1999. The tag popped off on 1 December 1999 off McClures Rock and was recovered a week later just north of McClures Beach at Driftwood Beach (Boustany et al. 2002). Six sharks were resighted in the same area within a week or two, in the same fall and winter season. For example, we identified the same female on 22 October, 30 November, and 3 December 2004, but we found no matches of the same shark in PRNS resighted in any other year. This pattern differs from SFI where biologists see many of the same sharks year after year (Klimley and Anderson 1996). The sex ratio of the 19 individual white sharks identified was 4 males to 9 females, with 6 not sexed.

From 1994 to 2003, there were 103 hours of decoy deployment off Tomales Point and Bird Rock, with a total of 17 observations, averaging one every 6.1 hours. However, in the fall 2004 season in 13 days, we deployed decoys over 50 hours with 28 observations, or one observation for every 1.8 h of deployment. By year, the number of observations ranged from 1 (in 1994) to 28 (in 2004).

DISCUSSION

White sharks are a primary marine predator at Point Reyes, and yet, little is known of the shark's habits and preferred prey at this location (Ainley et al. 1981, Ainley et al. 1985, Kelly and Klimley 2003). Point Reyes poses difficulties in the study of sharks due to inclement weather (fog and wind) and treacherous seas near rocky shores; consequently, the data presented here are conservative, and are constrained by studying an uncommon, secretive species in a logistically difficult environment. We therefore consider these data as preliminary and not definitive patterns.

Spatial Distribution, Habitat Use, and Prey

There are two pronounced patterns in shark sighting data at PRNS. First, most observations were clustered in three areas: the Point Reyes Headlands, McClures Rock, and Tomales Point. Second, most observations were close to shore in water depths from 5 m to 30 m. Similarly, at SFI, most shark predation occurred in depths from 5.5 m to 36.6 m and were within 400 m of shore (Klimley et al. 1992). At PRNS, we found that the majority of sightings were in similar depths as SFI. Most observations occurred in

depths < 30 m; 63% were in water <10 m deep, and 90% were within 800 m of shore. Only one predation event was observed well off shore (5.5 km); all other sightings that were > 1.5 km from shore were scavenging events. At SFI, researchers found that the sharks stayed close to the bottom in <30 m depth, and when in water depths >90m, they drifted off the bottom, staying at a constant depth (Goldman and Anderson 1999). Researchers speculate that the sharks are keeping sight of the surface where they capture their prey near seal rookeries (Strong et al. 1992, Goldman and Anderson 1999). If this is the case, then water clarity should affect the depth at which the sharks are swimming and, if the waters were less clear or murky, sharks might come into shallower water closer to shore. Likely, the sharks are just offshore in a narrow band where water depth is 5-30 m, searching for prey.

At PRNS, white sharks are in an ideal location to prey on pinnipeds that congregate onshore and to scavenge on marine mammal carcasses (especially whales) that are entrained in nearshore currents. One should not underestimate the energy a dead cetacean represents compared to pinnipeds, which can be difficult and dangerous to capture. For example, a large white shark (~943 kg) can survive up to 45 days after feeding on 30 kg of blubber (Carey et al. 1982). Consequently, scavenging events may represent a primary food source for sharks. Scavenging events can attract as many as four white sharks to feed at one time, such as occurred on a sperm whale carcass in 2004 and when a humpback whale carcass drifted into Drakes Bay on 2 October 2000 and out again 7 days later (Kelly and Klimley 2003, Curtis et al. 2006). Large dead marine mammals such as sperm whales, northern elephant seals, or baleen whales, can leave an odor corridor that can be carried for many kilometers (Carey et al. 1982). These odor corridors move uniquely depending on the wind and nearshore currents at the time. We speculate that white sharks close to shore detect these odor corridors and follow them to the source.

Numerous dead marine mammals are entrained in the nearshore eddies of Point Reyes and therefore provide excellent feeding opportunities for sharks. Many carcasses subsequently wash ashore on the beaches (Long and Jones 1996; National Marine Mammal Stranding Network, National Park Service, Unpubl. Data). PRNS juts 14 km into the ocean from the main coast and has two large beach areas where carcasses deposit. Point Reyes Beach faces northwest and Drakes and Limantour beaches face south. As a result of these conditions, thousands of stranded seabirds, fishes, sharks, turtles, pinnipeds and whales (Long et al. 1996) strand at PRNS, and many of the marine mammal carcasses have evidence of white shark bites (Long and Jones 1996, National Marine Mammal Stranding Network, Unpubl. Data, National Park Service, Unpubl. Data). While in this study we only looked at direct evidence of shark sightings, it is evident that some shark-bitten carcasses not in this study were fed upon by sharks near shore before beaching (Long and Jones 1996).

