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ECOLOGICAL STUDIES OF SABLEFISH IN MONTEREY BAY

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From a 1973–1974 baseline study, 3681 sablefish were collected, 2630 of which were from traps set at four regular depths, and the additional 1,051 from commercial fishing activities. The traps were very selective at depths greater than 549 m, but incidental species of both invertebrates and fishes outnumbered sablefish in traps set at 91 m. Catch rates at this shallow depth were consistently low, and higher catch rates occurred in traps set between 549 and 1372 m. Sablefish increased in mean size with depth, and the highest percentage of "large" fish (greater than 64 cm SL) was found between 914 and 1372 m. Seasonality was characterized by elevated catch rates and the presence of larger fish during the summer months in waters shallower than 193 m, whereas little seasonality in sablefish numbers occurred in deeper waters. Overall, female sablefish predominated, with males most numerous among small fish. Sablefish in Monterey Bay spawned between November and February in waters deeper than 549 m, and more ripe individuals were found in the larger size classes in deeper waters. Stomach content analysis of 314 fish indicated that sablefish shift their diets as they get larger and move to deeper waters from pelagic fishes and cephalopods to more demersal fishes and crustacean prey. Coincident with this dietary shift was an increase in the intensity of infection of larval nematodes. A total of 164 of the 1450 sablefish tagged and released during the study was recaptured during the subsequent eight years. Accurate information on date and location of recapture for 121 of these individuals indicates that most did not migrate out of the Monterey Submarine Canyon. Of the 10 fish recaptured out of the general area, nine had moved north, and only one had moved south.

INTRODUCTION

Despite the continually growing body of literature on the natural history and fishery biology of the sablefish, *Anoplopoma fimbria,* much still needs to be known about the ecology of local populations and how it differs among areas. Sablefish range from relatively shallow waters as juveniles to depths over 1500 m as adults (Phillips 1954, Phillips and Imamura 1954, Shubnikov 1963, Heyamoto and Alton 1965, Miller and Lea 1972, Hart 1973, Parks and Hughes 1981). They spawn during the winter in deep waters, mature between 5 and 7 years old, live at least to 20 years (Beamish and Chilton 1982), produce numerous eggs and larvae, which develop in surface waters, and spend several years in shallow water before entering the demersal, commercial fishery (Low, Tanonaka, and Shippen 1976, DeWees 1980). Sablefish are top carnivores, which have been reported to opportunistically feed primarily on fishes, cephalopods, and crustaceans (Shubnikov 1963, Conway 1967, Grinols and Gill 1968, Low et al. 1976, Shaw 1984). Long migrations have been reported from tag returns, but in general they appear to exhibit little exchange among areas and are localized in their distribution (Holmberg and Jones 1954, Phillips 1969, Low et al. 1976).

Prior to 1973, the sablefish fishery in Monterey Bay involved only a few boats and was primarily a longline operation, but shifted to a trap fishery in that year (Phillips 1954, 1958, Parrish 1973, James Hardwick, Calif. Dept. Fish and Game, pers. comm.). These traps were developed by the gear research base of the National Marine Fisheries Service in Seattle (Hughes et al. 1970, High 1971, Parks 1973, Low et al. 1976), and have proven to be quite effective at selectively capturing sablefish. Since little information was available about the feasibility of using such traps in the local Monterey Bay sablefish fishery, and little ecological information was available about the local population of sablefish, this baseline study was undertaken. The major objectives were to (i) determine the catch rates and size frequencies of sablefish caught in traps set at different depths and during different seasons, (ii) characterize their reproductive cycles, feeding habits, and parasite fauna, and (iii) evaluate their migratory patterns through tagging studies.

MATERIALS AND METHODS

Sablefish were collected primarily using traps, but otter trawls, hook-and-line, and gill nets were also employed. Commercial lampara net and purse seine catches of anchovy and squid were also sampled for juvenile sablefish, and additional specimens were obtained from the local commercial trap fishermen.

Our traps were based upon a design described by Hipkins (1974), and were constructed of 1.3 cm reinforcing bars, welded together so they formed a rectangular frame box 76.2 cm x 76.2 cm x 182.9 cm. Nylon netting, 8.9 cm stretch mesh, was hung with nylon twine from the rectangular frame with a funnel made of the same material at one end. The netting on the door at the other end was hung with cotton twine so that it would serve as a escape panel in the event the trap was lost. The bait was held in a plastic jar, perforated with 2 mm holes so that odors could diffuse out, yet not allow hagfishes or amphipods to enter and consume the bait. Baits included market squid, *Loligo opalescens,* northern anchovy, *Engraulis mordax,* Pacific herring, *Clupea harengus pallasi,* and various demersal fishes.

Three traps were generally placed 110 m apart on a 1.3 cm ground line that was tethered to a buoy line at one end. The buoy line was approximately 25% longer than the depth of the water and had a support buoy and a spar buoy with a radar reflector and red flag attached at the surface end.

Stations were located in the Monterey Submarine Canyon (Figure 1), with stations A and B at 915 m (500 fm), C and D at 549 m (300 fm), E and F at 183 m (100 fm), and G and H at 91 m (50 fm) of water. These stations were chosen primarily for their depth and bottom topography. Occasional samples were taken at depths exceeding 915 m, but these depths were not sampled regularly. Sampling at the regular stations was conducted on a monthly basis from November 1973 to November 1974. Weather conditions occasionally prevented monthly samples at all depths.

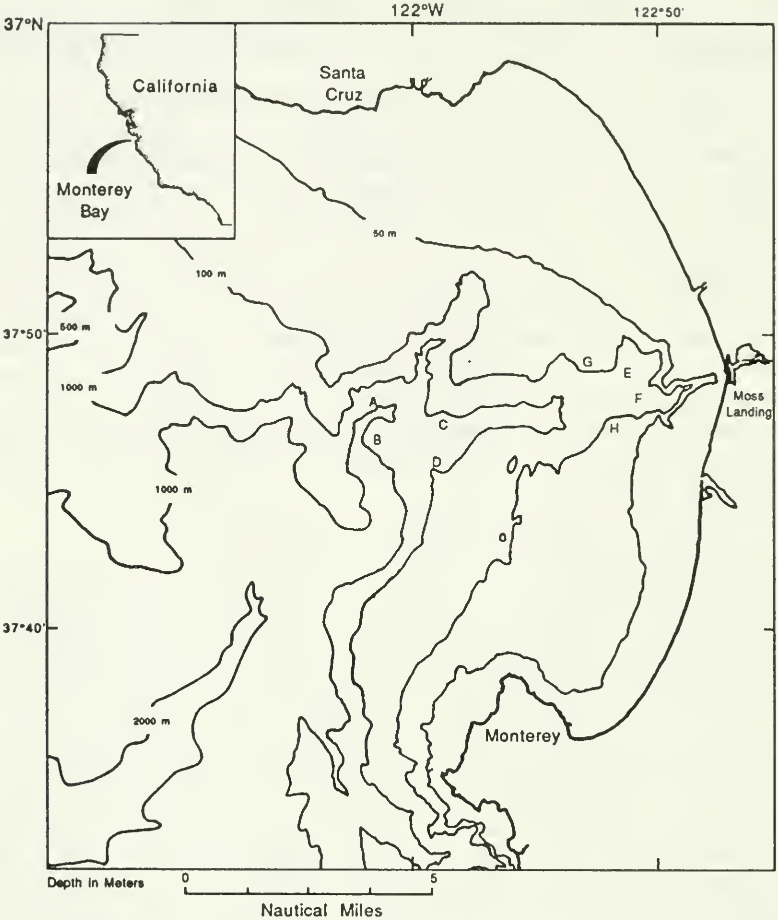

FIGURE 1. Monterey Bay, California, and the Monterey Submarine Canyon with depth contours given in fathoms. Station locations are labelled A–H. Stations A and B are at 915 m (500 fms), C and D at 91 m (50 fms), E and F at 183 m (100 fms), and G and H at 91 m (50 fms).

Fish captured in the traps were either tagged and returned alive to the water or were saved and dissected. Fish to be tagged were immediately removed from the trap and placed in galvanized washtubs or plastic-lined boxes filled with running seawater. When catches were too large for the holding tanks, the remaining fish were kept in the trap and sprayed with seawater or the trap was lowered back into the water until the fish could all be tagged. Serially numbered anchor tags (Floy Tag and Manufacturing Company), with the address of the Moss Landing Marine Laboratories printed on them, were securely inserted on the left side of the fish, ventral and posterior to the origin of the first dorsal fin, with a tagging gun (Floy FD-67) (Kennedy and Smith 1972). Prior to release, standard lengths (SL) were recorded and a scale sample was taken. Upon being returned to the water, the condition of the tagged fish was categorized as: good, fair, or poor.

Sablefish collected were usually processed at sea. Measurement of standard length to the nearest 0.5 cm, weight to the nearest 0.5 lb (0.227 kg), and sex were recorded. Fork length can be calculated by multiplying standard length by 1.08 (Heizer 1967) and total length by 0.938 (Phillips 1954). The gonads, and stomach and intestines were removed and fixed in 10% formalin and were later changed to 40% isopropyl alcohol. The gonads were analyzed for reproductive maturity and the gut retained for feeding habit studies. Otoliths and scales were taken for age determination. Other species of fishes and invertebrates caught in traps at the different depths were tabulated. In addition to size frequency distribution using 2 cm size intervals, sablefish from each trap were counted and sorted into the three size classes commonly used by sablefish buyers: "small," less than 5 lb (2.27 kg); "medium," 5–7 lb (2.27–3.18 kg); "large," more than 7 lb (3.18 kg). In tagging, where only the standard length was recorded, the weight of a fish was derived from an empirical regression equation ($W_{lb} = (0.00002)\ SL_{cm}^{3.08}$; $r = 0.959$) by the method of least squares. Percent composition by number of the three size classes of sablefish was calculated for different depths and seasons. Catch rates, in numbers per trap and weight of fish per trap, were calculated for different depths and seasons. Only intact fish were counted. Size frequencies of fish from all collecting methods were compared among depths and seasons.

Gonad indices were calculated using the formula:

$$\text{G.I.} = \frac{\text{Weight of gonad (gm)}}{\text{Weight of fish (gm)}} \times 100.$$

Gonad indices were compared by depth and season for different size classes of sablefish.

The stomachs to be used for feeding habit analysis were dissected on shore; their contents were removed, identified to the lowest possible taxa, and counted, and relative volumes were estimated. Taxa often overlapped because unidentified fishes was a separate category than a given species of fish. Prey importance was measured as percent by number, percent by volume, percent frequency of occurrance, and by the combined Index of Relative Importance (I.R.I.) of Pinkas et al. (1971), which equals the sum of the percent by number and by volume multiplied by the percent frequency of occurrence. Feeding habit data were separated into the three size classes already defined, which roughly correspond to increasing depths of occurrence. Sufficiency of sample size was evaluated by plotting cumulative prey taxa against number of stomachs (see Cailliet 1977).

Mesenteric larval nematodes were identified (Smith and Wooten 1978) and counted. The intensity (number of parasites per each infected host) was plotted against the standard length of the host.

When we recaptured fish or fish were returned to us by fishermen, information on their recapture location, depth, date, time, collecting method, and size was recorded when available. Time at large was calculated, and distance traveled was estimated using the most reasonable linear pathway on a nautical chart. Frequency histograms of times at large were prepared, and recapture locations were plotted both for Monterey Bay and California-Oregon coast recaptures. Changes in depth of occurrence between original tagging location and subsequent recapture site were noted. For those fish with accurate measurements, mean growth increments, in cm per year, were calculated.

RESULTS

From fall 1973 through 1974, 203 traps were set, capturing 2630 sablefish (Table 1). Of these, 1450 were tagged, measured, and released. In addition, 1051 sablefish from other sources were sampled.

TABLE 1. Fishes and Invertebrates Caught in Sablefish Traps.

	DEPTH (meters)			
SPECIES	*91*	*183*	*300*	*915*
Fishes:				
Anoplopma fimbria	27	619	875	1109
Antimora microlepis			1	6
Citharichthys sordidus	87	1		
Coryphaenoides acrolepis				11
Albatrossia pectoralis				1
Echinorhinus cookei			1	
Eopsetta jordani	1			
Eptatretus deani				17
Eptratretus stouti	132		1	
Merluccius productus	2			
Microstomus pacificus			3	
Ophiodon elongatus	25	3	2	
Paraliparis sp.				1
Sebastes spp.	1		2	
Sebastes melanostomus			1	
Sebastes paucispinis		1		
Sebastes pinniger	28			
Sebastes rosenblatti		2		
Sebastolobus spp.			3	
Somniosus pacificus			1	
Squalus acanthias	1			
Apristurus brunneus (egg case)			1	
Invertebrates:				
Allocentrotus fragilis			2	
Anthomastus ritteri			2	
Asteronyx loveni			2	
Brisaster townsendi		1		
Cancer antennarius	1			
Cancer magister	4			
Cancer productus	43			
Chionoecetes tanneri				1
Holothuroids			7	
Pleurobranchaea californica	2			
Rathbunaster californicus			3	
Salps	1			
Stylatula elongata			2	
Number of traps set:	34	44	77	48

Sablefish traps were extremely selective at all depths except 91 m, where the other species of fishes were five times as abundant (Table 1). Of the species caught incidentally in shallow water, the Pacific hagfish, *Eptatretus stouti,* the Pacific sanddab, *Citharichthys sordidus,* the canary rockfish, *Sebastes pinniger,* and the lingcod, *Ophiodon elongatus,* were the most commonly ~ncountered.

If Pacific hagfish catches are not considered in these shallow catches (they were caught only in early-model bait containers and are not adequately sampled, since they are smaller than the mesh), there were still three times more incidental fishes caught than sablefish. Excluding the 91 m samples, only 16 species of fishes and eight species of invertebrates were captured in sablefish traps, and the numbers of individuals of other species were greatly dominated by sablefish (2603 to 59). At these deeper stations, which are nearer the center of the depth distribution of sablefish, even fewer species were caught (Table 1). Notable among these were the Pacific grenadier, *Coryphaenoides acrolepis,* the giant grenadier, *Albatrossia pectoralis,* the black hagfish, *Eptatretus deani,* and the finescale codling, *Antimora microlepis.*

Catch rates increased with depth (Tables 1, 2). Catch rates of sablefish were consistently low at the 91 m stations with only 27 fish captured in 34 sets over the year. Both mean number and mean weight of sablefish per trap set were highest at the 915 m stations (Table 2).

TABLE 2. Mean Number of Fish and Mean Weight of Catch Per Trap for One-and Two-Day Sets. Numbers Represent Mean Values ± the 95% Confidence Intervals for the Mean. Mean Percents Were Calculated from the Percent of "Large" (>7 lb), "Medium" (5–7 lb), and "Small" (<5 lb) Fish For Each Trap.

	Depth (meters)			
	183	*549*	*915*	*≧1098*
Mean number of fish per trap......	17.1 ± 5.3	13.1 ± 3.9	26.4 ± 6.0	20.8 ± 6.1
Mean percent small fish	74.5 ± 10.5	47.2 ± 7.7	43.5 ± 7.6	5.9 ± 4.8
Mean percent medium fish	14.5 ± 7.3	21.8 ± 5.1	24.7 ± 3.9	27.1 ± 8.2
Mean percent large fish..........	4.9 ± 3.2	26.4 ± 7.3	31.8 ± 6.8	67.1 ± 5.4
Mean weight (kg) of catch per trap...........................	28.0 ± 9.5	34.6 ± 10.4	81.9 ± 19.8	80.8 ± 25.6
Number of traps	33	43	31	8

The mean sizes of sablefish increased with depth, with "small" fish predominating the catches from the shallow stations and "large" fish predominating deeper (Figure 3, Table 2). Fish caught with surface gear such as lampara nets and purse seines ranged from 18 to 26 cm SL, while otter trawl-caught sablefish ranged from 21 to 50 cm SL (Figure 2). Fish smaller than 33 cm SL were not retained by our traps, although small individuals were sometimes gilled by the mesh. The fish captured at 549 m averaged 55.9 ± 0.7 cm SL, and fish smaller than 40 cm SL were virtually absent from collections at this depth. Fish from the two deeper stations had significantly larger mean sizes (58.9 ± 0.6 cm SL and 64.1 ± 1.0 cm SL, respectively), a fact which is reflected in the significantly higher proportion of "large" fish taken at these two deeper stations. No fish smaller than 48 cm SL was caught at or below 1098 m. One trap set at 1830 m yielded four large sablefish.

Seasonal variations in size class were most prominent at the 183 m stations (Figure 3), where "small" fish constituted an overwhelming percentage of the catch. "Large" fish were absent there from September through February, and only a few "large" fish were present from March through August. "Medium" and "large" fish were more numerous at the 183 m stations during the summer months, while "small" fish became correspondingly less so. "Large" fish were more abundant at the 549 and 915 m stations, and the relative proportions of the three size classes caught at these two stations did not appear to differ much seasonally (Figure 3).

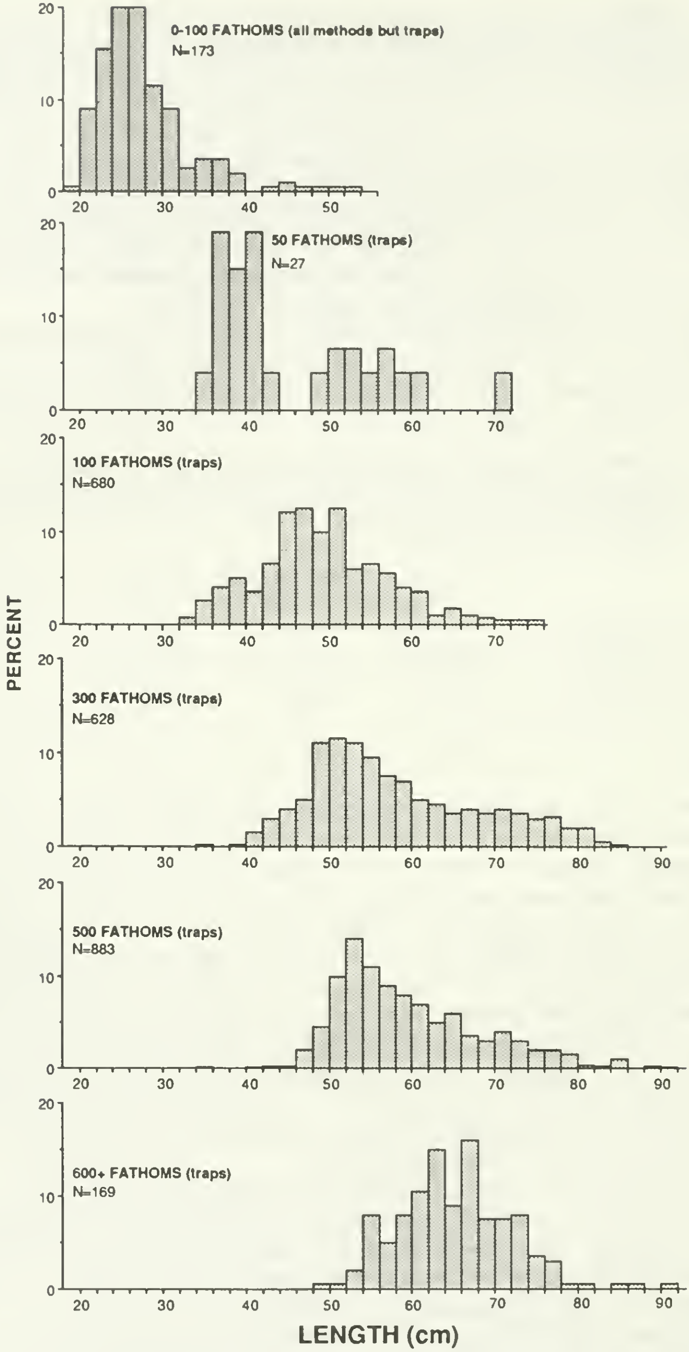

FIGURE 2. Percent length frequencies of sablefish by depth. For 0–183 m, fish were caught with otter trawls, purse seines, gill nets, and hook and line. Fish from all other depths were caught with traps. N = the total number of fish measured for standard length to the nearest 2 cm at each depth.

