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CHLORINATED HYDROCARBONS IN MARINE MAMMALS

Studies of contaminant biomagnification have shown that long-lived top predators usually accumulate the highest levels of synthetic organic contaminants. SCCWRP's study of pollutant flow through marine food webs (Schafer et al. 1982) found much higher levels of chlorinated hydrocarbons in sea lions than in any other member of the coastal pelagic food web. The present study, a rudimentary beginning toward understanding the effects of contaminants on mammals, was undertaken with the following limitations. The taking of mammals is prohibited; as a result we were forced to use animals accidentally killed or beached of whatever species, age, sex, or health condition was available for our mammal tissue samples. Moreover, the lack of natural history information about many species makes it difficult to interpret the tissue data and thereby determine possible adverse effects caused by the accumlation of high levels of contaminants. However, even though we are uncertain about whether our preliminary findings indicate biological effects, nonetheless we think the extremely high levels of chlorinated hydrocarbons found in some individuals require further study by an appropriate agency.

METHODS

Most animals that we have sampled recently were collected by members of the California Marine Mammal Stranding Network centered at the National Marine Fisheries Service Southwest Region on Terminal Island and the Southwest Fisheries Center in La Jolla; the majority of these animals were stranded or washed up on the beaches of Los Angeles and Orange Counties. The northern elephant seals were taken at San Nicolas Island under a National Marine Fisheries permit issued to the University of Southern California at Los Angeles, and tissues were made available to us.

Since beginning this study, we have increased the number of tissues sampled and the amount of physical data recorded as we have become more aware of individual variations. Two to five tissues from each of 26 individuals of seven species were collected. Cetacean muscle and blubber samples were taken from the area next to the dorsal fin, and pinnipeds were sampled in the middorsal region; special care was used to prevent the blubber from contaminating the muscle tissue sample. A midlobe section of the liver and about half of a kidney were collected from each animal. Brain samples were taken through the foramen magnum at the base of the skull or from the area of the cerebellum exposed when the skull cap has been removed. Samples of 200 to 500 g each were excised during necropsies and were redissected at our laboratory under cleaner conditions. The extraction and analysis techniques were the same as those described in another chapter of this report (see Gossett et al., this volume). The Marine Mammal Stranding Network, which performs necropsies on most individuals, provided us with the available vital statistics.

RESULTS

A summary of results is presented in Table 1. The most frequently sampled species was the common dolphin *(Delphinus delphis)*, with ten animals collected. Mean concentrations (ppm wet weight) of total DDT were as follows: blubber, 277 (n = 11); muscle, 4.95 (n = 11); liver, 21.6 (n = 11); kidney, 7.46 (n = 5); and brain, 3.34 (n = 7). Total PCB concentrations were these: blubber, 9.07 (n = 11); muscle, 0.49 (n = 11); liver, 1.39 (n = 11); kidney, 1.86 (n = 6); and brain, 0.36 (n = 5).

The second most sampled species, and the most contaminated, was the coastal bottlenose dolphin *(Tursiops truncatus)*. The mean total DDT concentrations of seven individuals (ppm wet weight) were as follows: blubber, 929 (n = 6); muscle, 14.1 (n = 3); liver, 56.2 (n = 4); kidney, 988 (n = 1); and brain, 17.9 (n = 1). The mean PCB concentrations were these: blubber, 53.0 (n = 5); muscle, 0.46 (n = 3); liver, 2.50 (n = 4); kidney, 12.9 (n = 1); and brain, 0.46 (n = 1).

Two adult male and two adult female northern elephant seals *(Mirounga angustirostris)* were collected from San Nicolas Island. The total DDT concentrations (ppm wet weight) were as follows: blubber, 7.64 (n = 4); muscle, 0.22 (n = 4); liver, 0.39 (n = 4); and kidney, 0.04 (n = 2). The mean PCB concentrations were as follows: blubber, 1.34 (n = 4); muscle, 0.02 (n = 4); liver, 0.13 (n = 4); and kidney, 0.02 (n = 2).

The only other species with more than one specimen was the white-sided dolphin *(Lagenorhynchus obliquidens)*, with one sample taken in 1977 and the other in 1982. The mean total DDT concentrations (ppm

Table 1. Total DDT and PCB concentration in mammals from southern California.