Pinnipeds are another important food source and white sharks can move inshore where pinnipeds congregate to reproduce, rest, and molt at terrestrial colonies throughout PRNS. Pinnipeds also forage intensively throughout PRNS in likely response to changes in prey abundance such as Pacific herring, *Clupea pallasi*, and salmonid runs in and adjacent to Tomales Bay during the winter (January to March),

northern anchovy, *Engraulis mordax*, and Pacific sardine, *Sardinops sagax*, in summer and fall. Most pinniped species congregate at Point Reyes Headlands and total estimated numbers of all species combined can exceed 5000 during annual peaks[1] (Sydeman and Allen, 1999). However, approximately 1000 harbor seals also haul out around Bird Rock at Tomales Point and on sand bars in the outer bay waters of Tomales Bay, adjacent to Tomales Point[1]. Over one thousand harbor seals also congregate at Drakes Estero, where white sharks were documented just offshore in this study[1]. Hundreds of California sea lions also haul out at Bodega Rock <10 km from Tomales Point during the fall and winter (Lowry and Forney 2005).

Seasonally, most sharks were observed at PRNS in the late summer and fall (Fig. 2A). The monthly peak observations of sharks also appeared to coincide with the seasonal peaks of pinnipeds (Fig. 2B). Harbor seal numbers, for example, peak in July during the annual molt when several thousand seals congregate at numerous locations at PRNS. Northern elephant seal numbers peak three times per year, coinciding with the fall juvenile haul out, the winter breeding season, and the spring molt. California sea lions congregate in the area when mostly males migrate north in the fall and likely forage on Pacific herring and salmon around Tomales Point and Tomales Bay. Thus, two pinniped species peak locally in the fall.

The seasonal peaks in pinniped numbers coincide with their respective annual activities related to foraging, breeding, and molting at PRNS. With multiple species numbers peaking during the same period such as July to October, there are increased opportunities for shark predation. Surprisingly, unlike ANI and SFI, pinniped prey identified at PRNS were not primarily northern elephant seals. However, we were unable to identify prey during many predation events (Ainley et al. 1985, Klimley et al. 1996). Also, off PRNS, 9 of the 30 predation events were in the area of McClures Rock and Tomales Point, where elephant seals generally do not occur (Sydeman and Allen 1999). Conversely, 21 predation events were near the Point Reyes Headlands where elephant seals are common, and 4 of the 5 pinniped species occur. Prior research at ANI and SFI concluded that the northern elephant seal was the preferred prey at those sites (Ainley et al. 1985). We suggest that this may not have been the case at PRNS, and that the white sharks off PRNS were preying mostly on California sea lions and harbor seals. California sea lions and harbor seals occur throughout PRNS waters and onshore; whereas elephant seals primarily occur at Point Reyes Headlands and adjacent beaches. Conversely, researchers only identified two harbor seals as prey from over 300 documented predation events at the SFI (S. Anderson, pers. obs.). Ainley and others (1985) also reported that sharks at PRNS fed primarily on harbor seals; however, much of the data from that study preceded the colonization of elephant seals at PRNS. Since 1980, the elephant seal colony at PRNS has increased exponentially, and in 2005 exceeded 2000 elephant seals during the breeding season (Sydeman and Allen 1999; S. Allen, Unpubl. Data). As the colony continues to grow and expand throughout PRNS, white sharks may switch from harbor seals and sea lions to elephant seals.

Regardless of prey, the number of sightings of white sharks at PRNS appeared lower than at SFI. At SFI, the sightings averaged once every 1.9 hrs of decoy deployment, compared to once every 6.0 hrs at PRNS (Anderson et al. 1996b). This difference may

be an artifact of a lower sample size at PRNS, since decoy survey deployment methods were the same at the two sites.

Sex Ratios and Movements

The white sharks sexed at PRNS were mostly female: 9 females to 4 males. Despite small sample sizes, this differs from SFI, where the ratio was essentially reversed - 8 females to 14 males. At SFI, male sharks are seen every year, whereas females are seen every other year (Anderson and Pyle 2003). Male and female white sharks off PRNS may have the same temporal pattern as at SFI and may segregate. Other shark species are known to segregate according to sex. For example; another lamnid, the salmon shark, segregates according to sex in Prince William Sound, Alaska where at least 98% are female (Scot Anderson**,** pers. observation).