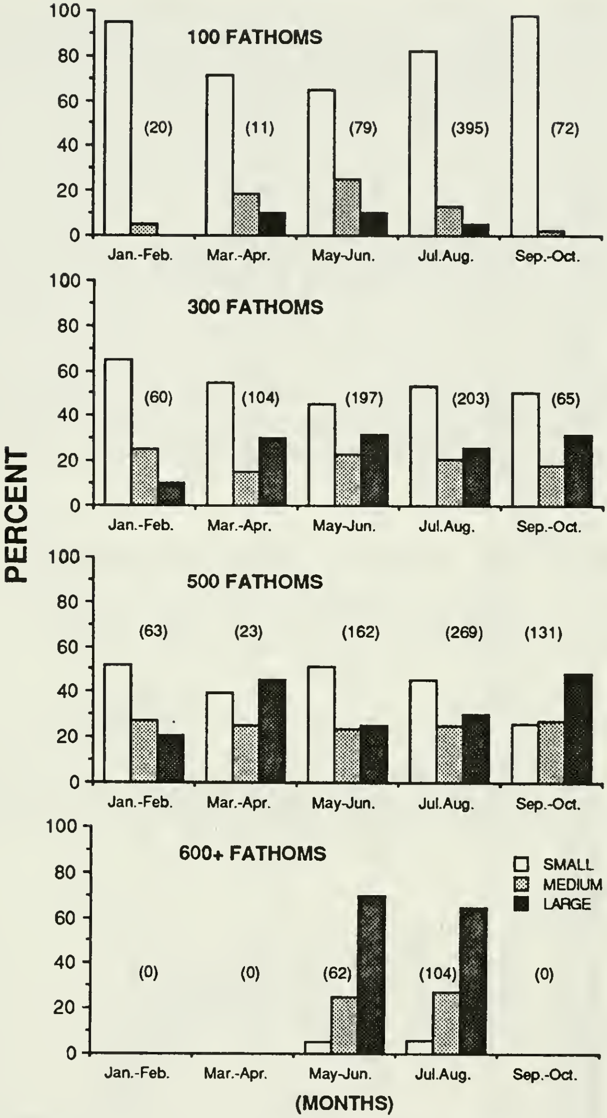

FIGURE 3. Seasonal variations in mean percent by number of "large" (>7 lb), "medium (5–7 lb), and "small" (<5 lb) sablefish at four sampling depths. The number of fish for each bimonthly period is given in parentheses.

The overall sex ratio for sablefish caught with all methods was one male to 3.64 females (22% male: Table 3). The sex ratios were closest to unity among small-sized sablefish but exhibited a striking predominance of females at all depths for the larger categories. The sex ratios for all depths combined were: for "small" sablefish, 1:1.4 (42% male); 1:9.9 (9% male); and for the "large" sablefish, 1:226 (0.4% male). Only one male was captured in the "large" category. Males outnumbered females only once at 915 m in the "small" category (Table 3).

TABLE 3. Mean Gonad Indices of Sablefish Captured in 1973–1974 by Depth of Capture and Bimonthly Intervals with 95% Confidence Intervals for the Mean. The Number Beneath Each Mean is Total Number of Individuals Sexed.

DEPTH		*MONTHS*					
(Meters)	*SEX*	*Jan.–Feb.*	*Mar.–Apr.*	*May–June*	*July–Aug.*	*Sept.–Oct.*	*Nov.–Dec.*
0–183	M	0.08 ± 0.05	0.05 ± 0.01	0.29 ± 0.25	0.14 ± 0.07	0.07 ± 0.1	0.04 ± 0.02 *
		6	17	10	27	23	4
	F	0.34 ± 0.10	0.16 ± 0.08	0.57 ± 0.07	0.54 ± 0.12	0.15 ± 0.04	0.05 ± 0.02 *
		12	32	57	91	40	15
549	M	0.11 ± 0.02	0.22 ± 0.20	0.34 ± 0.24	0.73 ± 0.53	1.76 ± 1.87	0.06 ± 0.02 *
		7	25	12	18	8	4
	F	1.16 ± 0.24	0.98 ± 0.15	0.98 ± 0.17	1.16 ± 0.41	2.41 ± 1.68	1.77 ± 0.76 *
		15	64	54	31	12	56
≧915	M	0.17 ± 0.58	0.24 ± 0.13	0.52 ± 0.31	0.90 ± 0.38	1.64 ± 1.75	2.39 ± 2.47
		10	8	9	34	9	5
	F	1.40 ± 91	1.41 ± 0.55	2.01 ± 0.42	2.30 ± 0.27	3.69 ± 0.72	4.05 ± 1.00
		19	20	106	115	63	60

* The fish used in these categories were from the 1973 season.

Gonad indices generally increased with fish size and with depth, and changed, in both males and females, seasonally (Table 3). These trends indicate that sablefish spawned from November through February in deeper waters, since the relative values were higher at the 915 m station than at either of the other more shallow ones, and the gonad indices for both sexes regularly increased as the year progressed from January-February until the following January-February. Gonad indices were low for both sexes in the smaller individuals in shallow waters and exhibited little noticeable seasonality.

Cumulative prey curves for stomach samples from the three size classes of sable fish indicated that sufficient samples were taken to characterize their feeding habits (Figure 4). The curve for "small" sablefish leveled at 12 stomachs, for "medium" fish at 18 stomachs, and for "large" fish at approximately 20 stomachs. The additional increases in this last curve were due to the occurrence of rare prey items which only occurred once in the analysis. In the "medium" fish, these trace prey items were drift seaweeds, *Callianassa,* and *Octopus,* while for the "large" sablefish, they were spider crabs, copepods, and isopods.

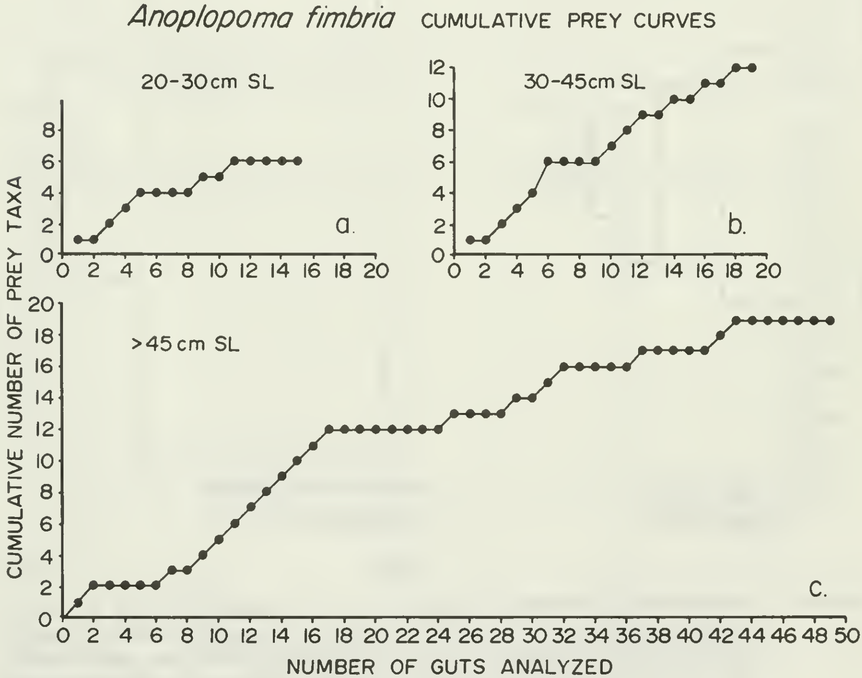

FIGURE 4. Cumulative prey taxa plotted against the number of sablefish guts analyzed for the three size classes to evaluate sufficiency of sample size. Most new prey items encountered after 10 guts in b and c were very rare.

"Small" sablefish, which generally occupy pelagic waters near the surface, fed primarily on pelagic fishes and cephalopods (Table 4, Figure 5). Their diet was dominated by the northern anchovy, but also contained the market squid, unidentified larval fishes, and the Pacific saury, *Cololabis saira.*

TABLE 4. Prey Items and Their Importance Values from 19 Stomachs of Sablefish, *Anoplopoma fimbria*, Between 20 and 30 cm SL from Monterey Bay, California. Higher Taxonomic Categories, Such as Fishes, Larval Fishes, and Cephalopoda, Could not be Identified into Smaller Taxa and Therefore Could Include Other Species Listed.

Prey Name	*% N*	*% V*	*% F*	*IRI*
Engraulis mordax	30.43	31.58	30.00	1860.30
Fishes (unidentified)	21.74	23.68	25.00	1135.50
Loligo opalescens	21.74	21.05	20.00	855.80
Larval fishes	13.04	10.53	10.00	235.70
Cololabis saira	4.35	5.26	5.00	48.05
Octopus spp.	4.35	5.26	5.00	48.05
Cephalopoda	4.35	2.63	5.00	34.90

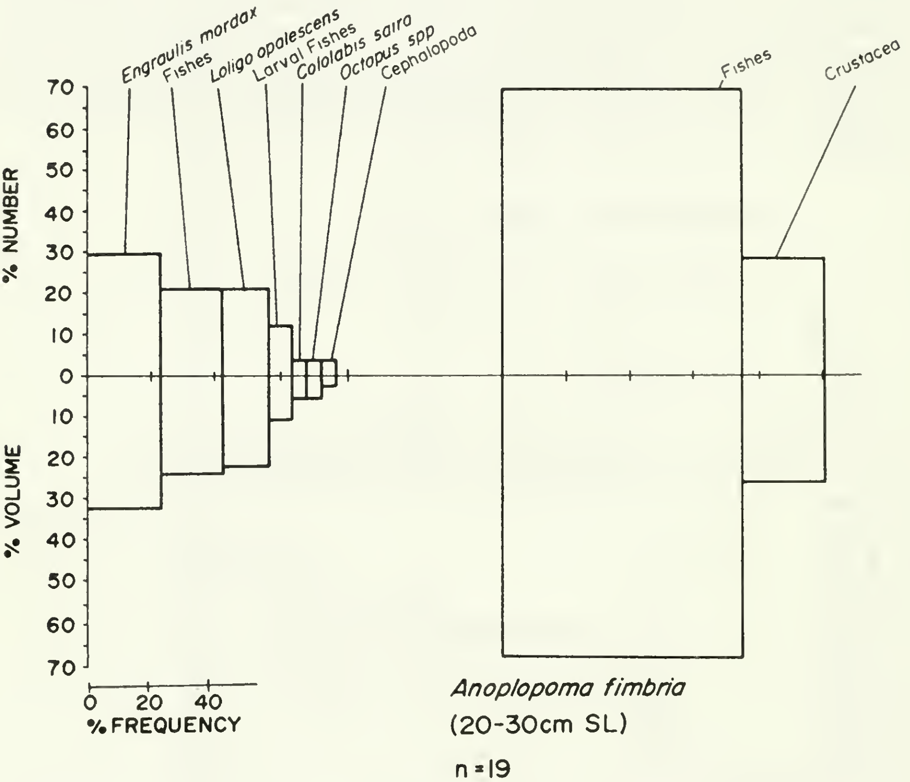

FIGURE 5. Index of relative importance diagrams of "small" sablefish to show the percent number, percent volume, and percent frequency of occurrence values for specific prey categories (left diagram), and prey lumped into broader taxa (right diagram). The percent frequency axis for each prey category is reset to 0%. Categories such as "fishes," "larval fishes," and "cephalopoda" represented unidentified remains of the general kind of organism.

"Medium" sablefish, which are estimated to be one to two years old (Beamish and Chilton 1982) and occupy intermediate depths between 91 and 549 m, switched to a diet of smaller crustaceans and fishes (Table 5, Figure 6). Their diet was dominated by euphausiids, amphipods, and small fishes, and occasional molluscs and polychaete worms were found.

TABLE 5. Prey Items and Their Importance Values from 46 Stomachs of Sablefish Between 30 and 45 cm SL from Depths of 50 to 300 Fathoms in the Monterey Submarine Canyon, California. Higher Taxa Could Not be Identified.

Prey Name	*% N*	*% V*	*% F*	*IRI*
Euphausiacea	82.12	15.73	12.50	1223.13
Amphipoda	14.62	24.20	23.44	909.94
Fishes (unidentified)	0.40	26.20	26.56	706.50
Orchomene spp.	2.32	5.72	6.25	50.25
Octopus spp.	0.09	6.49	6.25	41.13
Decapod shrimp	0.09	5.39	6.25	34.25
Polychaeta	0.12	4.40	3.13	14.15
Sebastes spp.	0.05	3.85	3.13	12.21
Decapod crab	0.02	2.20	1.56	3.46
Callianassa goniophthalma	0.02	2.20	1.56	3.46
Isopoda	0.02	1.32	1.56	2.09
Lampetra tridentata	0.02	0.88	1.56	1.41
Gonatus spp.	0.02	0.88	1.56	1.40
Drift seaweed	0.02	0.44	1.56	0.72
Cephalopoda	0.02	0.09	1.56	0.17
Pelecypoda	0.02	0.02	1.56	0.06

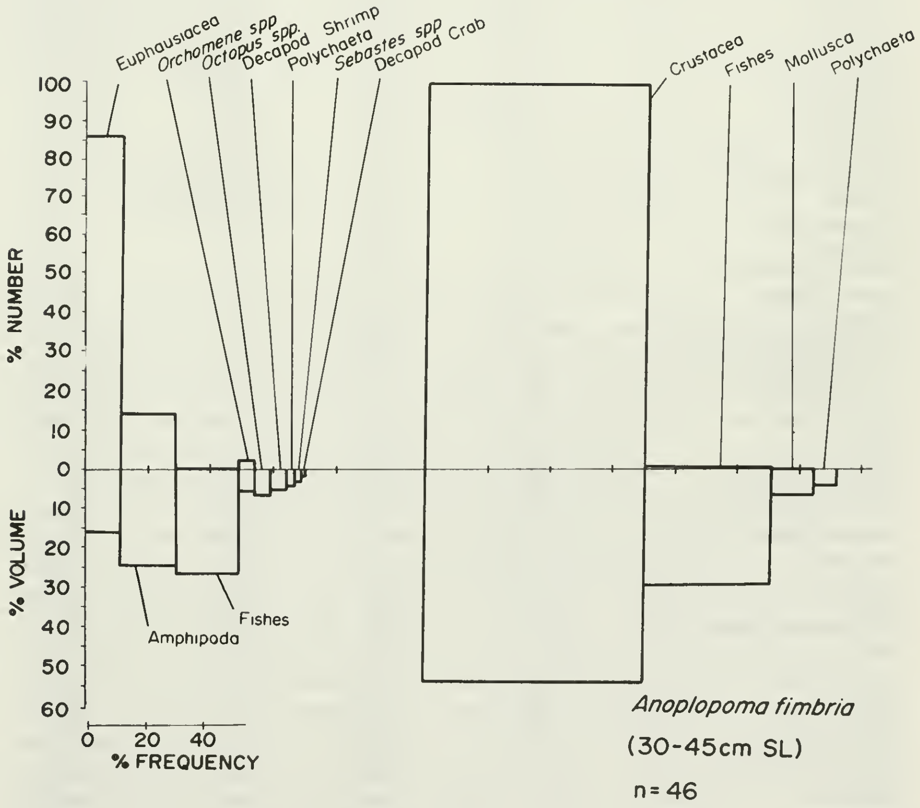

FIGURE 6. Prey of "medium" sablefish. See Figure 5 caption for details.

"Large" sablefish, which occupy deeper waters and are older then two years, consumed a much wider variety of prey (Table 6, Figure 7). Their diet was dominated by unidentifiable fish remains, presumably from the genera for which identifiable remains were noted: the Pacific hake, *Merluccius productus,* and the rockfishes in the genus *Sebastes.* These were followed quite closely by the crustaceans, including primarily euphausiids, amphipods, and decapod shrimp. Some molluscs, including cephalopods and octopods, were also found.

TABLE 6. Prey Items and Their Importance Values from 249 Stomachs of Sablefish over 45 cm SL from Portions Deeper than 300 Fathoms of the Monterey Submarine Canyon, California. In Some Cases, Higher Taxa (e.g., Fishes, Cephalopoda) Could not be Further Reduced. Others (Pleuronectiformes, Crustacea) Represent Further Reduction but may Still Include Lower Taxa (e.g., *Parophrys vetulus, Citharichthys sordidus*).

Prey Name	*% N*	*% V*	*% F*	*IRI*
Fishes (unidentified)	2.43	34.69	29.68	1101.72
Euphausiacea	76.71	3.81	4.90	394.55
Merluccius productus	0.57	8.84	6.92	65.12
Amphipoda	3.84	5.42	5.76	53.34
Decapod shrimp	0.64	5.37	7.49	45.01
Orchomene spp.	3.36	4.04	4.90	36.26
Cephalopoda	0.50	4.96	6.05	33.03
Octopus spp.	0.30	3.77	3.46	14.08
Fish eggs	9.19	0.85	0.86	8.63
Sebastes spp.	0.20	2.50	2.59	6.99
Pleuronectiformes	0.16	2.16	2.02	4.69
Polychaeta	0.20	1.95	2.02	4.34
Elasmobranch	0.14	2.02	1.73	3.74
Decapod crab	0.16	1.49	2.02	3.33
Crustacea	0.18	1.71	1.73	3.27
Terrestrial vegetation	0.14	1.55	1.73	2.92
Cnidaria	0.11	1.59	1.44	2.45
Eptatretus stouti	0.09	1.55	1.15	1.89
Pelecypoda	0.14	0.79	1.73	1.61
Chitonectes tanneri	0.09	1.29	1.15	1.59
Squalus acanthias	0.09	1.25	1.15	1.54
Gonatus spp.	0.14	1.09	1.15	1.41
Anoplopoma fimbria	0.05	0.81	0.58	0.50
Drift seaweed	0.07	0.49	0.86	0.48
Loxorhynchus spp.	0.05	0.75	0.58	0.46
Paralithodes spp.	0.05	0.40	0.86	0.39
Salpidae	0.05	0.56	0.58	0.35
Engraulis mordax	0.05	0.48	0.58	0.31
Microstomus pacificus	0.05	0.41	0.58	0.27
Citharichthys sordidus	0.02	0.40	0.29	0.12
Porichthys notatus	0.02	0.40	0.29	0.12
Gastropoda	0.02	0.40	0.29	0.12
Holothuroidea	0.02	0.40	0.29	0.12
Zoarcidae	0.02	0.40	0.29	0.12
Vampyrotheuthis infernalis	0.02	0.40	0.29	0.12
Bathylagus spp.	0.02	0.36	0.29	0.11
Parophrys vetulus	0.02	0.20	0.29	0.06
Isopoda	0.02	0.20	0.29	0.06
Lycodapus spp.	0.02	0.14	0.29	0.05
Gnathophausia ingens	0.02	0.06	0.29	0.02
Caprella spp.	0.02	0.02	0.29	0.01
Copepoda	0.02	0.00	0.29	0.01

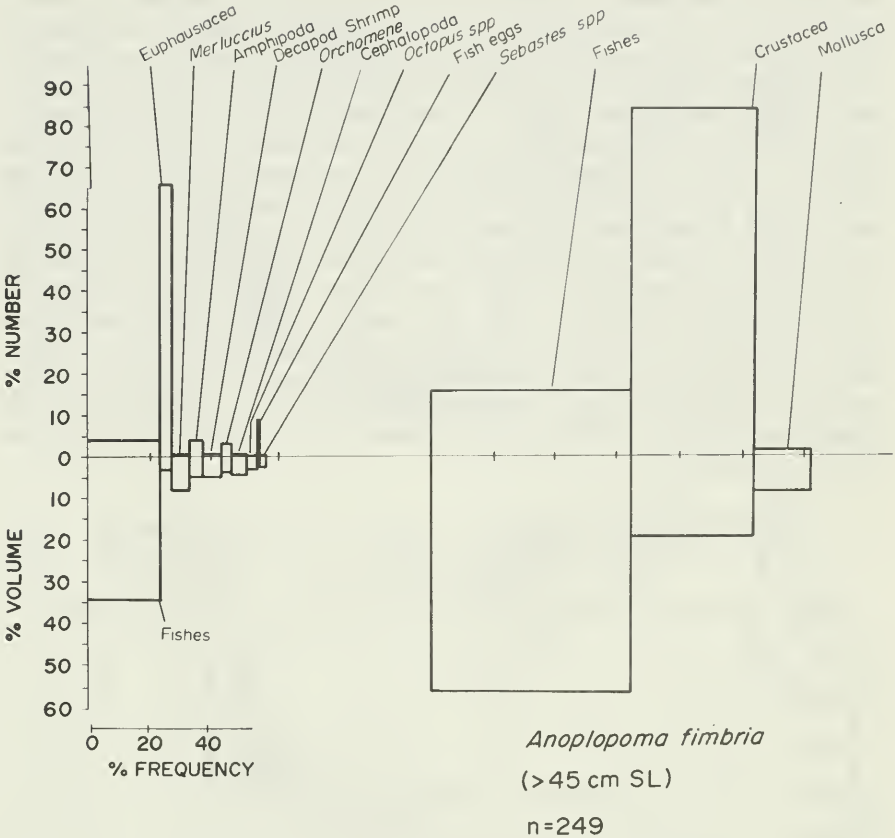

FIGURE 7. Prey of "large" sablefish. See Figure 5 caption for details.

Two genera of larval nematodes, *Phocanema* and *Anisakis* (Ascaridida: Anisakidae), were found in sablefish coeloms and intestinal tracts. The intensity of larval nematode infections in sablefish increased with host length and presumably with age (Figure 8). A similar curve of intensity versus host weight would presumably produce a more linear relationship.

In the eight years since tagged sablefish were released, 12.1% (178) were recaptured, most remaining in the Monterey Submarine Canyon (Figure 9). The majority of the tagged fish were recaptured within three years of the original tagging date; however, several returns came in as long as eight years later. The majority (91%) of the tags returned were from sablefish trap catches by commercial fishermen, while only 5% were from commercial trawlers. The remainder of the returns (4%) were from our own trap collections.

The recovery rates differed with condition of sablefish prior to release after tagging. Of the 169 fish tagged and released in poor condition, only 11 were recovered, a 6.5% recovery rate. The 256 fish in fair condition and the 871 fish in good condition yielded 9.4% and 14.0% recovery rates, respectively. Those released with unknown conditions yielded a 15.1% recovery rate. Thus, fish released in good condition appear to have a better survival rate and are more available for recapture. Considering these differences, the actual overall recovery rate was probably closer to 14%. Accurate information on date and location of recapture was available for 121 of these tag returns, and all but 10 of these were recaptured within the Monterey Submarine Canyon, very close to their original tagging site (Figure 9). Direction moved was difficult to assess, since sablefish recaptures tended to conform to depth contours within the canyon. A total of 74 "small" sablefish were recaptured; all but two of the returned fish had stayed within the canyon confines, and the majority of these were at large for less than two years (Figure 9a). Similarly, 58 "medium" fish were recaptured within Monterey Bay, all of which had remained in the canyon for less than two years (Figure 9b). Fewer "large" sablefish were recaptured, but the majority of these also were recaptured in the canyon axis within two years (Figure 9c). Those fish which were tagged in relatively shallow water (200–600 m) tended to be recaptured in deeper water, with 79% of them moving at least 200 m deeper. Those fish tagged in water between 600 and 1400 m deep were most often (84% of the recaptures) recaptured in water that was 200–300 m shallower.

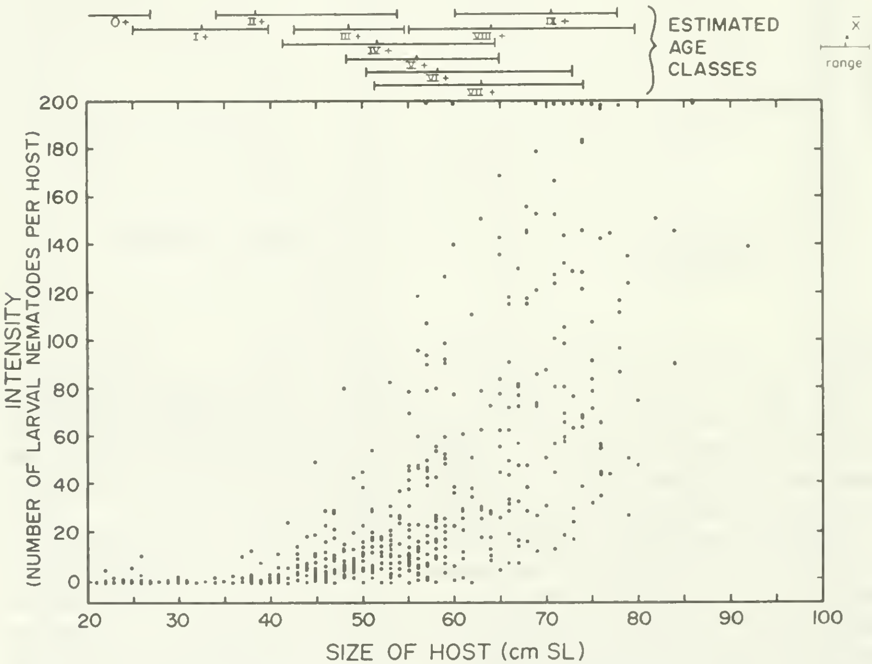

FIGURE 8. Intensity (number of parasites per infected host) of nematode parasites with size of sablefish. The estimated age classes are from Pruter (1954).

Only 10 long-range migrations were detected from the tag returns within the eight-year period (Figure 10). One was to the south, off the Big Sur coast, and was a 75 cm SL fish tagged in 657 m of water in July of 1971 by the National Marine Fisheries Service and recaptured by a trap fisherman 18 July 1975. The other nine recaptures were to the north, and ranged from a short migration of one individual caught off San Francisco to the longest migration distance, a fish tagged 24 July 1974 at 459 m and recovered 12 September 1981 off Newport,

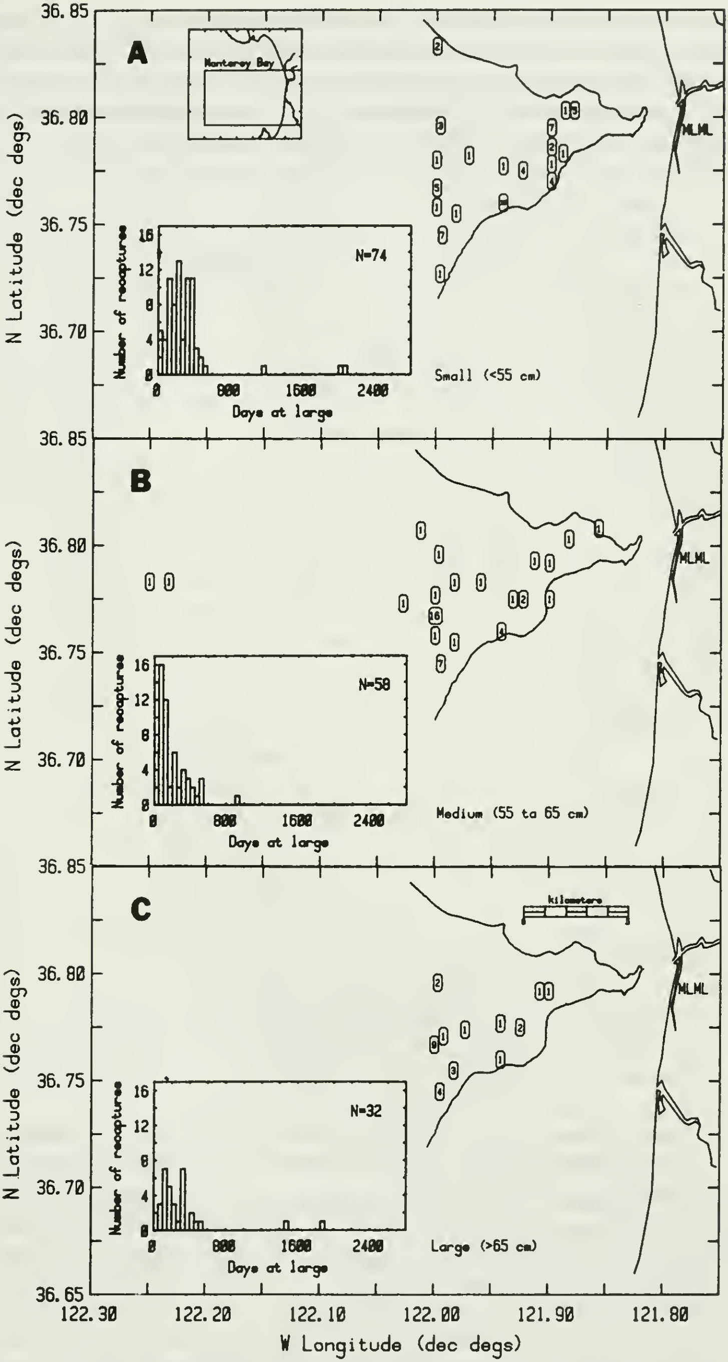

FIGURE 9. The number and location of tagged sablefish recaptured within Monterey Bay. Figure 9a is for "small," 9b for "medium," and 9c for "large" sablefish. All fish were originally tagged in the canyon at the 183, 549, and 915 m stations. The histogram insert shows the frequency of days at large prior to recapture for these fish.

Oregon, by a commercial trawler. One additional fish migrated southward; it had been tagged by a Russian vessel off Half Moon Bay 17 October 1974 and was recovered by a trap fisherman at 567 m in the Monterey Submarine Canyon (Figure 10). Very recently (20 September 1987), one additional tag return was reported from Fort Bragg. This fish was originally tagged and released 13 August 1974 in 192 m and was recovered in 549 m by a longliner.

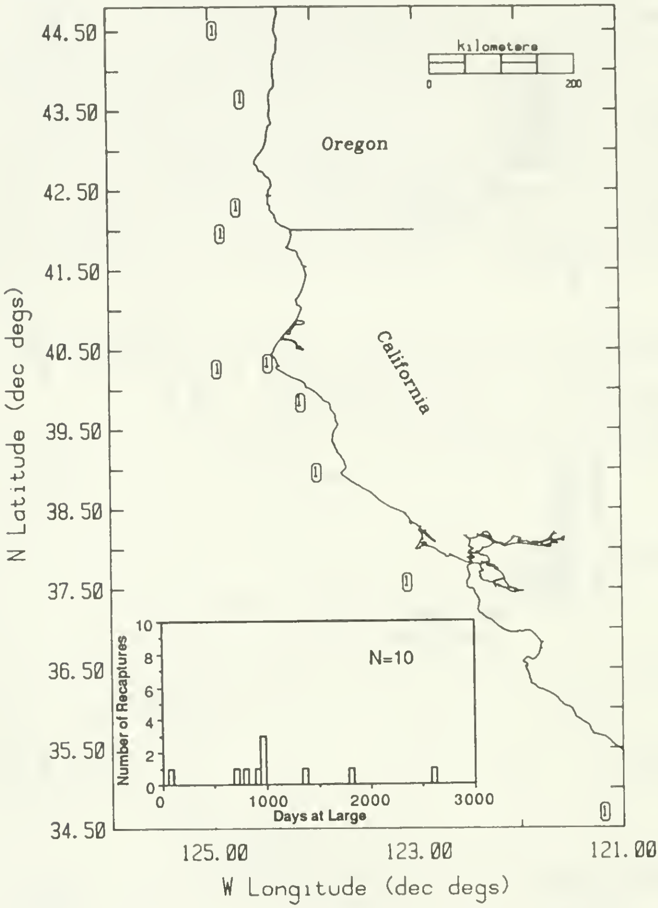

FIGURE 10. The number and location of tagged sablefish recaptured outside of the Monterey Bay area. All fish were originally tagged in the canyon at the 183, 549, and 915 m stations.

Growth information from lengths at tagging and recapturing was available for 53 sablefish. The mean growth for 21 "small" sablefish was 5.27 ± 6.45 cm per year. Similar values for the 25 "medium" and 7 "large" sablefish were 8.04 ± 10.87 and 4.07 ± 4.84 cm per year.

DISCUSSION

Catch rates and size composition of trap-caught sablefish are affected by many factors. We have chosen to evaluate those factors which were known to influence sablefish distribution, were likely to affect the commercial catch, and were practical to measure during a resource study limited to one year in

Monterey Bay. Thus, we concentrated on the effects of depth and season on catches of sablefish and incidental species.

From an economic point of view, fishing at depths of 914–1097 m yields the highest weight of sablefish per trap. The catch from these depths is more profitable, since the catch rate is high and "large" fish comprise the majority of the catch. A decision to fish this deep should be considered against other factors such as increased transit time, boat operating costs, retrieval time, and the flabby condition (and marketability) of some of the fish caught there (James Hardwick, Calif. Dept. Fish and Game, pers. comm.)

Sablefish traps were considerably more selective at the 549 and 915 m depths than at shallower depths. It appears that only a few species are susceptible to trapping (Parks 1973), either due to behavior or mesh size. Heyamoto and Alton (1965), using trawls off the mouth of the Columbia River, reported that sablefish comprised over 50% of the catch at 503–824 m, while at about 91–275 m, sablefish usually made up less than 10% of the catch by weight. Heimann (1963) sampled the trawl fishery in Monterey Bay and found that sablefish comprised 4.1% by weight of the commercial trawl catch at 238–366 m but only 0.9–1.4% at depths from 55–238 m. Hughes et al. (1970), from 222 trap sets in depths of 295–366 m off Washington, reported catching only four species other than sablefish. Parks (1973) reported that four species in addition to sablefish were taken in traps at depths of 183 and 275 m off Oregon, while at the 366 and 458 m depths, sablefish was the only species captured. On the other hand, trawls near his traps captured 31 other species. Fitch (Calif. Dept. Fish and Game, pers. comm.) reported that 46 species of fishes, many of which were relatively rare or unusual, were taken in sablefish traps set in 366 to 1400 m off southern California between July 1977 and May 1980.

From our Monterey Bay trap sets, sablefish were most abundant at 915 to 1190 m and were still quite abundant at their previously reported maximum depth (1565 m: Miller and Lea 1972). Heyamoto and Alton (1965), however, reported that maximum abundances of trawl-caught sablefish off Oregon were between 366 and 824 m and that no sablefish were caught below 1190 m. Similar results were reported by Alverson et al. (1964). Trawl-caught sablefish are generally not as large as those caught in traps (Parks 1973), and this may make their conclusions about depths of maximum abundance slightly misleading. Since traps catch larger sablefish and since larger sablefish live in deeper water (Phillips 1954, Heyamoto and Alton 1965, Kennedy and Fletcher 1968), our records of maximum abundance of sablefish are deeper than previously reported. It should be noted that the depression in our catch rates at 549 m could be due to pressure from recent intense trap fishing and set line fishing that has been concentrated at that depth for many years (James Hardwick, Calif. Dept. Fish and Game, pers. comm.). Phillips (1954) reported that longline-caught sablefish from 275–732 m in Monterey Bay were smaller than those landed in Eureka or Fort Bragg. Since the Monterey Bay population of sablefish is within the southern portion of the sablefish range, Phillips (1954) proposed that they were smaller because they inhabited an area that was environmentally unfavorable. Apparently, sablefish in the Monterey Submarine Canyon live deeper than the northern fish and thus were not adequately sampled by the commercial fleet studied by Phillips (1954). It is also possible that size and depth distribution could be affected by canyon topography or oceanography.

Sablefish reportedly migrate offshore to deeper water during the winter months (Alverson et al. 1964, Heyamoto and Alton 1965). Our results appear to confirm this seasonal migration and show how this migration varies with size of sablefish. Our 183 m stations showed increased catch rates during July and August along with the movement of larger fish into shallower depths as shown by the increase of the percent "large" and "medium" sablefish during the summer months. Unfortunately, we had no samples at 1098–1281 m during January or February, when "large" sablefish were generally lacking at any of our regularly sampled depths. Since this is when sablefish are reported to live deeper, a high percentage of "large" fish at these depths would account for the dearth of large sablefish at the other stations, assuming the fish remain in the canyon.

The overall sex ratio of adults (78% female) is similar to those obtained by Parks (1973) for trap-caught sablefish off Oregon, and Mason et al. (1983) off Canada. Parks (1973) found that trawl-caught sablefish had only 39% females and attributed this difference to the fact that larger fish, which are predominately female (Edson 1954, Pruter 1954), can avoid the trawl and therefore the trawl captures smaller fish, which are more often male than female. Our "small" sablefish were 42% male, approximating the 1:1 ratio reported by Kennedy and Smith (1973) for small (maximum size = 48 cm) fish caught off Vancouver Island with hook and line. Only 0.4% of our "large" sablefish were males, apparently because males do not get as large as females, as reported by Edson (1954) for sablefish off Alaska.

In agreement with published information, our gonad indices indicate that sablefish in Monterey Bay spawn in the winter months, with peak spawning activity from November through February. Phillips (1954) noted spawning of California sablefish from December to April, with peak activity occurring in January and February. Similar results have been reported off Oregon, Washington, and Canada: Thompson (1941) suggested, from eggs in plankton samples, that spawning started in February; Heyamoto and Alton (1965) noted spent and spawning individuals in March; Bell and Gharrett (1945) noted spawning in November and through February; Bell and Pruter (1954) noted ripe individuals in November and spent females in January; and Mason et al. (1983) noted the spawning period off Canada to be between January and April. Gonad indices also indicate that the more ripe fish are found in deeper waters, since individuals of the same size have, on the average, a higher gonad index at greater depths. We have observed gravid females at our 549, 915, and deeper than 1098 m sampling depths.

The sablefish is a dominant predator in the deep benthic waters of Monterey Bay and the eastern Pacific in general and therefore may be a strong influencing factor in regulating the benthic communities in these environments. Our findings that sablefish are top carnivores which eat those organisms that are most available to them agrees with previous studies of their feeding habits elsewhere. Grinols and Gill (1968) found that juvenile sablefish attracted to nightlights consumed small epipelagic fishes like the Pacific saury and blue lanternfish, *Tarletonbeania crenularis,* which presumably were also attracted to the nightlight. Conway (1967), from studies of sablefish gut contents off southern California, reported that sablefish in their first year consumed planktonic organisms like copepods, euphausiids, and larvaceans, and then switched to more benthic organisms at age two and older. These organisms were primarily crustaceans such as amphipods, mysids, and euphausiids, cephalopods, gastropods, and fishes. In sablefish over three years of age, the diet was mostly fish such as *Sebastolobus* spp. and cephalopods. Shubnikov (1963) also found fishes and benthic invertebrates like ophiuroids, pandalid shrimps, and octopods in the stomachs of adult sablefish from the Bering Sea. From our stomach contents, the prevalence of amphipods may be due to the odoriferous attraction of the bait canister to these organisms, thus making them more likely to be found in the stomachs of captive sablefish. However, since Conway (1967) and Shubnikov (1963) found similar prey items, these prey could very likely be natural prey items, regardless of this unnatural accumulation factor.

The increasing tendency for more larval nematodes to infect larger sablefish hosts can at least be partially explained by the shift in diet from planktonic forms to benthic crustaceans and has been found previously (Conway 1967). The adult nematodes of these species are found in pinnipeds and cetaceans, and their eggs are discharged with the feces of the host (Smith and Wooten 1978). The eggs are consumed by small crustaceans. these micro-crustaceans are then eaten by planktivores, such as small fish and cephalopods, which in turn are food for larger predators. These long-lived larvae may serially infect several intermediate hosts before being ingested by a suitable marine mammal. During its first year, the sablefish feeds heavily on fish, especially the planktivorous anchovy and cephalopods. Both food sources are likely intermediate hosts for these nematodes. the prevalence of infection for one-year sablefish was 21.1% (24/113 fish investigated), with an average intensity (number of larval nematodes per infected host) of 2.0, ranging from 1 to 11. In older fish, the consumption of more crustaceans, especially euphausiids and amphipods, may continue the increase in larval infections. The prevalence increased in medium fish to 65.9% (58/88 fish examined), with an intensity of 6.3, range from 1 to 50. In the oldest fish, which consume mostly fishes but also some crustaceans, the accumulation of larval nematodes continues and increases even more throughout their life, with a prevalence of 97.1%, intensity 45.9, range 1 to 510. It should be noted that both of the above species of larval nematodes are potentially dangerous to humans if consumed in improperly prepared fish.

Our sablefish tagging results indicate that sablefish in Monterey Bay are relatively parochial, since they do not seem to migrate in great number from this area. However, these results may reflect the intense localized fishing effort and strong cooperation of the local fishermen rather than real patterns of limited migration, but they do agree with the results of other tagging studies. Phillips et al. (1954), Phillips (1969), Kennedy and Smith (1972), Holmberg and Jones (1954) and Shaw (1984) have found that sablefish stocks in the Pacific Northwest are generally of a local nature. However, some have exhibited long-range migrations (Pasquale 1964, Phillips 1969, Pattie 1970, Low et al. 1976, Shaw 1984). Parrish et al. (1981) implicate early life stages and current patterns in understanding the distribution patterns and dispersal mechanism of fish like sablefish, rather than long-range migrations of adult individuals. Indeed, the major reason for the collapse of the local sablefish trap fishery (James Hardwick, Calif. Dept. Fish and Game, pers. comm.) may have been a combination of intense localized fishing pressure and the lack of major immigration mechanisms into this area. If this is true, it will take a few years for dispersal of their neustonic larvae from the north to re-occupy and reestablish the relatively large densities of benthic adult sablefish populations in the Monterey Bay area.

Growth increments from recaptured tagged sablefish agree quite well with growth information from Pruter (1954), Heizer (1967), Shubnikov (1968), Low et al. (1976), and Beamish and Chilton (1982).