The movements of white sharks to and from PRNS can be looked at individually and socially. While the record is thin, some evidence exists of individual movement between PRNS and SFI. We have records of sharks documented in PRNS moving to SFI and from SFI to PRNS in the same and alternate seasons (data from this study). We have also seen three observations of the same shark in the same area over a 42-day period off Tomales Point. The reversed sex ratios between PRNS and SFI indicate that these may be two different groups of sharks. Researchers at SFI also see many of the same sharks throughout the season. So while there is some movement of sharks between SFI and PRNS, it appears to be minimal, even though PRNS and SFI are only 28 km apart.

HUMAN INTERACTIONS

The attacks that took place in PRNS during the study period show where humans and white sharks overlap. All attacks occurred in the fall close to shore in water <10 m deep, and all the victims survived. Humans who dive for abalone, spearfish, or surf in open water in or near areas where sharks have been sighted or near seal colonies appear to be at the highest risk of attack. When measured as person-hours in the water, the risk at PRNS may be higher for those people who surf or dive than for those in southern California (south of Point Conception) where white shark observations are rare (Miller and Collier 1980, McCosker and Lea 1996, McCosker and Lea 2006).

CONCLUSIONS

The data presented here on white shark observations in and around PRNS have shown that white sharks in California follow a pattern of preying on primarily pinnipeds in the fall and early winter but can occur in most months of the year (McCosker and Lea 2006), as described at both SFI and ANI. This limited dataset suggests that harbor seals and sea lions may be important prey at PRNS, compared to SFI where northern elephant seals are the primary prey. Habitat, as measured by water depth, distance from shore, and time of year where and when white sharks occur, is similar for PRNS, SFI, and ANI. Lastly, PRNS provided an opportunity to compare shark presence in sandy versus

rocky habitats since SFI is almost entirely rocky habitat. We found the shark encounters are primarily in the rocky habitats of Tomales Point and Point Reyes Headlands; although, sharks do occur off sandy beaches such as Limantour Beach where there are whale carcasses and seal colonies.

ACKNOWLEDGMENTS

This paper is dedicated to the late G. Chan, professor of biology at the College of Marin. We thank the staff of the Point Reyes National Seashore, Gulf of the Farallones National Marine Sanctuary and Cordell Bank National Marine Sanctuary. We also thank A. Boustany, M. Mongozan, A. Molina, R. Bajajos, T. Baty, W. Booth, S. Koenig, R. Stallcup, B. Andreozzi, C.M. Prier, T. Curtis, J. Kelly, J. Turanto, D.L. Huntwork, M. Jenssen, J. Sellagman, R. Evans, J. Clark, D. Press, G. Conde, K. Goldman, R. Ridge and T. Tanner. J. Kinyon and D. George provided advice on Fig. 1. Comments by R. Lea, G. Cailliet, and two anonymous reviewers greatly improved this paper.

LITERATURE CITED

Ainley D.G., R.P. Henderson, H.R. Huber, R.J. Boekelheide, S.G. Allen, and T.L. McElroy. 1985. Dynamics of white shark/pinniped interactions in the Gulf of the Farallones. Memoirs 9:109-122.

Ainley D.G., H.R. Huber, R.P. Henderson, T.J. Lewis, and S.H. Morrell. 1981. Predation by sharks on pinnipeds at the Farallon Islands. Fishery Bulletin 78:941-945.

Allen S.G., H.R. Huber, C.A. Ribic, and D.G. Ainley. 1989. Population dynamics of harbor seals in the Gulf of the Farallones, California. California Fish and Game:224-232.

Anderson S.D., and K.J. Goldman. 1996. Photographic evidence of white shark movements in California waters. California Fish and Game 82:182-186.

Anderson S.D., P.R. Henderson, P. Pyle, and D.G. Ainley. 1996a. White shark reactions to unbaited decoys. Pgs. 223-228. *In:* Klimley A.P. and D.G. Ainley, Eds. Great White Sharks: The Biology of *Carcharodon carcharias*, Academic Press, San Diego.

Anderson S.D., A.P. Klimley, P. Pyle, and R.P. Henderson. 1996b. Tidal height and white shark predation at the Farallon Islands, California. Pgs. 275-279. *In:* Klimley A.P. and D.G. Ainley, Eds. Great White Sharks: The Biology of *Carcharadon carchadias*, Academic Press, San Diego.

Anderson S.D., and P. Pyle. 2003. A temporal, sex-specific occurrence pattern among white sharks at the South Farallon Islands, California. California Fish and Game 89:96-101.

Boustany A.M., S.F. Davis, P. Pyle, S.D. Anderson, B.J. LeBoeuf, and B.A. Block. 2002. Expanded niche for white sharks. Nature 415:35-36.