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CHARACTERIZATION OF BLACK-TAILED DEER HABITATS IN A NORTHERN CALIFORNIA OAK-CONIFER ZONE [1]

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Hardwoods, especially California black oak, *Quercus kelloggii,* provide a valuable food source for Columbian black-tailed deer, *Odocoileus hemionus columbianus,* in conifer forests of northern California. A detailed vegetation survey conducted at elevations of 600–1500 m in the Shasta-Trinity National Forest resulted in description of seven oak-conifer habitat types. Black oak was of greatest abundance and basal area (22 ft^2/acre) in Douglas fir, *Pseudotsuga menziesii,* dominated forests of low to moderate canopy closure. Oak basal area was lowest in dense canopy forest types. Seedling, sapling, and mature black oak trees were all present in four conifer dominated habitats, but not in recent clearcuts which had negligible levels of hardwood retention. Deer use as determined from pellet-group densities was highest in mature conifer types with lowest canopy closure. Deer use was positively associated with oak basal area which explained 29% of the variation in observed deer pellet-group densities. Hardwoods in conifer forests are likely an important contributor to deer herd productivity, especially in areas where important winter range habitats are limiting or have been eliminated by development.

INTRODUCTION

Recognition that hardwoods and hardwood range provide valuable forage, fuelwood, watershed, and wildlife habitat in California has increased in recent years (Plumb 1979, Passof et al. 1985, Mayer et al. 1986, Plumb and Pillsbury 1986). This is resulting in greater efforts to manage and sustain hardwoods on rangelands and forests in the state. At elevations from about 600–1,800 m (2,000–6,000 ft) in the Sierra Nevada, Cascade, and Klamath ranges, hardwoods occur as associates in conifer forests. The major hardwood species in these areas include California black oak, *Quercus kelloggii;* Oregon white oak, *Quercus garryana;* canyon live oak, *Q. chrysolepis;* interior live oak, *Q. wislizenii,* tanoak, *Lithocarpus densiflorus;* big-leaf maple, *Acer macrophyllum,* and madrone, *Arbutus menziesii.* Five conifers share dominance in these forest communities: Douglas fir, *Pseudotsuga menziesii;* sugar pine, *Pinus lambertiana;* ponderosa pine, *P. ponderosa;* white fir, *Abies concolor;* and incense cedar, *Libocedrus decurrens,* (Rundel et al. 1977).

Hardwoods provide an important habitat component for many wildlife species (Barrett 1979) and enhance the diversity of conifer forests. Migratory black-tailed deer, *Odocoileus hemionus,* winter in the oak-conifer zone while non-migratory (resident) deer are present year-round. Nutritionally, deer depend heavily on oak mast (acorns and fallen leaves) for energy and for

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storing fat during fall and early winter to help carry them them through the winter (Dixon 1934, Leach and Hiehle 1957). Migratory deer will delay in fall holding areas where a mast crop is available until storms cause them to move to lower elevation winter ranges (Bertram and Rempel 1977, Loft et al. 1984). Foliage of young or shrub oaks also provides browse for migratory deer during the winter and spring, and for resident deer all year.

Logging operations generally have the greatest land use impact on conifer forest, often resulting in conflict between timber and wildlife interests regarding the effects of logging on wildlife. Oaks are often damaged or removed during logging and the loss of potential forage may adversely affect deer herd production on limiting winter ranges. Present forest management guidelines generally recommend hardwood retention levels for wildlife habitat in conifer dominated stands to be the equivalent of at least 5 ft^2/acre (200 ft^2/40 acre) (Mayer et al. 1986), yet there is little quantitative information on desirable or present levels of hardwoods for deer and other wildlife species. Potter and Johnston (1979) recommended a retention level of at least 10 ft^2/acre in north slope stands typically dominated by conifers. Potter and Johnston (1979) and Tappeiner and McDonald (1979) also suggest maintaining aggregations or pure stands of oaks in their present form as these sites often have limited potential for conifer production.

Current hardwood retention guidelines were apparently developed on a small project bases without data which were regionally applicable (Potter and Johnston 1979). Bolsinger (1979) reported a hardwood basal area of 52 ft^2/acre in a Trinity County mixed stand which had been selectively logged 20 and 10 years past. Other than these reported values for Trinity County, we are unaware of any studies quantifying hardwood abundance in the oak-conifer forest zones of northern California. Some general hardwood volumes in the northern interior region of California have been reported by this same author (Bolsinger 1976).

Our objectives in this study were to characterize habitats where oaks were in association with the conifer dominated forest community, and to examine the relationship between oak abundance in conifer forest habitats and deer use.

METHODS

The study area, located on the range of the Weaverville deer herd in the Shasta-Trinity National Forest, California is in a Douglas fir-mixed conifer forest zone and has been described in detail elsewhere (Sawyer and Thornburgh 1977, Loft et al. 1984). Habitat characterization plots were sampled in areas used by radio-collared deer on the west side of Trinity and Lewiston reservoirs (Peterson 1983, Loft et al. 1984). Specific areas were: Davis/Hobel Creeks, East Fork Stuarts Fork/Taylor Gulch (EFSF), Slate Creek, Smith Gulch, and Buckeye Ridge. The Davis/Hobel Creek, EFSF, and Slate Creek areas are used during mild winters, spring and fall migration periods and as summer range by migratory deer, while Smith Gulch and Buckeye Ridge areas are used year-round by non-migratory resident deer and as winter range for migratory deer.

Habitat characterization plots (main plots) were 100 m^2 (0.0247 acre) in size with a radius of 5.65 m (18.5 ft) from plot center. Plots were randomly located provided they fell within the habitat type. Trees greater than 2 m (6 ft) in height were evaluated in the main plots. Characteristics of trees in each habitat that were recorded in main plots were: the frequency or number of plots each species occurred in (Freq.), number of trees sampled (No. Trees), diameter at breast height (DBH), height (Ht.), number of stems per acre (Stems/Acre), and basal area in ft ^{2}/acre (Basal Area). The range of values were also reported.

A circular 50 m ^{2} (0.0124 acre) shrub plot, nested within the main plot, was used to evaluate shrub and tree vegetation 30–200 cm (1–6 ft) in height. Characteristics of sapling trees and shrubs recorded were: frequency, height, diameter (Diam.), percentage relative cover (Rel. cov), density of individual species (Dens.), and form class (Form). Form class was estimated following Dasmann (1951) where: 1 = all available, little or no hedging; 2 = all available, moderately hedged; 3 = all available, tightly hedged; and 4 = largely available, little or no hedging.

A 1 m ^{2} (3 ft ^{2}) grid was used to evaluate herbaceous vegetation at each of the four cardinal directions on the perimeter of the main plot. Tree and shrub vegetation less than 30 cm (12 in.) tall were also evaluated within the herbaceous plots. Characteristics estimated were: frequency, percentage relative cover, and mean grazing/browsing utilization class (Utl.) (1 = none, 2 = little, 3 = moderate, and 4 = heavy).

Ecological site variables measured or estimated and summarized in main plots were: elevation, slope, dominant aspect, seral stage, tree canopy closure, pellet-group counts, distance to water, height-length-diameter of stumps and down logs, hiding cover, and percentage cover of shrubs, herbaceous vegetation, litter, rocks, and bare ground.

Seral stage was estimated following Verner and Boss (1980) and averaged among plots. The four stages were: 1 = Grass/forb stage- with or without scattered shrubs and seedlings; 2 = Shrub/seedling/sapling stage- mixed or pure stands of shrubs, seedlings, and saplings to 20 ft; 3 = Pole/medium tree stage- larger trees from 20–50 ft in height; and 4 = Large tree stage- trees generally over 50 ft in height, except for non-conifer species. Tree canopy closure was also estimated following Verner and Boss (1980) where canopy classes were: 1 = tree canopy cover from 0 to 39%; 2 = cover from 40 to 69%; and 3 = cover greater than 70%.

Deer pellet-groups were counted within each main plot. Although use of pellet-group counts as an index of habitat use has been questioned (Collins and Urness 1981), recent work indicates they are of value in discerning varying levels of habitat use (Leopold et al. 1984, Loft and Kie 1988). Pellet-groups from the previous year were discolored and omitted from the counts.

Deer hiding cover was evaluated at the perimeter of the main plot from plot center at the 4 cardinal directions (Loft et al. 1987). A 1 m ^{2} grid was used to estimate the percentage of the vertical grid obscured by vegetation at 0.5 m height intervals up to 2 m.

Sampled trees of the 5 conifer species and black oak were grouped into one of 3 DBH classes (0–6, 7–12, and 13 or more inches) to obtain a general estimate of age structure distribution for each habitat. Regression analysis was used to examine the relationship between deer use and basal area of oaks from all plots where oak species were present. Data were collected using the metric system and converted to English units for forestry management applications.

RESULTS AND DISCUSSION

Habitat Types

The seven habitat types characterized were four conifer dominated forest habitats (1,2,3, and 4), one oak dominated habitat (5), and two early seral habitats of conifer forest types (6 and 7) (Table 1 and Appendices 1–7). Types 1, 2, and 5 were located in more xeric, lower elevation areas near the south end of Trinity Lake (Slate Creek, Smith Gulch, and Buckeye Ridge). Types 3, 4, 6, and 7 were located in more mesic areas at higher elevations west of Trinity Lake (Davis and Hobel Creeks, EFSF, and Slate Creek). Following are general descriptions of the habitats. Habitat types 1 through 7 correspond with Appendices 1 through 7. The series number suggests a corresponding cover type as described in "Shasta-Trinity National Forest Vegetation and Miscellaneous Cover Types" (author and date unknown). The more general, but corresponding U.S. Forest Service timber type (TT) polygon classification for the area sampled is also given (eg., TT:DF4G).

Type 1. *Pseudotsuga menziesii / Pinus ponderosa / Quercus kelloggii.* Series 623. TT:DF3G, DF4G, DFPP3G, PPDF3G. A Douglas fir (182 ft^2/acre) forest type occurring near 2,900 ft elevation with scattered large pines. Representative plots were located on north slopes and in drainages at Smith Gulch, Slate Creek, and Buckeye Ridge. Black oak comprised about 11 ft^2/acre of basal area with 87% of the trees less than 6 in dbh (Table 2). Hazelnut, *Corylus cornuta californica,* and Pacific dogwood, *Cornus nuttallii,* were the most abundant understory trees while poison oak, *Toxicodendron diversiloba,* was the most abundant shrub species.

TABLE 2. Percentage of Sampled Trees Occurring in Each of Three Diameter (DBH) Classes in Four Forest Habitats In Trinity County, California. n = Total Number of Trees Sampled in Habitat.

Species	*Diameter class (inches)*	*Habitat type 1*	*2*	*3*	*4*
Abies concolor		n=0	n=0	n=92	n=157
	0–6	0%	0%	82%	76%
	7–12	0	0	7	16
	13+	0	0	11	8
Libocedrus decurrens		n=10	n=5	n=72	n=55
	0–6	60	80	82	90
	7–12	30	0	11	5
	13+	10	20	7	5
Pinus lambertiana		n=25	n=42	n=49	n=44
	0–6	80	81	76	77
	7–12	12	12	14	5
	13+	8	7	10	18
Pinus ponderosa		n=14	n=36	n=14	n=10
	0–6	36	64	21	30
	7–12	7	19	29	10
	13+	57	17	50	60
Pseudotsuga menziesii		n=384	n=158	n=159	n=267
	0–6	74	85	78	53
	7–12	16	11	14	17
	13+	10	4	8	30
Quercus kelloggii		n=54	n=38	n=43	n=27
	0–6	87	71	75	41
	7–12	7	18	16	44
	13+	6	11	9	15

TABLE 1. Ecological Characteristics (Means ± s.e.) of Seven Habitat Types in Trinity County, California. Habitat Type Numbers Correspond with Appendices 1–7. See Text for Explanation of Measured Variables.

Variable	Habitat type						
	1	*2*	*3*	*4*	*5*	*6*	*7*
Number of plots	31	15	23	40	10	14	33
Elevation (ft)	2,905 ± 50	2,780 ± 70	3,335 ± 85	3,170 ± 45	2,720 ± 90	3,264 ± 40	3,260 ± 50
Slope (%)	37 ± 3	34 ± 3	14 ± 2	37 ± 3	39 ± 3	17 ± 2	30 ± 3
Aspect	N	NE-S	NE-E	N-S	S	E-SE	N
Seral stage	3.5 ± 0.1	3.4 ± 0.1	3.4 ± 0.1	3.9 ± 0.1	3.4 ± 0.2	1.4 ± 0.2	2.8 ± 0.1
Tree canopy closure	2.2 ± 0.1	1.6 ± 0.2	1.7 ± 0.1	2.4 ± 0.1	1.8 ± 0.3	1.0 ± 0	1.3 ± 0.1
Shrub cover (%)	22 ± 4	17 ± 4	27 ± 4	30 ± 3	16 ± 5	34 ± 5	62 ± 3
Herbaceous cover (%)	8 ± 2	9 ± 3	14 ± 3	7 ± 1	1 ± 0.3	7 ± 2	12 ± 2
Non-persist. litter (%)	55 ± 4	61 ± 5	47 ± 4	48 ± 4	62 ± 8	4 ± 1	27 ± 3
Persistent litter (%)	25 ± 3	19 ± 4	22 ± 3	24 ± 3	15 ± 5	12 ± 3	19 ± 3
Rock (%)	3 ± 1	3 ± 2	2 ± 1	0.3 ± 0.1	11 ± 6	1 ± 0.5	1 ± 0.5
Bare ground (%)	1 ± 1	4 ± 1	3 ± 1	7 ± 1	8 ± 3	61 ± 6	13 ± 3
Pellet-groups/acre	89 ± 24	182 ± 48	158 ± 31	97 ± 15	206 ± 42	162 ± 51	187 ± 53
Distance to water (ft)	1,440 ± 175	1,485 ± 270	1,085 ± 135	728 ± 100	935 ± 285	865 ± 135	940 ± 150
Number of stumps	0.7 ± 0.1	0.6 ± 0.2	0.8 ± 0.2	0.7 ± 0.1	0.4 ± 0.2	1 ± 0.2	1 ± 0.1
Height (in.)	17 ± 2	22 ± 4	33 ± 3	37 ± 3	20 ± 5	42 ± 6	37 ± 2
Diameter (in.)	29 ± 6	20 ± 3	36 ± 4	34 ± 2	18 ± 4	35 ± 3	41 ± 3
Number of down logs	1.3 ± 0.2	0.9 ± 0.2	1.9 ± 0.4	1.3 ± 0.1	1.1 ± 0.3	1.6 ± 0.4	2 ± 0.2
Length (in.)	153 ± 20	186 ± 24	126 ± 15	153 ± 15	182 ± 33	135 ± 17	125 ± 10
Diameter (in.)	16 ± 1	17 ± 1	21 ± 2	30 ± 5	13 ± 2	22 ± 3	27 ± 3
Hiding cover (%)							
0–18 in.	24 ± 4	23 ± 4	29 ± 4	31 ± 3	18 ± 5	26 ± 5	64 ± 4
18–36 in.	17 ± 3	19 ± 3	22 ± 3	24 ± 3	16 ± 5	5 ± 2	59 ± 4
36–54 in.	14 ± 3	19 ± 3	22 ± 3	23 ± 3	15 ± 4	1 ± 1	54 ± 4
54–72 in.	15 ± 4	20 ± 4	20 ± 3	24 ± 3	18 ± 6	0	52 ± 4

Type 2. *Pseudotsuga menziesii / Pinus* sp. / *Quercus kelloggii.* Series 622A. TT:DFPP2N, DFPP3N, PPDF3N, DF3N, DF4N. Douglas fir dominated (85 ft^2/acre) this fairly open and xeric forest type with sugar and ponderosa pines as sub-dominants. Sample plots were located in the same areas as Type 1 but on more easterly and southerly aspects. Pines were more abundant in this type than in Type 1. Black oak occurred in greater average density (100 stems/acre) and basal area (22 ft^2/acre) than in the other three forest types and sapling and seedling trees were common. Shrub cover was low and dominated by *Symphoricarpos mollis* and poison oak.

Type 3. *Pseudotsuga menziesii* mixed conifer. Series 622–623. TT:WFDF3P/SM, DF3G, DF4G, DFWF3G, DFPP3N, DFPP4N. This type was similar to Type 2, but at a higher elevation (3,335 ft) included white fir (44 ft^2/acre as a codominant with Douglas fir (74 ft^2/acre). Sample plots were located near Slate Creek, EFSF, and Davis and Hobel Creeks. Ponderosa pine, sugar pine, incense cedar, and black oak were also common giving the type its mixed-conifer character. The shrub understory was dominated by sapling conifers, dogwoods, and bracken fern, *Pteridium aquilinum.* Herbaceous cover was the highest among the seven habitat types. Tree canopy cover was fairly low and oak basal area was fairly high (22 ft^2/acre).

Type 4. *Pseudotsuga menziesii / Abies concolor / Cornus nuttallii.* Series 624. TT:DF4G, DF3G, DFWF4G. Large Douglas fir trees (269 ft^2/acre) dominated this dense habitat type which had a more advanced seral stage and higher canopy cover than any other type. Representative plots were on north aspect slopes at Slate Creek, EFSF, and in Taylor Gulch. White fir (56 ft^2/acre) was the most common subdominant tree and large pines were occasional. Dogwoods were abundant in the shaded understory. Oak basal area averaged 18 ft^2/acre and the density of oaks was more evenly distributed among the 3 diameter classes than in the other forest types.

Type 5. *Quercus garryana / Pseudotsuga menziesii.* Series 502. TT:DFPP2N, DFPP2P, HW. This type occurred on south aspect slopes around Trinity and Lewiston Lakes with plots located in the Smith Gulch and Buckeye Creek areas west of Trinity Dam. Oregon white oak was dominant (55 ft^2/acre) with some trees near 3 ft in diameter. Shrub and herbaceous cover was low except in openings where tree litter accumulation was absent. The abundance of Douglas fir and pines in the type reflects the patchiness or small size of some of the oak stands and close proximity to conifer dominated types. Black oak was common in the tree and shrub layer.

Type 6. *Pseudotsuga menziesii / Abies concolor.* clearcut. TT:UX. This type was characterized in areas near Taylor Gulch and Davis Creek which had been clearcut in the late 1970's (mean diameter of stumps was 35 in.), hence were less than 5 years old when sampled in 1981. No overstory canopy existed and vegetative cover was low as evidenced by the average shrub cover (34%) and low percentage of hiding cover available. No oaks occurred in sample plots although a few damaged trees were observed in the type indicating some oak retention had been considered.

Type 7. *Cornus nuttallii / Ceanothus integerrimus.* Series 424. TT:DF3N, DF3S/SM, DF2N. This seral stage of habitat type 4 occurred on north and east aspect slopes near Trinity Lake. The type had dense shrub and small tree cover (62%) with many down logs and was likely a result of fire or logging (without restocking) induced disturbance within the past 30 years. Dogwoods and deerbrush were the dominant species up to 10 ft in height. Douglas fir and white fir were the dominant overstory trees. The understory was dominated by *Trientalis latifolia, Linnaea borealis,* and perennial grasses. Oak abundance was low in both the tree and shrub layers, while hiding cover was higher than in any other type.

Oak-Conifer-Deer Relationships

The four conifer dominated habitat types (1–4) each had a feature distinguishing them from the other 3: (i) Type 1 occurred at low elevations, had comparatively high tree canopy closure, and white fir was absent; (ii) Type 2 occurred at low elevations, had low tree canopy closure, and white fir was absent; (iii) Type 3 occurred at high elevations, had low tree canopy closure, and white fir was present; and (iv) Type 4 occurred at high elevations, had high tree canopy closure, and white fir was present (Tables 1 and 2, Appendices 1–4). Examination of sampled tree densities indicated that incense cedar, like white fir, was more abundant in the higher elevation forest types.

Type 4 had the highest seral stage ($\overline{x} = 3.9$) and the highest proportion of tree species greater than 13 or more inches in diameter. Types 2 and 3 were of earlier seral stages and lowest tree canopy closure (Table 1), but had the highest basal area of oak trees (both 22 ft^2/acre). Oak basal area in the denser canopy forest types 1 and 4 was 12 and 18 ft^2/acre, respectively. The lower basal area in dense forest types is likely caused by overtopping of oaks by conifers, with a subsequent die-off of the oaks (Tappeiner and McDonald 1979). Regardless of type, oak basal areas in conifer dominated forest habitats were more than double the often prescribed retention levels of 5 ft^2/acre. Deer pellet-group densities in the lower tree canopy closure types were almost double the levels detected in dense tree canopy types.

Deer use was higher in the Oregon white oak type than in any other type (Table 1) indicating the importance of that particular oak species and habitat, but we also wanted to evaluate how oaks in conifer dominated stands contributed to deer use. At the habitat level, deer use was positively associated with oak basal area in the conifer types. Types 1, 4, 3, and 2 had mean pellet-group densities of 89, 97, 158, and 182 pellet-groups/acre, respectively. Corresponding oak basal areas were 12, 12, 18, and 22 ft^2/acre. On a plot basis, basal area of oak trees (oak occurred in 53 of the 109 conifer dominated habitat plots) regressed against deer pellet-groups indicated a significant, positive relationship between the 2 variables (Fig. 1). Oak basal area explained 29% of the observed variation in pellet-group densities. The relationship is not strikingly high since deer are probably more responsive to oak abundance on a scale of hectares than on a 0.01 ha plot scale and would not select habitat at such a fine-grain, and because other variables contribute to deer habitat selection. However, at both the habitat and plot level, the data indicates deer use in conifer forest habitats is positively influenced by oak abundance. Some investigators feel that basal area may not reflect acorn production as well as crown diameter (Potter and Johnston 1979, J. Fiske, pers. comm.), so deer use could be more closely correlated with crown diameter.

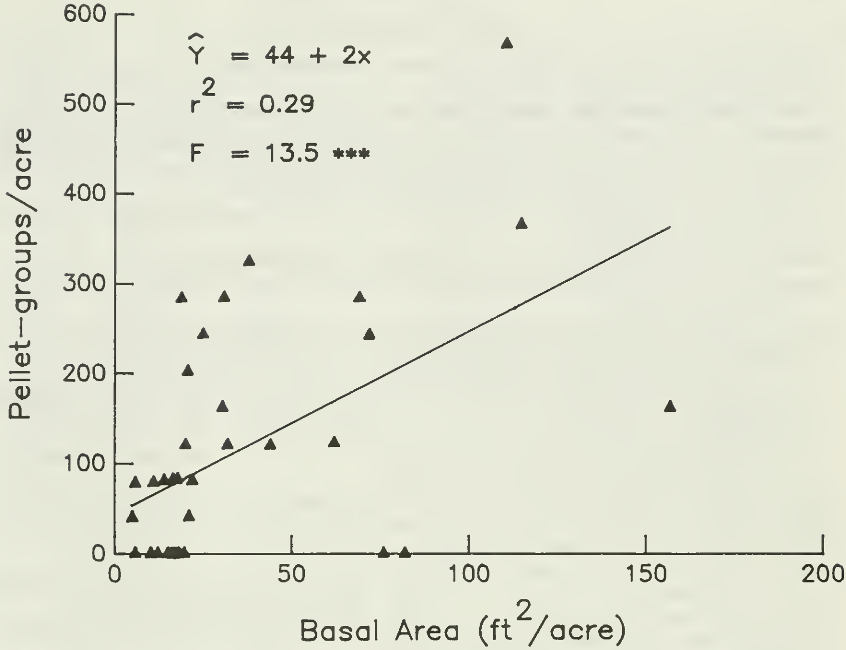

FIGURE 1. Relationship between deer pellet-groups and basal area of oak trees in individual sample plots of four conifer forest dominated habitats (types 1–4), Shasta-Trinity National Forest, California.

Conifer dominated habitats with oaks as an associated species are used by deer during spring and fall migrations, during mild winters, and during summer by an undetermined but significant number of animals. Kerns (1979) reported that the oak-conifer habitat was marginally used by wildlife compared to oak dominated habitats which were heavily used. In areas where oak habitats and other key habitats are plentiful, we would concur. However, in areas where oak dominated or other suitable habitats are not plentiful, we would expect loss of hardwoods in conifer forest habitats to have a negative impact on deer because of the loss of a critical food supply. The Weaverville deer herd is known to occupy winter ranges which are now limiting and in poor condition because of reservoir construction (Kie and Menke 1980, Kie et al. 1984). Because of the loss of winter habitat in this area, we suggest that oaks in the conifer forest habitats now have a more important role in deer herd productivity. These habitats may also be more important to deer than would normally be the case on other deer ranges in California that have limiting winter ranges as a result of reservoir construction, development, or other disturbance.

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APPENDIX 1. ***Pseudotsuga menziesii / Pinus ponderosa / Quercus kelloggii*** **habitat type (31 plots). See text for description of variables.**

	Trees (> 6 ft height)										Sapling trees/shrubs (1–6 ft height)						Seedling trees/shrubs (< 1 ft)		
		No.	DBH (in)		Height (ft)		Stems/Acre		Basal Area			Ht.	Diam.	Rel.				Rel.	
Woody Species	Freq.	Trees	x ± se	Range	x ± se	Range	x ± se	Range	x ± se	Range	Freq.	(in)	(in)	cov	Dens.	Form	Freq.	cov	Utl
Abies concolor											1	17	23	38	6	1			
Acer macrophyllum	3	9	4±1	1–9	27±6	10–56	12±8	0–283	2±2	0–42	2	22±6	19±7	26±11	5±2	2	12	16±10	1
Cornus nuttallii	4	19	1±1	1–4	12±1	6–23	24±16	0–486	0.2±.2	0–5	10	23±4	26±6	33±7	4±1	1	5	7±2	1
Cornus sessilis	1	1	1	1	13	13	8±8	0–283	0.1±.1	0–2	1	40	17	38	11	2	4	10±1	1
Corylus cornuta	8	73	1±1	1–2	12±1	6–13	97±49	0–1295	0.5±.3	0–10	12	39±4	45±6	36±6	6±1	2	20	13±3	1
Libocedrus decurrens	4	10	6±3	2–31	29±12	7–121	12±8	0–242	8±7	0–219							4	4±3	1
Pinus lambertiana	14	25	5±2	1–42	23±6	7–118	33±9	0–202	20±14	0–385	12	37±6	28±5	10±3	3±2	1	1	4	1
Pinus ponderosa	9	14	20±4	2–54	83±12	16–154	18±6	0–162	63±27	0–652	3	34±2	10±1	7±4	3±2	1	1	9	1
Pseudotsuga menziesii	31	384	5±1	1–54	31±2	7–164	505±77	2–1780	182±30	1–659	14	32±4	22±2	35±7	11±3	1	38	10±2	1
Quercus chrysolepis	3	3	6±3	1–12	29±9	16–46	4±2	0–40	1±1	0–29	1	20	19	3	15	1			
Quercus garryana	3	4	2±1	1–4	17±4	10–30	5±3	0–81	0.2±.1	0–4	2	15±1	38±7	9±6	1	1	1	1	1
Quercus kelloggii	18	54	4±1	1–20	19±2	7–50	70±17	0–364	11±4	0–117	12	21±3	22±4	21±4	3±1	2	22	13±6	1
Quercus wislizenii											10	23±4	20±2	19±4	3±1	2	9	11±12	1
Taxus brevifolia	1	2	5±1	4–6	28±8	26–29	18±18	0–566	3±3	0–94									
Snags	3	3	23±8	10–37	80±29	70–130	4±2	0–41	0.8±.3	0–2									
Amelanchier pallida											4	17±7	19±2	6±3	2±.1	2	4	2±1	1
Apocynum sp.																	1	9	1
Arctostaphylos patula											1	24	30	15	1	1			
Berberis sp.																	1	24	1
Ceanothus integerrimus											3	31±3	24±2	18±10	5±2	2			
Ceanothus lemmonii											1	5	16	3	2	3	6	14±3	2
Lupinus sp.											2	11±1	7±4	9±6	8±6	1	3	25±12	1
Polystichum sp.											1	16	28	15	2	1			
Pteridium aquilinum											5	15±1	15±1	17±6	10±3	1	5	14±2	1
Rhus trilobata																	1	5	1
Ribes sp.																	2	11±10	1
Rosa californica											8	17±2	11±1	18±5	8±3	1			
Rosa sp.											6	13±2	13±2	15±5	5±1	2	18	12±3	1
Rubus parviflorus											1	14	8	3	3	2			
Rubus sp.																	6	5±4	1
Symphoricarpos mollis											5	7±1	12±1	15±6	7±3	2			
Toxicodendron diversiloba											20	16±2	13±1	35±7	11±2	1			

Continued on p. 170.

APPENDIX 2. ***Pseudotsuga menziesii / Pinus* sp. / *Quercus kelloggii* habitat type (15 plots). See text for description of variables.**

	Trees (> 6 ft height)										Sapling trees/shrubs (1–6 ft height)						Seedling trees/shrubs (< 1 ft)		
		No.	DBH (in)		Height (ft)		Stems/Acre		Basal Area			Ht.	Diam.	Rel.				Rel.	
Woody Species	Freq.	Trees	x ± se	Range	x ± se	Range	x ± se	Range	x ± se	Range	Freq.	(in)	(in)	cov	Dens.	Form	Freq.	cov	Utl
Cornus nuttallii											1	35	26	65	5	2			
Corylus cornuta	1	10	1		10		27 ± 27	0–405	0.1 ± .1	0–1	2	30 ± 3	43 ± 7	38 ± 7	5 ± 3	2			
Libocedrus decurrens	2	5	5 ± 2	1–13	27 ± 9	6–49	14 ± 11	0–162	4 ± 3	0–37	1	13	8	25	7	1			
Pinus lambertiana	12	42	5 ± 1	1–44	22 ± 4	7–118	113 ± 36	0–486	56 ± 34	0–462	9	41 ± 6	32 ± 5	27 ± 7	4 ± 1	1			
Pinus ponderosa	9	36	7 ± 1	1–26	32 ± 3	7–95	97 ± 34	0–405	38 ± 12	0–154	4	28 ± 6	15 ± 4	9 ± 4	3 ± 2	1	2	10 ± 6	1
Pseudotsuga menziesii	15	158	4 ± 1	1–37	33 ± 5	6–105	426 ± 82	80–931	85 ± 26	1–335	12	37 ± 4	22 ± 2	33 ± 8	6 ± 2	1	6	8 ± 4	1
Quercus kelloggii	11	38	5 ± 1	2–15	27 ± 2	9–59	100 ± 26	0–324	22 ± 7	0–76	9	33 ± 5	28 ± 5	47 ± 11	6 ± 2	2	10	13 ± 5	1
Quercus wislizenii											5	26 ± 10	24 ± 8	15 ± 3	2 ± 1	1	1	24	1
Taxus brevifolia																	1	10	4
Amelanchier pallida																	1	4	1
Arctostaphylos viscida											3	92 ± 10	72 ± 3	40 ± 15	2 ± 1	4			
Ceanothus integerrimus											1	16	17	3	1	2			
Ceanothus lemmonii											1	5	15	3	1	3	1	3	2
Lupinus sp.											1	6	15	15	11	2	6	5 ± 2	1
Pteridium aquilinum											3	14 ± 1	16 ± 3	14 ± 12	7 ± 5	1	2	11 ± 8	1
Rosa californica											3	16 ± 4	16 ± 1	23 ± 8	3 ± 1	2	1	13	1
Rosa sp.											1	31	14	15	7	3			
Symphoricarpos mollis											5	14 ± 3	12 ± 2	19 ± 8	6 ± 3	1	5	14 ± 4	1
Toxicodendron diversiloba																	6	5 ± 1	1

Herbaceous species	Freq	Rel cov	Utl		Freq	Rel cov	Utl		Freq	Rel cov	Utl
Agoseris sp.	2	4	1	Festuca californica	7	45 ± 14	1	Juncus sp.	2	2 ± 1	1
Aster sp.	1	17	1	Festuca megalura	6	12 ± 2	1	Lotus sp.	4	8 ± 7	1
Bromus sp.	3	4 ± 2	1	Festuca occidentalis	6	14 ± 6	1	Melica californica	2	9 ± 9	1
Calachortus sp.	4	9 ± 5	1	Galium sp.	5	11 ± 6	1	Stipa occidentalis	1	4	1
Carex sp.	1	4	1	Hieracium albiflorum	5	3 ± 1	1	Trientalis latifolia	1	4	1
Chimaphila umbellatum	1	9	1	Hordeum sp.	3	46 ± 12	1	Vicia sp.	3	7 ± 2	1
Convolvulus sp.	1	1	1	Iris sp.	5	13 ± 8	1	Other composites	2	19 ± 18	1

APPENDIX 3. ***Pseudotsuga menziesii*** **mixed conifer forest habitat type (23 plots). See text for description of variables.**

	Trees (> 6 ft height)										Sapling trees/shrubs (1–6 ft height)						Seedling trees/shrubs (< 1 ft)		
		No.	DBH (in)		Height (ft)		Stems/Acre		Basal Area			Ht.	Diam.	Rel.				Rel.	
Woody Species	Freq.	Trees	x ± se	Range	x ± se	Range	x ± se	Range	x ± se	Range	Freq.	(in)	(in)	cov	Dens.	Form	Freq.	cov	Utl
Abies concolor	15	92	4±1	1–32	22±2	7–131	178±47	0–850	44±17	0–274	13	33±3	23±2	12±3	4±1	1	4	2±2	1
Cornus nuttallii	11	67	2±1	1–4	12±2	7–20	118±38	0–648	2±1	0–13	13	38±5	31±6	38±6	11±3	1–2	12	15±5	2
Cornus sessilis											7	30±6	35±8	25±13	3±1	1	1	1	1
Corylus cornuta											3	34±10	42±13	30±7	7±3	3	5	32±31	1
Libocedrus decurrens	11	72	4±1	1–19	20±2	7–69	127±45	0–809	22±9	0–159	12	35±3	20±2	31±8	12±5	1	28	2±1	1
Pinus lambertiana	17	49	5±1	1–27	29±4	7–115	86±19	0–324	31±11	0–170	12	39±4	22±3	7±2	3±1	1	6	10±8	1
Pinus ponderosa	9	14	14±3	1–29	71±12	13–141	27±9	0–162	42±17	0–272	5	46±7	30±5	16±7	3±1	1	1	9	1
Pseudotsuga menziesii	20	159	5±1	1–37	27±2	7–148	274±59	0–971	74±19	0–317	11	39±4	23±3	20±6	4±1	1	15	4±1	1
Quercus garryana	1	1	7		36		2±2	0–40	1±1	0–11									
Quercus kelloggii	14	43	5±1	1–23	25±3	10–79	76±31	0–688	21±7	0–115	8	29±6	23±5	13±4	3±1	1–2	5	26±2	1
Quercus wislizenii	1	1	2		13		2±2	0–40	.5±.5	0—3									
Snags	3	3	7±1	4–9	15±3	10–20	5±3	0–40	2±1	0–20									
Amelanchier pallida											2	22±13	22±9	3±2	1	1–2	11	6±3	1
Apocynum sp.																	3	1	1
Berberis sp.											6	10±2	12±2	16±7	13±5	3	29	14±5	1
Castanopsis sempervirens											1	28	35	38	7	1			
Ceanothus integerrimus											5	56±10	51±7	29±5	4±1	2	1	15	4
Ceanothus lemmonii											2	8±1	23±1	20±14	7±5	2–3	1	21	3
Lathyrus sp.											1	16	9	3	2	1			
Lupinus sp.											4	22±4	22±5	11±9	5±3	2	13	8±3	1
Potentilla sp.																	5	3	1
Pteridium aquilinum											13	13±2	14±1	30±9	21±9	1	19	13±6	1
Rhamnus californica											7	33±4	29±5	33±10	6±2	1	2	8±2	1
Rhododendron occidentalis											2	66±13	44±14	20±18	4±3	1			
Rosa californica											9	14±2	12±2	9±4	4±1	2	33	11±2	2
Rubus parviflorus											2	10±2	10±4	3±1	3±1	1	17	6±2	1
Rubus sp.																	1	9	1
Symphoricarpos mollis											6	8±2	12±1	17±4	10±4	2	28	9±2	1

Continued on p. 170.

APPENDIX 4. *Pseudotsuga menziesii / Abies concolor / Cornus nuttallii* habitat type (40 plots). See text for description of variables.

	Trees (> 6 ft height)										Sapling trees/shrubs (1–6 ft height)						Seedling trees/shrubs (< 1 ft)		
		No.	DBH (in)		Height (ft)		Stems/Acre		Basal Area			Ht.	Diam.	Rel.				Rel.	
Woody Species	Freq.	Trees	x ± se	Range	x ± se	Range	x ± se	Range	x ± se	Range	Freq.	(in)	(in)	cov	Dens.	Form	Freq.	cov	Utl
Abies concolor	30	157	5±1	1–45	31±2	7–135	159±29	0–607	56±17	0–544	23	37±3	28±3	16±3	4±1	1	15	2±1	1
Acer macrophyllum	3	9	6±1	1–12	34±5	7–59	9±6	0–243	3±2	0–45	3	22±5	20±1	7±4	2±1	1	1	9	3
Alnus rhombifolia	1	1	14		46		1±1	0–40	1±1	0–44									
Arbutus menziesii	2	3	5±2	2–7	13±2	10–16	3±2	0–81	.5±.5	0–20									
Castanopsis chrysophylla	3	7	2±.5	2–4	17±3	13–30	7±5	0–162	.2±.1	0–5									
Cornus nuttallii	19	222	2±.3	1–5	14±3	7–30	225±55	0–1133	2±.6	0–14	24	33±3	27±2	34±6	14±4	1	20	9±3	1
Cornus sessilis	5	35	1±.2	1–2	9±1	7–10	35±21	0–769	.1±.1	0–3	12	41±4	38±5	32±7	10±3	1	9	12±3	1
Corylus cornuta	2	15	1	1	8±1	7–10	15±12	0–486	.1±.1	0–.4	17	32±4	41±7	25±5	4±1	1	3	12±8	1
Libocedrus decurrens	13	55	4±1	1–23	20±3	7–95	57±21	0–648	11±6	0–231	16	28±3	20±3	15±5	5±2	1	30	6±2	1
Pinus lambertiana	13	44	7±2	1–57	34±7	7–151	45±26	0–1052	52±23	0–719	17	37±4	23±3	10±2	2±1	1	9	4±2	1
Pinus ponderosa	5	10	18±5	1–39	83±20	7–167	10±5	0–121	29±16	0–471	2	49±9	25±6	9±6	2±1	1			
Pseudotsuga menziesii	38	267	10±.7	1–76	47±3	7–164	268±40	0–1214	269±41	0–986	17	30±4	20±2	15±4	3±1	1	33	3±1	1
Quercus chrysolepis	1	3	7		30		3±3	0–121	.8±.8	0–33									
Quercus garryana	3	11	4±1	2–9	16±2	10–26	11±7	0–202	2±1	0–49	1	12	8	15	3	1	4	17±8	1
Quercus kelloggii	10	27	7±1	2–25	35±3	10–69	28±11	0–364	15±9	0–231	19	26±3	21±2	15±3	5±1	1	23	6±2	1
Quercus wislizenii	2	3	1±.3	1–2	10±2	7–13	3±2	0–81	.1±.1	0–1	4	58±10	47±4	23±8	2±1	1	1	9	1
Salix sp.	1	10	2±.3	2–3	26		10±10	0–405	.3±.3	0—12									
Taxus brevifolia	6	16	4±1	1–19	13±1	7–20	16±9	0–324	3±2	0–79	6	20±4	20±2	4±2	1±1	2	8	6±1	1
Snags	9	13	10±2	3–27	39±9	10–128	13±5	0–162	11±5	0–158									
Amelanchier pallida											6	8±1	17±3	12±6	3±1	2	1	8	1
Apocynum sp.																	1	9	1
Arctostaphylos patula											1	60	63	38	2	1			
Berberis sp.											10	10±2	14±3	25±6	36±13	1	27	16±5	1
Castanopsis sempervirens											1	18	14	3	1	1			
Ceanothus integerrimus											7	48±7	35±8	29±5	6±1	2	1	4	1
Ceanothus prostatus											1	2	14	3	4	1	1	17	1
Cercis occidentalis											1	79	65	15	1	1			
Lupinus sp.											2	18±2	14±3	20±18	10±6	1	3	4	1
Pteridium aquilinum											15	14±1	15±1	11±3	5±1	1			
Rhamnus californica											1	24	9	3	1	2			
Rhododendron occidentalis											1	44	70	15	1	1			
Rosa californica											18	17±2	14±2	16±4	9±2	2	41	11±2	1
Rubus sp.											7	9±1	10±2	8±3	8±4	1	18	14±3	1
Symphoricarpos mollis											15	10±1	10±2	10±3	7±2	2	44	12±3	1
Toxicodendron californica											8	17±2	9±1	21±7	16±4	1	19	16±4	1

APPENDIX 5. ***Quercus garryana / Pseudotsuga menziesii*** **habitat type (10 plots). See text for description of variables.**