Carey F.G., J.W. Kanwisher, O. Brazier, G. Gabrielson, J.G. Casey, and H.L. Pratt. 1982. Temperature and activies of a white shark, *Carcharodon carcharias*. Copeia 1982:254-260.

Castro J. 1983. The Sharks of North American Waters, Vol. Texas A&M University Press, College Station.

Curtis T.H., J.T. Kelly, K.L. Menard, R.K. Laroche, R.E. Jones, and A.P. Klimley. 2006. Observations on the behavior of white sharks scavenging from a whale carcass at Point Reyes, California. California Fish and Game 92:113-124.

Goldman K.J., and S.D. Anderson. 1999. Space utilization and swimming depth of white sharks, Carcharodon carcharias, at the South Farallon Islands, Central California. Environmental

Biology of Fishes 56:351-364.
Kelly J.T., and A.P. Klimley. 2003. The occurrence of the white shark, *Carcharodon carcharias*, at the Point Reyes Headlands, California. California Fish and Game 89:187-196.
Klimley A.P., and S.D. Anderson. 1996. Residency patterns of white sharks at the South Farallon Islands, California. Pgs. 365-373. *In:* Klimley A.P. and D.G. Ainley, Eds. Great White Sharks: The Biology of *Carcharodon carcharias*, Academic Press, San Diego.
Klimley A.P., S.D. Anderson, P. Pyle, and R.P. Henderson. 1992. Spatiotemporal patterns of white shark *(Carcharodon carcharias)* predation at the South Farallon Islands, California. Copeia 1992:680-690.
Klimley A.P., B.J.L. Boeuf, K.M. Cantara, J.E. Richert, S.F. Davis, S.V. Sommeran, and J.T. Kelly. 2001. The hunting strategy of white sharks *(Carcharodon carcharias)* near a seal colony. Marine Biology 138:617-636.
Klimley A.P., P. Pyle, and S.D. Anderson. 1996. The behavior of white sharks and their pinniped prey during predatory attacks. Pgs. 175-191. *In:* Klimley A.P. and D.G. Ainley, Eds. Great White Sharks: The Biology of *Carcharodon cacharias*, Academic Press, San Diego.
Long D.J., K.D. Hanni, P. Pyle, J. Roletto, R.E. Jones, and R. Bandar. 1996. White shark predation on four pinniped species in central California waters: Geographic and temporal patterns inferred from wounded carcasses. Pgs. 263-274. *In:* Klimley A.P. and D.G. Ainley, Eds. Great White Sharks: the Biology of *Carcharodon carcharias*, Academic Press, San Diego.
Long D.J., and R.E. Jones. 1996. White shark predation and scavenging on cetaceans in the eastern North Pacific Ocean. Pgs. 293-307. *In:* Klimey A.P. and D.G. Ainley, Eds. Great White Sharks: the Biology of Carcharodon carcharias, Academic Press, San Diego.
Lowry M.S., and K.A. Forney. 2005. Abundance and distribution of California sea lions (*Zalophus californianus*) in central and northern California during 1998 and summer 1999. Fish Bull 103:331-343.
McCosker J.E. 1985. White shark attack behavior: Observations of and speculations about predator and prey strategies. Memoirs of the Southern California Academy of Sciences 9:123-135.
McCosker J.E., and R.N. Lea. 1996. White shark attacks in the Eastern Tropical Pacific Ocean: an update and analysis. Pgs. 419-434. *In:* Klimley A.P. and D.G. Ainley, Eds. Great White Sharks: The Biology of *Carcharodon carcharias*, Academic Press, San Diego.
McCosker J.E., and R.N. Lea. 2006. White shark attacks upon humans in California and Oregon, 1993-2003. Proceedings of the California Academy of Sciences 57:479-501.
Miller D.J., and R. Collier. 1980. Shark attacks in California and Oregon, 1926-1979. California Fish and Game 67:76-104.
Strong W.R., R.C. Murphy, B.D. Bruce, and D.R. Nelson. 1992. Movements and associated observations of bait-attracted white sharks *(Carcharodon carcharias)*: A preliminary report. Australian Journal of Marine and Freshwater Research 43:13-20.
Sydeman W.J., and S.G. Allen. 1999. Pinniped population dynamics in central California: Correlations with sea surface temperature and upwelling indices. Marine Mammal Science 15:446-461.
Wing S.R., L.W. Botsford, S.V. Ralston, and J.L. Largier. 1998. Meroplanktonic Distribution and Circulation in a Coastal Retention Zone of the Northern California Upwelling System. Limnology and Oceanography 43:1710-1721.

Received: 27 January 2007
Accepted: 14 April 2007