	Trees (> 6 ft height)										Sapling trees/shrubs (1–6 ft height)						Seedling trees/shrubs (< 1 ft)		
		No.	DBH (in)		Height (ft)		Stems/Acre		Basal Area			Ht.	Diam.	Rel.				Rel.	
Woody Species	Freq.	Trees	x ± se	Range	x ± se	Range	x ± se	Range	x ± se	Range	Freq.	(in)	(in)	cov	Dens.	Form	Freq.	cov	Utl
Pinus lambertiana	4	13	9±6	2–18	36±10	10–85	53±29	0–283	26±17	0–141	2	38±22	33±23	9±6	2±1	1	1	24	1
Pinus ponderosa	4	21	6±4	2–12	30±6	10–56	85±55	0–567	11±6	0–48	1	75	48	3	1	1	2	1	1
Pseudotsuga menziesii	7	57	8±5	1–23	39±6	6–89	231±96	0–809	73±31	0–311	3	46±17	30±9	46±28	2±1	1	5	23±1	1
Quercus garryana	9	42	8±8	2–32	23±5	10–55	166±44	0–445	55±26	0–248	3	49±15	42±14	46±21	5±1	2	2	24±4	1
Quercus kelloggii	6	11	7±7	1–20	30±6	10–59	45±14	0–121	15±9	0–89	5	35±13	33±10	25±12	4±1	3			
Quercus wislizenii	2	7	4±2	1–7	20±3	10–26	28±21	0–202	3±3	0–81	3	13±2	20±4	60±24	4±3	1	1	24	1
Arctostaphylos viscida											2	78±9	62±3	98	12±3	4			
Ceanothus lemmonii											1	4	11	98	2	3			
Toxicodendron diversiloba											2	22±2	23±4	9±6	4±2	3			

Herbaceous species	Freq	Rel cov	Utl
Aira caryophylla	3	9±3	1
Aster sp.	1	14	1
Bromus sp. (perenn.)	4	14±10	1
Bromus sp. (annuals)	2	9±4	1
Bromus tectorum	4	11±2	1

APPENDIX 6. ***Pseudotsuga menziesii / Abies concolor / Pinus*** **sp. habitat type (clearcut of Type 4) (14 plots). See text for description of variables.**

	Trees (> 6 ft height)										Sapling trees/shrubs (1–6 ft height)						Seedling trees/shrubs (< 1 ft)		
		No.	DBH (in)		Height (ft)		Stems/Acre		Basal Area			Ht.	Diam.	Rel.				Rel.	
Woody Species	Freq.	Trees	x ± se	Range	x ± se	Range	x ± se	Range	x ± se	Range	Freq.	(in)	(in)	cov	Dens.	Form	Freq.	cov	Utl
Abies concolor	1	1	5		36		3±3	0–40	0.4±.4	0–6									
Castanopsis chrysophylla											1	26	32	15	2	1	4	3±2	1
Cornus nuttallii											6	26±3	24±4	31±9	8±2	2–3	13	11±3	2
Cornus sessilis											2	11±2	10±4	3±2	3±2	3			
Corylus cornuta											1	22	25	3	40	2			
Libocedrus decurrens	2	9	4±1	2–7	23±6	9–49	26±21	0–283	3±2	0–27									
Pinus lambertiana	1	1	9		49		3±3	0–40	1±1	0–18	3	18±3	14±5	7±4	4±2	1	5	9±9	1
Pinus ponderosa	5	7	3±1	1–9	11±2	6–23	20±8	0–81	2±1	0–18									
Pseudotsuga menziesii	2	4	6±3	1–13	36±14	7–65	12±9	0–121	4±4	0–55	2	50±22	48±30	9±6	2±1	3			
Quercus kelloggii																	1	21	1
Apocynum sp.											1	16	3	3	3	1	16	21±5	1
Berberis sp.											3	14±3	18±3	11±5	6±3	2	18	18±5	3
Ceanothus integerrimus											3	5±2	10±11	7±4	3±2	1	1	9	1
Ceanothus prostatus											9	16±1	14±1	40±12	53±23	1	1	4	1
Lupinus sp.											5	14±3	10±2	17±6	6±3	1	9	9±5	1
Pteridium aquilinum											1	14	12	3	1	2	6	12±3	2
Rosa californica											4	15±6	8±2	23±8	14±6	1	1	4	1
Rosa sp.											1	3	28	38	10	1	5	6±2	1
Rubus vitifolius											1	7	12	3	2	2			
Rubus sp.																	1	4	1
Symphoricarpos mollis																	8	10±1	2

Herbaceous species	Freq	Rel cov	Utl		Freq	Rel cov	Utl
Adenocaulon bicolor	2	9±6	1	Erysimum sp.	1	1	1
Arabis sp.	4	11±3	2	Festuca sp. (annuals)	16	13±4	1
Bromus sp.	4	9±4	2	Festuca californica	1	1	1
Chimaphila umbellatum	1	1	1	Festuca occidentalis	8	9±3	2
Danthonia californica	1	4	1	Linnae borealis	5	2±1	1
Deschampsia danthonoides	3	55±10	1	Stipa sp.	2	14	2
Elymus glaucus	3	11±6	1	Vicia sp.	3	12±8	2

APPENDIX 7. ***Cornus nuttallii/Ceanothus integerrimus*** **transition shrub habitat type, (33 plots). See text for description of variables.**

	Trees (> 6 ft height)										Sapling trees/shrubs (1–6 ft height)						Seedling trees/shrubs (< 1 ft)		
		No.	DBH (in)		Height (ft)		Stems/Acre		Basal Area			Ht.	Diam.	Real.				Rel.	
Woody Species	Freq.	Trees	x ± se	Range	x ± se	Range	x ± se	Range	x ± se	Range	Freq.	(in)	(in)	cov	Dens.	Form	Freq.	cov	Utl
Abies concolor	28	139	5±.4	1–18	24±2	6–82	171±33	0–931	35±9	0–195	19	22±2	36±4	9±2	2±1	1	13	5±4	1
Acer macrophyllum	10	62	2±.3	1–11	17±1	6–46	76±26	0–526	4±2	0–37	5	16±3	32±8	7±3	3±1	1	6	9±5	2
Alnus rhombifolia	1	12	2		18		15±15	0–486	.3±.3	0–10							1	1	1
Arbutus menziesii	3	4	3±1	1–5	19±3	12–24	5±3	0–81	1±.5	0–10	1	33	37	15	2	1			
Castanopsis chrysophylla	8	53	3±1	1–23	18±2	6–64	65±24	0–486	7±5	0–159	9	48±22	54±20	15±4	12±11	1			
Cornus nuttallii	31	566	1±.6	1–3	11±3	6–18	694±101	0–2630	7±1	0–40	26	27±3	37±3	23±3	7±11	1–2	12	5±2	1
Cornus sessilis	11	182	1±.1	1–2	9±2	6–12	223±86	0–2226	.7±.3	0–8	19	31±3	43±4	20±4	8±2	1	13	7±4	1
Corylus cornuta	18	219	1±.2	1–2	9±1	6–12	277±71	0–1295	1±.3	0–8	26	37±5	39±4	14±3	4±1	1	1	9	1
Libocedrus decurrens	3	10	2±.4	1–4	11±1	7–15	12±8	0–243	.4±.2	0–7	8	16±3	27±6	4±1	3±1	1	3	1	1
Pinus lambertiana	6	10	4±2	1—15	21±5	6–45	12±6	0–202	3±2	0–52	1	25	38	3	1	1			
Pinus ponderosa	5	9	4±1	1–9	21±4	10–45	11±5	0–121	2±1	0—20							1	1	1
Pseudotsuga menziesii	24	113	4±1	1–41	20±2	6–134	145±36	0–890	49±18	0—363	7	23±2	45±5	11±5	4±3	1	5	10±7	1
Quercus garryana											1	20	14	3	1	1			
Quercus kelloggii	5	12	4±1	1–13	23±4	6–51	15±7	0–162	3±2	0—43	7	22±5	30±4	8±3	3±1	2	10	2±1	1
Quercus wislizenii	5	7	2±.4	1–3	10±1	6–15	9±4	0–121	.2±.2	0—2	3	37±10	50±18	18±10	3±2	1			
Taxus brevifolia	9	20	7±1	2–22	20±3	9–48	25±8	0–162	12±6	0–184	6	22±6	26±3	24±6	7±2	2	2	13±12	1
Snags	3	4	30±12	9–55	17±7	6–36	5±3	0–81	36±25	0–670									
Amelanchier pallida											6	25±5	24±7	7±2	2±1	1			
Apocynum sp.																	6	2±1	1
Arctostaphylos viscida											1	16	25	3	1	2			
Berberis sp.											14	11±1	10±1	18±6	15±4	1	43	13±3	1
Ceanothus integerrimus											26	60±4	72±4	43±4	9±1	2	10	2±1	2
Eriogonum sp.											1	4	22	3	7	1			
Garrya fremontii											1	17	24	3	1	3			
Lathyrus sp.											1	11	23	15	6	2			
Leucothe davisiae											1	39	42	15	4	1			
Lupinus sp.											3	23±2	16±5	11±4	6±3	1	7	2±1	1
Pteridium aquilinum											14	17±1	17±1	25±5	14±3	1	6	2±1	1
Rosa californica											24	11±1	16±2	10±2	7±1	2	55	8±2	1
Rubus parviflorus											19	15±3	8±2	12±2	8±1	1	51	11±2	1
Rubus sp.											14	16±3	17±2	8±2	7±2	2	18	7±2	3
Symphoricarpos mollis											15	13±1	10±1	7±1	6±1	1	60	13±2	1
Toxicodendron diversiloba											1	25	48	3	1	1	1	9	1

Continued on p. 171.

APPENDIX 1. *(Continued)*

Herbaceous species	*Freq*	*Rel cov*	*Utl*		*Freq*	*Rel cov*	*Utl*		*Freq*	*Rel cov*	*Utl*
Adenocaulon bicolor	29	11 ± 3	1	Festuca californica	17	31 ± 12	1	Pyrola picta	1	17	1
Asarum sp.	3	14 ± 3	1	Galium sp.	4	2 ± 1	1	Ranunculus sp.	4	2 ± 1	1
Bromus sp.	30	9 ± 4	1	Hieracium albiflorum	28	10 ± 2	1	Smilacina racemosa	6	16 ± 3	1
Calachortus sp.	9	3 ± 1	1	Iris sp.	1	9	1	Trientalis latifolia	20	14 ± 7	1
Carex sp.	7	13 ± 3	1	Lilium sp.	4	7 ± 6	1	Vicia sp.	15	7 ± 3	2
Chimaphila umbellatum	16	7 ± 3	1	Linnae borealis	2	1	1	Other composites	13	8 ± 2	1
Elymus glaucus	1	4	1	Lotus sp.	1	4	1				
Erigeron sp.	1	1	1	Pterospora andromedia	1	1	1				

APPENDIX 3. *(Continued)*

Herbaceous species	*Freq*	*Rel cov*	*Utl*		*Freq*	*Rel cov*	*Utl*		*Freq*	*Rel cov*	*Utl*
Adenocaulon bicolor	4	8 ± 1	2	Festuca californica	29	23 ± 4	1	Ranunculus sp.	1	1	1
Agropyron sp.	1	1	1	Galium sp.	1	49	1	Rumex sp.	3	2 ± 1	1
Agrostis sp.	1	4	1	Hieracium albiflorum	14	3 ± 1	1	Sisrinchium sp.	1	1	1
Aira caryophylla	1	1	1	Holcus lanatus	8	6 ± 3	1	Smilacena racemosa	1	2	1
Asclepius sp.	1	17	1	Hordeum sp.	3	10 ± 10	1	Stipa sp.	8	12 ± 8	1
Brodiaea sp.	3	3 ± 2	1	Iris sp.	12	13 ± 4	1	Trientalis latifolia	36	17 ± 4	1
Bromus sp.	25	7 ± 3	2	Juncus sp.	7	12 ± 3	1	Trifolium sp.	12	33 ± 11	1
Carex sp.	19	6 ± 2	1	Lilium sp.	6	8 ± 5	2	Vicia sp.	1	5	2
Chimaphila umbellatum	17	7 ± 3	1	Linnae borealis	14	18 ± 7	1	Viola sp.	7	2 ± 1	1
Convolvulus sp.	9	3 ± 2	2	Lotus sp.	4	4 ± 1	1	Other composites	9	1 ± 1	1
Crepis sp.	1	4	1	Mentha sp.	12	2 ± 1	1				
Danthonia californica	4	13 ± 4	1	Perideridia sp.	3	4 ± 1	1				
Elymus glaucus	9	7 ± 4	1	Plantago sp.	2	4	1				
Erigeron sp.	1	1	1	Poa sp.	1	1	1				
Festuca sp. (annuals)	18	8 ± 4	1	Pyrola picta	5	9 ± 8	1				

APPENDIX 4. *(Continued)*

Herbaceous species	*Freq*	*Rel cov*	*Utl*		*Freq*	*Rel cov*	*Utl*		*Freq*	*Rel cov*	*Utl*
Adenocaulon bicolor	32	15±5	1	Festuca sp. (perenn.)	63	13±2	1	Melica californica	8	23±3	1
Bromus sp. (perennials)	26	4±2	1	Festuca occidentalis	9	17±5	1	Pyrola picta	18	7±2	1
Bromus tectorum	1	1	1	Galium sp.	20	5±1	1	Ranunculus sp.	1	1	1
Carex sp.	9	4±2	1	Hieracium albiflorum	24	7±5	1	Smilacena racemosa	10	4±2	1
Chimaphila umbellatum	37	16±3	1	Iris sp.	17	3±2	1	Trientalis latifolia	65	19±4	1
Elymus glaucus	3	34±8	1	Juncus sp.	1	9	1	Veratrum californicum	6	7±5	1
Erythronium sp.	1	1	1	Lilium sp.	1	9	1	Vicia sp.	3	13±8	1
Festuca sp. (annuals)	8	18±9	1	Linnae borealis	30	32±7	1				

APPENDIX 7. *(Continued)*

Herbaceous species	*Freq.*	*Rel cov*	*Utl*		*Freq.*	*Rel cov*	*Utl*		*Freq.*	*Rel cov*	*Utl*
Adenocaulon bicolor	9	6±5	1	Elymus glaucus	2	4±1	1	Melica californica	3	6±3	1
Aira caryophylla	2	4	1	Festuca sp.	42	8±2	2	Penstemon sp.	1	4	1
Antennaria rosea	1	1	1	Festuca californica	16	7±3	1	Poa sp.	2	1	1
Arabis sp.	1	1	1	Galium sp.	13	6±3	1	Pyrola picta	9	2±1	1
Asarum sp.	5	5±4	1	Gilia sp.	1	4	1	Ranunculus sp.	1	1	1
Bromus sp. (perenn.)	40	10±2	1	Hieracium albiflorum	4	6±3	1	Smilacena racemosa	7	6±2	1
Bromus tectorum	1	31	1	Iris sp.	3	7±7	1	Stipa sp.	1	1	1
Carex sp.	10	6±2	1	Juncus sp.	1	19	1	Trientalis latifolia	89	34±4	1
Castilleja sp.	5	4±2	2	Lilium sp.	3	6±3	2	Vicia sp.	8	2±1	1
Chimaphila umbellatum	22	7±2	1	Linnaea borealis	60	22±3	1	Other composites	3	12±8	1

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NOTES

ON SOME ABNORMALITIES IN THE CHELAE OF COMMERCIAL CRABS (GENUS *CANCER*) FROM BAJA CALIFORNIA, MEXICO

Teratologic abnormalities in crustacean chelae have been documented since long ago. According to Fischer (1888), records in literature date from the beginning of the eighteenth century, when abnormalities in *Astacus fluviatilis* were described by Valentin and by von Rosenhof as early as 1730 and 1755, respectively. The explanation for such deformities, already foreseen by von Rosenhof (Fischer 1888), has been developed by Przibram (1921), Shuster, Ulmer and van Engel (1936) and by Shelton, Turby and Shelton (1981). It is considered that these abnormalities probably result from failure of deep wounds to heal when such wounds are inflicted on still soft cuticule, whether after moulting or while regenerating.

Experimentally, the abnormalities have been induced on repeated occasions (Przibram 1921, Reed 1904, Zeleny 1905, Emmel 1907, all mentioned by Legendre 1925). Shelton (1982) maintained abnormal specimens alive in the laboratory and found that deformities persisted within the same relative size after moulting.

To my knowledge, deformities have been described for the genus *Cancer* only from the European species *C. pagurus* (Fischer 1888, Le Senechal 1888, Legendre 1925, Abeloos 1936, Nouvel 1961, Deunff 1969, Shelton, Turby and Shelton 1981, Shelton 1982) and from the western North American *C. magister* (Butler 1956).

This note describes four abnormal chelae from the private collection of J. Buenrostro collected by fishermen in the vicinity of Ensenada, Baja California, México. These abnormalities are as follow (Figure 1):

(i) Left cheliped of *C. antennarius* (Figure 1—upper left). The deformity grows from the proximal dorsal margin of the dactylopodite. It closely resembles both fingers but lacks an articulation in between. The dactylopodite is somewhat reduced and its longitudinal axis is inwardly deviated. Restrained movement of the dactylopodite must have favored development of bryozoan colonies growing on the articulation.

(ii) Right cheliped of *C. anthonyi* (Figure 1—upper right). The outgrowth emerges from the cutting edge of the dactylopodite. It is oriented downwards and outwards. Movement of articulation is not obstructed. In contrast to the other three cases, this outgrowth exhibits a perfect mirror-image symmetry in coloration and external edges of the outgrowth.

(iii) Left cheliped of *C. anthonyi* (Figure 1—lower left). The abnormality arises ventrally from the proximal portion of the fixed finger; it is oriented forwards and the inner margins are dark colored and provided with teeth.

(iv) Left cheliped of *C. anthonyi* (Figure 1—lower right). The deformity emerges proximally from ventral margin of the protopodite. Mirror-image symmetry is not as good as case No. 2. The ends are somewhat twisted and dark colored on the inner margins and tips. Regular teeth are present but do not reach the tips.

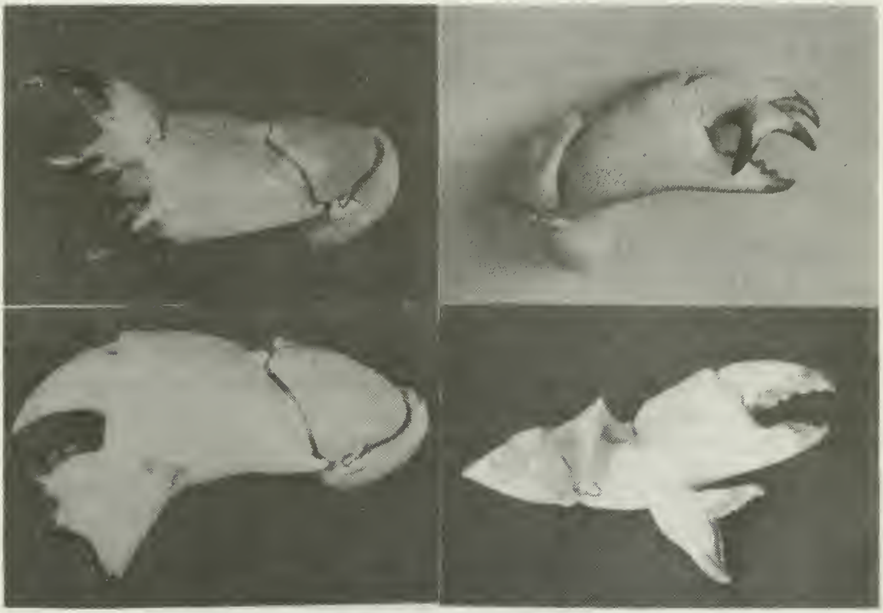

FIGURE 1. *Cancer* Chelae abnormalities. Upper left—left cheliped of *C. antennarius* upper right—right cheliped of *C. anthonyi*; lower left—left cheliped of *C. anthonyi*; lower right—left cheliped of *C. anthonyi.*

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SECOND RECORD OF *CUBICEPS PARADOXUS* AND *ANTENNARIUS AVALONIS* FROM CALIFORNIA

On 29 August 1986, a *Cubiceps paradoxus* (Family Nomeidae) was caught in Los Angeles Harbor near San Pedro, Ca. (lat 33° 43′ N, long 118° 17′ W). The specimen (Figure 1, 360 mm standard length (SL), 435 mm total length (TL), CMM 87.10.1) was gaffed by Dewaine Holland and brought to Cabrillo Marine Museum. It is the second adult specimen ever taken.

FIGURE 1. *Cubiceps paradoxus* (360 mm SL). Second known adult specimen (CMM 87.10.1). Photograph by S. Vogel.

Characters diagnostic for this species are the absence of teeth on the vomer, uniserial teeth present on the palatines, lateral line scales 90 and long caudal peduncle. *C. paradoxus* appears to be adapted for a pelagic, midwater habitat. This specimen, caught while swimming at the surface, bears no wounds or diseases to explain its unlikely appearance in shallow coastal waters.

In 1976 Ahlstrom, Butler, and Sumida captured three juvenile specimens in the central Pacific in a midwater trawl and suspected they were a new species of *Cubiceps*. It was called *Cubiceps* sp. B. They also felt that a large nomeid captured off Portuguese Bend, Ca. on 11 August 1954, reported as *C. gracilis* (Fitch and Lavenberg 1968), was the same undescribed species. Butler (1979) revised the genus *Cubiceps* and designated the specimen caught off Portuguese Bend as the holotype of *C. paradoxus* (LACM 37048-1).

A second California specimen of the roughjaw frogfish, *Antennarius avalonis* (Family Antennariidae), was caught by Roger Wasserman in Scotchmans Cove at Laguna Beach, Ca. (lat 33° 33′ N, long 117° 49′ W) on 12 April 1986. This specimen represented an increase in its northern distribution of approximately 22 km. The first record of *A. avalonis* was collected at Avalon, Santa Catalina Island, Ca. (lat 33° 21′ N, long 118° 19′ W) in 1907 (Jordan and Starks 1907). The validity of this record was questioned by Pietsch and Grobecker (1987) who noted that although this fish was held at a local aquarium, its origin of capture was uncertain. They speculated that it may have been brought alive from elsewhere and, after its death, included with locally collected animals. This second record, also from southern California, increased the liklihood of the validity of the first Avalon specimen.

The specimen (Figure 2, CMM 87.4.1) was taken from a shallow reef at a depth of 13 m in Laguna Beach on hook and line using Pacific herring, *Clupea harengus,* as bait. The fish measured 275 mm SL, 330 mm TL, and is distinguished from other frogfishes by a single prominent dorsal ringed ocellus, escal morphology and bifurcate fin rays (Miller and Lea 1972, Pietsch and Grobecker 1987, Thomson, Findley and Kerstitch 1979). The specimen was kept alive for four months in a 50 gallon aquarium at Cabrillo Marine Museum, feeding sporadically on free-swimming topsmelt, *Atherinops affinis.*

FIGURE 2. *Antennarius avalonis* (275 mm SL). The second specimen caught in California (CMM 87.4.1). Photograph by S. Vogel.

A. avalonis occurs commonly in the Gulf of California, and extends southward to Peru as juveniles. Larger individuals, like this one, are found only in deeper water, according to Thomson et al. (1979). The northern occurrence of the roughjaw frogfish in California waters may be attributed to the strong influx of warm water, El Niño, which last occurred in 1982–83. During this period five fish species were reported north of their previous known northern limits, and 13 additional species were reported as "rare occurrences", sighted only sporadically in their northern range (Fluharty 1984). It is therefore possible that a warm water intrusion may have deposited a specimen of *A. avalonis* in a suitable reef habitat where it had been able to survive for three years.

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RECENT RECORDS OF THE SANTA CRUZ KANGAROO RAT, *DIPODOMYS VENUSTUS VENUSTUS,* IN SANTA CRUZ COUNTY

The Santa Cruz kangaroo rat, *Dipodomys venustus venustus,* is known to inhabit the low foothills of the Santa Cruz Mountains, primarily in Santa Cruz County (Grinnell 1922). It appears to be limited to sandy chaparral habitat consisting mostly of *Arctostaphyllos* sp. and *Ceanothus* sp. (Hawbecker 1949, Rudd 1948). Most specimens have been collected around Mt. Hermon, Felton, and Bonny Doon in a habitat described as ponderosa pine parkland (Thomas 1961). This habitat now totals less than 7 square miles in the Mt. Hermon area, mostly in small isolated parcels of land. The historical range of *D. v. venustus* in Santa Cruz County is indicated in Figure 1. The other subspecies *D. v. sanctiluciae,* is found farther south, primarily in the Santa Lucia Mountain foothills of Monterey and San Luis Obispo counties, in similar chaparral habitat (Grinnel 1922).

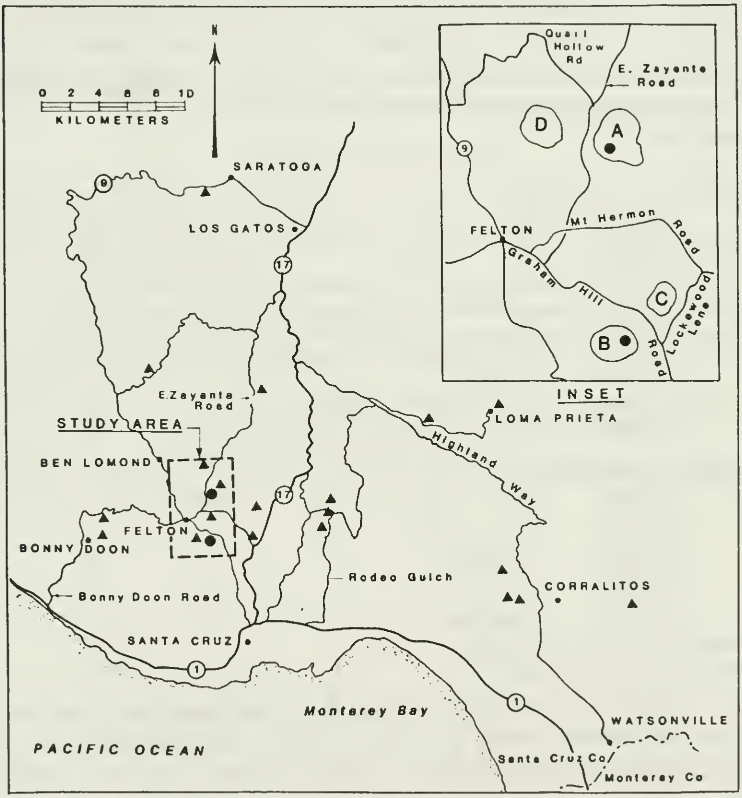

FIGURE 1. Distribution of *Dipodomys venustus venustus.* Triangles indicate locations of *D. v. venustus* trapped historically. Circles indicate where kangaroo rats were caught in this study; see inset for details. A=Old Kaiser Quarry site, B=Henry Cowell State Park site, C=Area C, D=San Quarry site.

Church (1961, 1969) trapped *D. v. venustus* specimens in 1960. During trapping surveys by other investigators in the 1970's and early 1980's, no kangaroo rats were captured or positively identified, and there was some word-of-mouth speculation that the animal had become extinct.

A live trapping study was conducted in the winter and spring of 1984 to determine the presence and distribution of *D. v. venustus*. Trapping was conducted in four parcels of relatively undisturbed sand parkland habitat around Felton and Mt. Hermon (Figure 1). Sherman live traps, set in stations of two traps per station, were placed approximately 15m apart in two or three parallel lines. Most traps were placed under small shrubs and bushes. Rolled oats were used to bait traps.

Area A was an abandoned sand quarry often referred to as the Old Kaiser Quarry, which has remained relatively undisturbed since the late 1960's; many endemic plants occur here. Seven kangaroo rats were caught in 737 trap nights, with two recaptures, between February and May 1984.

Area B was a ridgetop located just north of Henry Cowell State Park. Three kangaroo rats were caught in 285 trap nights, with two recaptures, between January and May 1984. Data for trapped kangaroo rats are shown in Table 1.

TABLE 1. Measurements and Other Data for *Dipodomys venustus venustus* Trapped in Santa Cruz Co., 1984. (Measurements are in millimeters, weight is in grams.)

KR#	*Trap Date*	*Total L.*	*Tail L.*	*Hind Foot Length*	*Ear*	*Weight*	*Sex*
Area A, Kaiser Quarry site:							
1	18 Feb 84	310	195	45	18	72	F
2	19 Feb 84	303	195	44	18	57	M
3	19 Feb 84	240	* 130	43	18	72	M
–	28 Apr 84	recapture					
4	20 Feb 84	250	170	45	17	78	M
5	2 Apr 84	260	* 165	44	17	75	F
–	15 Apr 84	recapture					
6	2 Apr 84	295	210	45	18	65	F
7	15 Apr 84	310	195	48	19	82	M
Area B, Henry Cowell State Park site:							
8	21 Jan 84	306	203	42	17	–	M
9	5 May 84	240	* 150	44	17	75	F
–	6 May 84	recapture				72	
–	7 May 84	recapture				78	
10	6 May 84	260	* 155	45	119	82	M
11	7 May 84	recapture				85	

KR# = identification number for individuals
* tail broken; affects total and tail lengths.

Area C was 2½ kilometers east of Area B. No kangaroo rats were trapped in 120 trap nights between March and June. However, observations in July 1984 of active kangaroo rat burrows and fresh tracks indicated that they occurred here as well.

Area D was a ridgetop behind an active sand quarry and was remarkable in that in 300 trap nights not a single rodent of any species was caught. A similar study in 1978 yielded the same results (Morangio 1978). The only fresh mammal sign observed here was that of gopher and rabbit.

One specimen of *D. v. venustus,* a trap mortality, was prepared for the museum collection at University of California at Santa Cruz.

This study confirms the presence of *D. v. venustus* in the Mt. Hermon area. Other historical locations appear to be still suitable for kangaroo rats, especially around Bonny Doon (see Figure 1). Much of the sand parkland habitat is disappearing due to an increase in development in the entire Santa Cruz area. However, *D. v. venustus* may not be restricted to the sand parkland areas around Mt. Hermon and Bonny Doon. The few specimens gathered outside the Santa Cruz mountain range may represent isolated populations of *D. v. venustus,* or more likely, an intergrade with kangaroo rats of similar species (Hawbecker 1940).

It is important to conduct a thorough survey of kangaroo rats throughout the Santa Cruz mountain region. If *D. v. venustus* truly is limited to sand parkland habitat, then as developments and sand quarrying operations continue in these areas, it faces the possibility of extinction.

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FAMILY HIMANTOLOPHIDAE ADDED TO THE ICHTHYOFAUNA OF THE TEMPERATE EASTERN NORTH PACIFIC

The Himantolophidae, footballfishes, is one of the most distinctive families of the ceratioid anglerfishes; the systematics are currently in revision (E. Bertelsen and G. Krefft, in press). *Himantolophus groenlandicus* Reinhardt, described in 1837, is the earliest known account of a ceratioid. Reinhardt's original description ". . . was based on a very large, damaged specimen of which only the illicium has been preserved (Bertelsen 1951:58)." Among female ceratioids, only the Himantolophidae have large bony plates in the skin of the body, each plate possessing a median spine. The family contains a single genus, *Himantolophus,* previously recorded from all major oceanic faunal regions with the exception of the temperate eastern North Pacific, eastern South Pacific, South Atlantic, and southeastern Indian Ocean (E. Bertelsen, pers. comm., Jan. 1986). *Himantolophus azurlucens* Beebe and Crane, from the tropical eastern Pacific off Panama, is known from only the type specimen. Most recently, Kharin (1984) described *H. borealis* from the western North Pacific off Japan. In addition to these two species, records of *Himantolophus* for the Pacific Ocean include *H. groenlandicus* from off Japan (originally described as *Corynolophus sagamius* Tanaka—see Bertelsen (1951:58) for discussion of names applied to *Himantolophus* taken off Japan) and *H. appelii* (Clarke) from off Australia and New Zealand.

On 18 December 1983 an "odd deep-sea fish" was captured by the OREGON BEAVER while trawling for Dover sole, *Microstomus pacificus,* on the edge of Santa Lucia Bank, off Morro Bay, California (lat 35°13.0'—05.0'N, long 121°22.1'—16.0'W) at 613 m. The specimen was saved by Tom Elliot, skipper of the vessel, and turned over to the California Department of Fish and Game for identification. The specimen, a female *Himantolophus,* 118 mm standard length (SL), was in reasonably good condition with the esca complete and undamaged; it is deposited at the Natural History Museum of Los Angeles County, Section of Ichthyology, LACM 43760-1. Approximately one year after the capture of the first eastern North Pacific *Himantolophus,* a second specimen (Figure 1), 185 mm SL, was captured alive on 3 January 1985. It was taken by the SIERRA MADRE while midwater trawling at 915–970 m over the Monterey Submarine Canyon (ca. lat 36°47'N, long 122°01'W). The specimen was maintained for approximately 65 h; it was put in iced sea water upon capture and held for 18 h, then transferred to Monterey Bay Aquarium where it survived until 0730 on 6 January. Haneda (1968) reported on luminescence in a Japanese specimen of *Himantolophus* kept alive for eight days; no luminescence was detected in an hour of observation of the Monterey Submarine Canyon specimen. This fish is deposited at the California Academy of Sciences, Department of Ichthyology, CAS 57639.

Both specimens appear to fit the concept of *H. groenlandicus* as diagnosed by Regan (1926) and Bertelsen (1951). However, with the material now available for the systematic revision mentioned above (Bertelsen and Krefft), there is evidence that *H. groenlandicus,* may comprise a number of closely related taxa, including a separate Pacific form (E. Bertelsen, pers. comm., 10 Feb 1986). Selected counts and morphometrics for the two eastern North Pacific specimens are given in Table 1. The esca, the primary character in separating species, is illustrated in Figure 2.

FIGURE 1. *Himantolophus* sp., CAS 57639, 185 mm SL, second known specimen from eastern North Pacific. Photograph by author.

TABLE 1. Measurements (in mm, before and after preservation), counts, and weights for eastern North Pacific *Himantolophus*.

	LACM 43760-1	*CAS 57639*
Total length	170 (157)	263 (235)
Standard length	118 (113)	185 (180)
Length of illicium	— (52)	91 (87)
Body weight (g)	— (150)	1004 (695)
Dorsal fin rays	5	5
Anal fin rays	4	4
Pectoral rays (left)	15	16
Caudal fin rays	9	9

The occurrence of *Himantolophus groenlandicus* Reinhardt (or a closely related species) off California adds the Himantolophidae to the ichthyofauna of the temperate eastern North Pacific Ocean.

It seems enigmatic that the presence of *Himantolophus* from the temperate eastern North Pacific has gone unnoticed until now. From the historic zoogeographical perspective, this oceanic region has been well collected and its fauna seemingly well documented (Clemens and Wilby 1961, Fitch and Lavenberg 1968, Quast and Hall 1972, Hart 1973, Hubbs, Follett, and Dempster 1979, among others). Perhaps the capture of these two specimens of *Himantolophus* reflects the current state of knowledge of deep-sea fishes in generaland indicates the value of future inner-space exploration.

FIGURE 2. Illicium and esca of *Himantolophus* sp., CAS 57639, left lateral view. Drawn by Robert Nielsen (ZMUC).

ACKNOWLEDGMENTS

I would like to thank the crews of the OREGON BEAVER and the SIERRA MADRE for saving these "odd deep-sea fish" in the interest of science. The illustration of the illicium was drawn by Robert Nielsen and I was permitted its use by the Zoological Museum, University of Copenhagen (ZMUC). My sincere appreciation to Erik Bertelsen, ZMUC, for his valuable comments during the preparation of this paper and for allowing use of the drawing which will be used in their (Bertelsen and Krefft) revision of the Himantolophidae. This research was supported in part by Federal Aid in Fish Restoration Act funds to California Dingell-Johnson F-25-R, Central California Marine Sportfish Survey.

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WILD CARNIVORE DEATHS DUE TO ANTICOAGULANT INTOXICATION

A dead raccoon, *Procyon lotor,* and a mountain lion, *Felis concolor,* were presented to the California Department of Fish and Game's Wildlife Investigations Laboratory in December 1986. Both had died near a stream in northern California. The mountain lion had been seen alive, but weakened, the day before its death. Unnatural causes of death were suspected because of the unusual finding of two animals together and their proximity to human activity.

The raccoon had normal body fat. There was no evidence of external trauma. Pinpoint hemorrhages were noted over the mucous membranes of the oral cavity. Pooled free blood was present in subcutaneous tissues. Non-clotting free blood was found in the abdominal cavity. The spleen and liver were enlarged.

The mountain lion was in good external condition at the time of death. The soft palate, tongue, and mucous membranes had pinpoint hemorrhages. The lungs were pink with no evidence of pneumonia. The heart appeared normal. The distal loops of the small intestine and colon had pinpoint and streaked hemorrhages. The entire digestive tract was engorged with water.

Blood and liver samples were sent to the U.S. Department of Agriculture, National Veterinary Services Laboratories in Ames, Iowa for anticoagulant residue analysis through M. Mount, D.V.M., at the University of California, Davis. Diphacinone residues were present at 55 and 44 parts per million (ppm) in raccoon blood and liver. Mountain lion blood contained 45 ppm. Liver residues from the mountain lion could not be determined.

Clinical signs and positive residues indicate anticoagulant intoxication.

The death of wild carnivores due to anticoagulants is not reported in the literature. Secondary poisoning has been demonstrated in the laboratory (Evans and Ward 1967, Mendenhall and Pank 1980). The source of the anticoagulant is unknown in this incident. We speculate large amounts of anticoagulant were available for consumption, possibly rodent baits placed contrary to label instructions which call for bait stations or for thin spreading. The death of carnivores and the large residues found in tissue samples could also lead to speculation that illegal meatbaits treated with technical diphacinone might have been involved. Diphacinone is currently registered as a rodenticide in California in both pellet and grain formulations. The active ingredient is added to baits at either 0.01 or 0.005 percent concentrations. Target animals are specified rodents. No carnivores can be legally taken by this material. The death of wild carnivores due to anticoagulants is unusual. Field personnel should be aware such a possibility is present and that anticoagulants can pose a hazard, especially if improperly used.

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BILL DEFORMITY IN A BRANDT'S CORMORANT CHICK

Bill deformities have been reported often in wild birds but primarily in passerines (see review by Pomeroy 1962). Recently, bill deformities have also been found in several species of seabirds (Threlfall 1968, Smith and Diem 1971, Hays and Risebrough 1972, Sealy 1978, Schubert 1982), including cormorants (Snow 1963, Stronks 1983, Hudson 1987). Few of these accounts have been accompanied by detailed anatomical, ecological, or behavioral notes (see Parkes 1969). We describe here a bill deformity in a Brandt's cormorant, *Phalacrocorax penicillatus,* chick from Southeast Farallon Island (SEFI), California.

On 21 July 1984, while counting Brandt's cormorant chicks in nests from a blind on SEFI (Carter and Hobson 1988), we observed a chick with a deformed upper mandible. We observed this chick with a 45x spotting scope and determined that it was about two-thirds the size of its two siblings. In none of the other nests was there as striking a difference in size between chicks within a brood. This site had been followed since 30 May when a banded 10-year-old male was seen copulating with an unbanded female. The 3-egg clutch was laid between 4 and 8 June; eggs appeared to have been laid two days apart as is usual (Ainley and Boekelheide, in press). The first egg hatched on 6 July, but not until 15 July were all three chicks observed in the nest. The second and third chicks usually hatch within 2 to 3 days of the first chick, but we were unable to determine this for this nest. Egg laying and hatching dates for this nest were near average in 1984 (Carter and Hobson 1988).

From 21 to 27 July (when the chicks were 15 to 24 days old), we observed seven chick feedings by parents at the nest. The deformed chick was fed only once. It begged weakly for several minutes after its siblings had been fed, but rarely contacted the adult's bill or gular region during begging attempts. On 25 July, we had the opportunity to examine these chicks closely while banding chicks in this colony at night (0045–0300 h PDT). The deformed chick was very weak and unable to sit up or stand freely like its siblings, but no wounds or other abnormalities were visible. Although this chick may have been a few days younger than its siblings, we suspect that its smaller size was related mainly to its deformity.

On 29 July when this brood was first left unattended by adults, a non-breeding male drove the chicks from the nest in the process of stealing the unattended nest materials. The non-breeder was chased away shortly thereafter by a returning adult and the two larger chicks returned to the nest site. The deformed chick was knocked downhill and crawled into another nest which already contained 3 chicks. At SEFI, nest-site creches (where chicks from adjacent nests temporarily huddle together at a nest site) often occur during the nestling stage (Carter and Hobson 1988). Although this chick was tolerated in the new nest, we did not observe it begging or being fed. It died there by 31 July at an age of 22 to 25 days.

After the breeding season, we collected the remains of the deformed chick (University of Manitoba Zoology Museum No. 2571). The upper mandible was curved laterally and smaller than average relative to the lower mandible. The skull was defleshed using an enzyme bath. Both the ramphotheca and the underlying bone of the upper mandible were deformed. The premaxillary and jugal bones curved to the left and the line joining the quadratojugal to the tip of the premaxilla measured 41.2 mm compared to the dentary which measured 75.6 mm. The deformity superficially resembled that of a Great cormorant, *P. carbo,* photographed by Stronks (1983).

Cormorants are highly susceptible to accumulating high concentrations of pollutants, which has resulted in reproductive failures due to eggshell thinning (Gress et al. 1973, Weseloh et al. 1983). Bill and other deformities also have been related to pollutants (Hays and Risebrough 1972, Hudson 1987). While such deformities have not been noted in previous years at SEFI, they have not been carefully searched for in small chicks or embryos which did not survive.

We thank the U.S. Fish and Wildlife Service for permission to collect the remains of the Brandt's cormorant chick. S. G. Sealy made helpful comments on this manuscript. This is Contribution No. 362 of the Point Reyes Bird Observatory.

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BOOK REVIEWS

Philosophy Gone Wild—Essays in Environmental Ethics

By Holmes Rolston III. Prometheus Books, New York, 1986; 269 p., $19.95.

With his usual perception, Aldo Leopold observed in *Round River* that: "One of the penalties of an ecological education is that one lives alone in a world of wounds." Most assuredly this applies to many individuals working within government resource management agencies who, with beleaguered staffs and budgets, are forced into a "second class citizen" role while the vast majority of available resources are used to satisfy the relatively superficial whims of the public recreation arena. Not that these whims are necessarily bad, but they pale when viewed in a context of human population explosion, worldwide habitat destruction, and the accelerating extinction rates that accompany the loss of genetic diversity. Current priorities lie far more in the realm of short-term political expediency than in assuring the perpetuation of biological integrity. Perhaps our true responsibilities should be debated and more clearly defined.

Where are the deep thinkers when we need them? Unfortunately, the politically appointed individuals occupying policy making levels of government, faced with an entirely new set of job circumstances in a field often completely foreign to them, simply cannot hit the ground running and must serve a lengthy apprenticeship before reaching an acceptable level of philosophical competence. Subordinate bureaucracy, anxious to keep the ship on an even keel irrespective of the compass heading, aren't about to give things a good shake despite the need. Inasmuch as people seldom do significant things without strong commitment or motivation, the scene inevitably moves into the realm of philosophy: just what is important to the individual involved or perhaps more appropriately, what is most politically expedient? A president of Columbia University observed over a half century ago "that thinking is one of the most unpopular amusements of the human race. Men hate it largely because they cannot do it. They hate it because if they enter upon it as a vocation or avocation it is likely to interfere with what they are doing."

It has long been my contention that if *A Sand County Almanac* were read, taken to heart, and its principles espoused by agency leadership, we would be well on our way to structuring the mature direction, staffing, and fortitude necessary to assure sound fish and wildlife programs well into the 21st century. And now I would add a complementary volume: *Philosophy Gone Wild.*

I first met Holmes Rolston following a seminar at Colorado State University, where he is a Professor of Philosophy specializing in environmental ethics. I recall that he was clad in a wool shirt and levis and not the coat and tie one would normally associate with one in his position. I found shortly thereafter that Dr. Rolston is also an accomplished naturalist (specializing in bryology), endowed with great skill in blending his two primary talents in literary form. He was in all probability either leaving for, or returning from, the field when I met him.

Philosophy Gone Wild comprises a compilation of his essays, all previously published, which will be read and enjoyed by anyone with a deep interest in Nature. The book is divided into four major subject areas: "Ethics and Nature," "Values in Nature," "Environmental Philosophy in Practice," and "Nature in Experience." Together, they constitute a delightful presentation of the environmental turn in philosophy.

"Ethics in Nature" explores the question, "Is there an ecological ethic?" (addressed in an essay of the same title), then follows with three additional essays encompassing the same area of thought.

His second section, "Values in Nature," again begins with an essay of the same title and then delves into a deeper evaluation (Was the snail darter *really* worth saving after all? Why?). Natural values are discussed in terms of life support, recreation, science, aesthetics, and last (but surely not least), sacrament. Later chapters ask whether values in Nature are subjective or objective, and, finally, Rolston takes us on a vicarious journey into Nature to allow us to ponder for ourselves just what these values are.

As a practicing conservation biologist, I found certain of Rolston's material to exceed textbook value, especially in his third section: "Environmental Philosophy in Practice." An example here is his eighth chapter: "Just Environmental Business," in which he discusses the ethical aspects of 32 separate maxims relating to environmental involvement within the worldwide business community. All contain highly applicable material, both substantial and theoretical.

This third section concludes with "Duties to Endangered Species," first published in *Bioscience.* Anyone who has been asked the question: "What good are they?" (and who hasn't!) should read and re-read the biological and ethical rationales used in the development of this theme. It seems the least we can do for a public, hungry for an acceptable explanation, that looks to us for the answers we so seldom are able to articulate. In this section Rolston's inordinate skill in blending science and philosophy become immediately apparent.

In the section "Species and Ecosystems" he states the following:

> A species is what it is inseparably from its environment. The species defends its kind against the world, but at the same time interacts with its environment, functions in the ecosystem, and is supported and shaped by it. The species and the community are complementary processes in synthesis, somewhat parallel to but a level above the way the species and the individual have distinguishable but entwined identities. Neither the individual nor the species stand alone; both are embedded in a system. It is not preservation of *species* but of *species in the system* that we desire. It is not just what they are but where they are that we must value correctly.

Within this same third section he provides conservationists with a superb one-liner to combat the shallow rationale that species extinctions are a natural phenomenon, and society should not be unduly concerned over them.

> It might seem that ending the history of a species now and again is not far out of line with the routines of the universe. But artificial extinction, caused by human encroachments, is radically different from natural extinction. Relevant differences make the two as morally distinct as death by natural causes is from murder. Though harmful to a species, extinction in nature is no evil in the system; it is rather the key to tomorrow. Such extinction is a normal turnover in ongoing speciation.

But to the sentimentalist (and I admit to being one), Rolston's Part IV, "Nature in Experience," cannot help but be a favorite, possibly because his experiences have so closely approximated my own (and I am sure yours, too). I was especially impressed by the following description from "Farewell, Washington County:"

> Once upon a July twilight I was gifted all undeserved with the loveliest of sunsets. The sun plunged behind the old snag that stood as a sentinel halfway up the western knob on the skyline near home, terminating the day with a blaze of glory that fired an orange-red across half the spacious firmament. It was as though the sinking sun had resolved to exhaust itself in activity and color. Dusk was spent in hues of crimson and violet that lined the deep purple stratocumulus, then to yield to encroaching darkness, but not before a bit of that July became part of me forever.

It is appropriate that Rolston's book should end with "The Pasqueflower" (first published in *Natural History* in 1979). He prefaces the essay with a quotation from *A Sand County Almanac:* ". . . the chance to find a pasqueflower is a right as inalienable as free speech," then proceeds in delightful prose to weave a theme from strands of climate, the seasons, classical literature, religion, plant taxonomy, and ecology to give a fitting ending, one indeed of hope, to conclude a most unusual book: "Let winters come, life will flower on as long as Earth shall last."

We live in a world dominated by utilitarian philosophies and concepts. Enlightened self interest is the hallmark of utilitarianism, and *Philosophy Gone Wild* makes a major contribution (in a very delightful way) to the inevitable and obvious conclusion that carried to its extreme, the most enlightened self interest can only be realized through the implementation of acceptable conservation practice, defined by Leopold as living in harmony with Nature. Rolston's book develops a sound philosophical rationale to accompany the biological reality which makes a deep thinker worry about the well being of the world ecosystem in the year 2087. They complement each other well. There is still time to act if Mankind is willing to sacrifice blind economic expediency to achieve long term survival. It is ironic that two of our most basic motivations, greed and self preservation, should come in conflict in such a terrifying way. The importance of environmental eithics and philosophy falls into a category of similar frustrations, all characterized by the statement: "If you have to ask the question, it is unlikely you will understand the answer."

—Phil Pister

Nudibranchs of Southern Africa A Guide to the Opisthobranch Molluscs of Southern Africa

by Terrence Gosliner. Sea Challengers. 1987. 136 p. $34.95, paperback.

After at least one abortive attempt to have this book published in South Africa—which almost finished the book—it is most satisfying to see Terry Gosliner's persistence rewarded and to have the book in print.

Although entitled *The Nudibranchs of Southern Africa,* it is the subtitle which is the more accurate description, for this book is an overview with color photos of the known shallow-water and intertidal opisthobranch molluscs of South Africa, not just those members of the Order Nudibranchia. However, I will admit that "Nudibranchs" is certainly a more "catchy" word to use in a title than opisthobranch.

The book is organized into several sections. In the first the author introduces the opisthobranch molluscs by discussing certain general aspects of their biology, including evolution, defense mechanisms, food, reproduction, systematics and biogeography, using South African species as examples. The second section gives a list of the South African species, a glossary of terms, and a key to the species. The final, and longest part of the book, is a species account, in which each species is illustrated with a color photograph coupled with a short narrative documenting its distinguishing features, natural history and distribution.

Among the molluscs, the opisthobranchs are a little-known group with relatively few, but dedicated, students. In many ways this is surprising because these animals are certainly among the most beautiful animals in the sea, and their delicate beauty and interesting habits certainly should attract the interests of amateur as well as serious students of molluscs. It will take books like this one, which have been all too rare in the past, to bring these animals to the attention of a wider audience. I therefore commend its publication.

One of the difficulties of writing a guidebook to a little-known group of organisms that will be of use to both amateurs and professionals is the problem of the amount and level of background information and necessary descriptive terms that must be introduced. The author has chosen here to provide an easily read and interesting general introduction with a minimal amount of terminology that emphasizes the most interseting features of opisthobranch natural history. He has coupled that with a more detailed coverage of biogeography and taxonomy, two of his own special interests. This should suit both amateur and professional without insulting either.

Although this introductory material is certainly of an appropriate length and is well designed to suit two disparate groups of users, I find that it could have been improved in one major way. The introductory section lacks any simple drawing of an opisthobranch with all the key terms labelled (i.e., notum, rhinophores, etc.). Indeed, this is a problem throughout the first part of the book. Whereas Gosliner has a number of drawings to complement the key, in all cases but that of the different rhinophore types, the drawings are never labelled with the terms. Thus, for example, in the key he uses the term "sperm groove" in couplet 34 and gives a reference to Fig. 5c, but 5c is a drawing of an aplysiid with no labels of parts whatsoever. This will be especially frustrating to any person not already familiar with the terminology of the group.

Although I find this to be a generally good and accurate book, I do find points of disagreement. I question, for example, the decision on the author's part in the systematic section of the introduction to list and discuss only some of the orders and leave out others. The orders Thecosomata, Gymnosomata, and Acochlidiacea are not mentioned. This is particularly a problem with respect to the Thecosomata as he includes a Thecosome, *Creseis,* in his species descriptions section.

The small glossary is removed from the introduction and would be more useful, I feel, if moved up either to where most terms are first discussed—namely, the introduction—or else placed at the end of the book, the traditional place for placement of such material. It could also benefit from expansion. Finally, the map of South Africa, with its collecting stations, is hidden away after the index and is not listed in the table of contents. It would improve the book if it were placed in the biogeography section where it most appropriately belongs.

The bulk of the book, the species accounts, are generally well done and interesting; and the color photos are of a uniform high quality. The only criticism I have here is that for most species there is no indication of size. To get that you have to go to the very last page of the book, where there is a list of the sizes of all animals in the book. Since this list is never referenced in the table of contents, the reader could easily completely overlook it. It would be far more useful to simply list the sizes in each species account.

The book is technically well done and printed, with few errors. I only noticed that Zoantharia was substituted for Zoanthidea on p. 9 and that the first couplet of the key had the second line duplicated. I would also question the statement that the radular variability of opisthobranchs is greater than that in prosobranchs, as Gosliner states on p. 9.

I do not wish to construe from the above criticisms that this is not a good book; indeed, my purpose in pointing out what I perceive as errors or problems is to encourage the author to make it better in some future revision. This is a fine book that will be welcomed by every serious student of opisthobranchs.

—James W. Nybakken

Playing God in Yellowstone

The Destruction of America's First National Park.

By Alston Chase. Atlantic Monthly Press, Boston, Massachusetts, 1986. xvi + 446 p. cloth. $24.95

In early May of 1987 my wife and I made our first visit to Yellowstone National Park. While there we spent much of our time photographing the animals and scenery, and hiking some of the many off-road trails. We were completely overwhelmed by the scenery and the abundance of life—particularly, elk and bison. We left the park feeling that here was an excellent example of how man can both protect and enjoy natural areas and the animal and plant communities they support. However, several times during our stay we did wonder why we saw very few mule deer and no signs of beaver or whitetail deer.

After leaving Yellowstone we spent a couple of days with friends at their Montana ranch. Here our illusions of the health of Yellowstone's plant and animal communities were shattered when our friend loaned us a book to read on the long journey home. The title was *Playing God in Yellowstone.*

Playing God in Yellowstone is a thoroughly researched and documented book whose thesis helps explain why visitors see few, if any beaver, and seldom, if ever, encounter bears. It explains the park's teeming numbers of elk and bison. And, finally, it documents how the park has been mismanaged over a long period of time by a rigid bureaucracy, responding primarily to political forces rather than to scientific recommendations by professional wildlife and fishery managers.

The author recounts the early history of the park region and the designated personnel, including the U.S. Army, who were given management responsibility during the late 1800's through the 1900's. During this period, park management focused on increasing the numbers of elk and bison. Unfortunately, as regards some of the other animals in park, these efforts succeeded only too well. Predator control *within the park* was a major part of these early efforts and by 1940 there were few if any mountain lions or wolves left in Yellowstone.

After the second World War the National Park Service, reacting to rumors that wolves were extinct in Yellowstone, attempted to secretly reestablish them in the park by bringing them in from other regions and releasing them. The outcome of their clandestine efforts was unsuccessful as the wolves did not stay in the park.

Alston Chase heavily documents the horror story of mismanagement of both the black and grizzly bears—the latter an endangered species.

Although since 1916 the National Park Service has been the appointed caretaker of this beautiful area, its efforts have often been based on harebrained theories totally unsupported by good scientific data. These theories have affected their policy even to the extent of refusing research permits to any scientists whose data and recommendations *might* differ from park service policy—in other words "Don't confuse us with the facts".

The author in the last two chapters discusses how the environmental movement of the 1960's and 1970's may have also unwittingly contributed to recent mismanagement of Yellowstone Park.

I strongly recommend that *Playing God in Yellowstone* become a standard reference for all wildlife and fishery administrators and biologists. It should be required reading for all undergraduates going into the wildlife and fisheries profession.

I agree with the author that it is not too late to reverse the damage that has occurred.

For this to happen, the National Park Service will have to completely change its philosophy and policies regarding how the resources in Yellowstone Park are to be managed. Because, manage they must, including feeding the bears, reducing the numbers of elk and bison and re-establishing predator populations, including wolves. This will require the expertise of not only park service biologists, but also wildlife biologists from the academic community and the various state agencies of the states that border the park.

—Daniel W. Gotshall

Mammals Of Arizona

By Donald F. Hoffmeister. 1986. The University of Arizona Press (Tucson, AZ) and the Arizona Game and Fish Department, xix + 602 p. $49.95 cloth.

Donald Hoffmeister is emeritus director of the Museum of Natural History and emeritus professor of ecology at the University of Illinois, but he is a westerner by birth and training. He has studied mammals in the western states since 1938 and in Arizona since 1948. His 35 years of attention to Arizona mammals have resulted in this monumental work, the first to describe in detail all the mammals of the state. The introduction to the book includes a discussion of the naturalists and mammalogists who have contributed to the knowledge of Arizona mammals in historic times. Because Hoffmeister is the historian of the American Society of Mammalogists, I had expected the latter discussion to provide more detail; editorial considerations maybe have prevented this.

The main part of this impressive book is arranged into the following chapters: 1. game mammals and endangered species. 2. Diseases transmissible to humans. 3. Physical and biotic factors. 4. biogeography. 5. Species accounts. Chapter 1 provides some historical harvest figures for the nine big game and four small game mammals, and lists the six furbearing and 10 predatory mammals. Included as predators, a classification not used by California, are the Coyote, all foxes (three species), Long-tailed Weasel, all skunks (four species), and Bobcat. A short discussion of fur-trapping and a longer commentary on predatory mammal control are contained in Chapter 1. The section on rare and endangered mammals in this chapter is brief, with no description of the plight of any species. Hoffmeister suggests additions to the very short official list of endangered mammals.

In Chapter 2 the author describes four diseases which are transmitted to the human mammal by other mammals in Arizona (these are rabies, plague, tularemia, and spotted fever) and lists other diseases for which Arizona mammals may serve as vectors or reservoirs. Chapter 3 has a section on historic changes occurring in Arizona which have affected the numbers and distribution of mammals since the arrival of European man. These are changes which have resulted from human activities and which mostly have been detrimental to the local survival of mammals. Among the annotated list of changes are damming of the upper and lower Colorado River; removal of water from streams through damming and diversion or through ground-water pumping; predatory mammal control; overgrazing by domestic animals; and removal of junipers over large areas for "range improvement". The chapter discusses topography, climate, and soils of Arizona, and includes an interesting section on adaptation of mammals to desert conditions.

Chapter 4 on biogeography begins to get into the real substance of the book. An annotated list of the vegetative communities is accompanied by state maps illustrating the distribution of the communities, and is followed by an analysis of the relationship between these communities and the mammalian fauna in Arizona (i.e., which species are found in which communities).

Chapter 5, the 138 species accounts, covers 525 pages of the 602 in the text of this book. The accounts are presented in taxonomic sequence, beginning with those in Order Insectivora. For each species (and subspecies when listed), the account discusses range, description, comparisons with similar species, secondary sexual variation (if any), cranial measurements, taxonomy (including the author's recommended changes in some cases), and life history.

Near the end of the book are sections on introduced, nonnative mammals (in which Hoffmeister comments that "The presence of [the European] ferret in a wild condition in Arizona should be of grave concern to ecologists and conservationists.") and on mammals of possible occurrence in Arizona. Following these sections are appendices on annual hunt figures for game mammals, common and scientific names of plants mentioned in the text, and type localities of mammals by county. A bibliography of nearly 600 references completes the book.

Although this is a book on mammals of Arizona, it has interest and value to mammalogists and biologists elsewhere, particularly in adjoining states. A quick examination of the checklist of Arizona mammals indicates that at least 77 of the 138 native mammals also are found in California. The information on life history in the accounts for these species will be useful to California workers. The mammalian fauna of Arizona is smaller in number of species, yet not too different in such number, from that in California. When examining this book, one wonders how such a work might come to exist for the mammals (or birds or reptiles or amphibians or fishes) of California. True, California has no Don Hoffmeister with 35 years of field experience. But, alas, we also have only three or four active mammalogists who are afield or who have students afield pursuing mammalian biogeographical and ecological problems. I was particularly interested to learn that financial support for *Mammals of Arizona* was provided by the Arizona nongame wildlife tax checkoff fund and the federal Pittman-Robertson fund.

—John Gustafson

Dynamics of Marine Fish Populations

By Brian J. Rothschild, Harvard University Press, 1986, xi + 277 p.

Population dynamics has been developed and expanded upon more in marine fisheries than in other branches of zoology. This has undoubtably resulted from the realization that indiscriminate harvesting could jeopardize future yields of these valuable resources and of the inability to directly assess most marine fish populations. As a result fisheries scientists have developed a broad range of models and methodologies to estimate population parameters and to predict the effects of various harvesting regimes. Despite the sophistication of techniques that have been developed, there have been major failures of a number of important fishery populations. The author begins this book with such examples.

He shows that fish-stock variability may be more the rule than exception. Chapter 3 contains a short exposition of fish-population-dynamics theory. However this book is not intended to be a treatise on fishery dynamics models or methodologies. The author is concerned more with the inability of the present technology to handle the inherent variability of biological systems. He describes the short-comings of current theory and necessity of population models to handle problems of pollution, habitat, and stock-rebuilding strategies. He points out "that formation of a new theory requires a better understanding of high-fecundity population dynamics and biological oceanography".

In Chapter 5 there is an examination of recruitment-stock linkage. The author points out that "A revaluation of the theory is necessary because there seems to be little correspondence between empirical data and theory". He suggests that the Paulik-diagram can be a useful tool in this context and this leads to "separate in-depth consideration of adult-related and larval-related transfer functions". In Chapter 6 and Chapter 7, adult and larval-related processes are examined. The author shows that egg production is an important part of the population-dynamics process but that it has been neglected. We need to know not only the total number of eggs produced but their size, energy stores, physiology and other factors that effect egg and larval survival. Once these factors are known, the effects of the oceanic environment on recruitment can be examined and alternate models can be developed. Chapter 8 contains an overview of the earlier chapters, descriptions of basic population-dynamics modules and the integeration of the modules into a population-dynamics process.

This book deals with a complex and technical subject. As such anyone who does not have some background knowledge of population dynamics may have difficulty with parts of the book. The author has shown that theories and models now in use in marine fisheries have frequently failed and perhaps why they have failed. He points out where work may be most productive and presents a conceptual model for future development. Anyone working in population dynamics or with marine fisheries should read this book.

—John J. Geibel

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INSTRUCTIONS TO AUTHORS

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