Species	Date Taken	Sex	Age (stage or years)	Cause of Death	Length (cm)	Weight (kg)	Total DDT (ppm wet weight) Blubber	Muscle	Liver	Kidney	Brain	Total PCB (ppm wet weight) Blubber	Muscle	Liver	Kidney	Brain
Common dolphin	1978	M	Adult	Parasite	185		451	4.33	34.9	13.2	6.9	25.6	3.08	9.47	7.03	
Common dolphin	1979	F	Adult	Disease	176		330.0	0.28	33.6			11.3	0.13	1.54	1.74	1.19
Common dolphin	1979	M	Adult	Disease	231	79	344	1.44	8.63	5.53	7.18	2.47	0.09	0.35	0.10	0.52
Common dolphin	1980	M	Adult	Disease	175	76.8	591	39.3	107			12.9	0.69	1.25		
Common dolphin	1980	M	Adult		190		610	2.79	22.4			15	0.04	0.73		
Common dolphin	1983	M	Adult		185	54.5	156	2.09	4.44		2.25	5.01	0.23	0.38		
Common dolphin	1983	M	Adult	Trauma		100	1.2	1.11	1.86			0.08	0.08	0.08		
Common dolphin	1983	M	Adult		202	85	392	1.12	20.8	15.9	2.50	5.24	0.02	0.36	0.16	0.03
Common dolphin	1983						45.5	0.38	2.47		0.62	5.73	0.04	0.06		0.04
Common dolphin	1984	M	Adult	Trauma	193	59	40.8	0.52	0.76	1.22	0.58	8.68	0.01	0.04	0.75	0.04
Common dolphin	1984	M		Trauma	203	59	83.0	1.03	1.01	1.46		7.81	0.06	0.09	0.09	
Coastal bottlenose dolphin	1980	F	0.1		127	24.5	126	1.30	5.38			9.78	0.19	0.05		
Coastal bottlenose dolphin	1980	M	0.1	Disease	121	18.6	230		16.5			9.70		0.83		
Coastal bottlenose dolphin	1980	F	~1.0	Disease	168	66			6.92					0.50		
Coastal bottlenose dolphin	1982	M			206	109	573					73.2	0.35			
Coastal bottlenose dolphin	1983	M			266		1922	20.8				128	0.84			
Coastal bottlenose dolphin	1983	F	28		287	164	653	20.1								
Coastal bottlenose dolphin	1984	F	<3	Disease	203	86.4	2070		196	988	17.9	44.5		8.16	12.9	0.46
Northern elephant seal	1983	F	6	Trauma	269		2.76	0.09	0.24			0.26	0.01	0.01		
Northern elephant seal	1983	M	6	Trauma	363		9.74	0.59	0.96			0.31	0.03	0.44		
Northern elephant seal	1984	F	6	Trauma	282		7.07	0.16	0.06	0.03		0.74	0.01	0.004	0.03	
Northern elephant seal	1984	M	6	Trauma	386		11.0	0.05	0.29	0.06		4.04	0.01	0.03	0.01	
White sided dolphin	1977						2.08	2.60	1.63	2.18		0.23	0.18	0.26	0.27	
White sided dolphin	1982						99.5	3.96				4.88	0.22			
Grey whale	1976		~1.0				0.47	0.04	8.4		0.53	0.23	0.03	0.43		0.09
Minke whale	1977	F	Adult	Trauma			587	5.44	11.6		43	27.8	0.30	0.74		5.32
Sperm whale	1983	M	~ 0.1				5.08	0.05				0.51	0.01			

wet weight) were as follows: blubber, 50.8 (n = 2); muscle, 3.28 (n = 2); liver, 1.63 (n = 1); and kidney, 2.18 (n = 1). The PCB concentrations were these: blubber, 2.55 (n = 2); muscle, 0.20 (n = 2); liver, 0.26 (n = 1) and kidney, 0.27 (n = 1).

Single specimens of sperm whale *(Physeter catadon)*, grey whale *(Eschrichitus robustus)*, and Minke whale *(Balenoptera acutorostrata)* were analyzed. The concentrations of total DDT (ppm wet weight) in the sperm whale were blubber, 5.08, and muscle, 0.05. Total PCB values were blubber, 0.51, and muscle, 0.01. The grey whale total DDT concentrations were as follows: blubber, 0.47, muscle, 0.04, liver, 8.4, and brain, 0.53. Total PCB values were blubber, <0.23; muscle, <0.03; liver, 0.43; and brain, 0.09. The Minke whale had DDT concentrations as follows: blubber, 587; muscle, 5.44; liver, 11.6; and brain, 43. The PCB concentrations were blubber, 27.8; muscle, 0.30; liver, 0.74; and brain, 5.32. These results are also listed in Table 1.

DISCUSSION

Many factors working individually and together complicate any attempt to compare individuals with respect to time, location, or species. First, the natural history of most of these animals is very incomplete. Most species have ranges of hundreds or thousands of miles. Separate populations are thought to mix or occasionally visit the southern California coast; resident and migrant individuals are known to occupy this region. Some species, such as bottlenose dolphins, have coastal and offshore populations with very different diets (Walker 1981). The age of each animal will have determined the length of time it has had to accumulate contaminants. We know that some species live for more than 30 years and that 15 years ago, municipal wastewater emissions of pesticides were 100 to 1000 times higher than those in 1983; however, we have no estimate of the half-life of these contaminants in blubber or other tissues in marine mammals. A second factor making comparison difficult is that several studies that have looked at many individuals of one species have shown major differences in male and female bioaccumulation (Gaskin 1983; Britt and Howard 1983); males continuously accumulate contaminants with age, while females decrease their body burdens while reproducing. A third complicating factor is that the condition of stranded animals varies greatly between those (presumably healthy) individuals killed by the trauma of collisions with boats or gill nets and those individuals with chronic illness and parasites. The latter animals may have used up their lipid reserves, thus possibly elevating contaminant concentrations in other tissues well above those of a healthy animal with the same mass of contaminants.

Despite these complications and uncertainties, the data collected can be used as a benchmark for future work on stranded animals. Several of the animals reported here and in previous reports for southern California (O'Shea et al. 1980) contained the highest levels of contaminants ever known to have been reported in marine cetaceans.

Although the numbers of samples are small, there appears to be a correlation between feeding and contaminant levels. Toothed animals like the bottlenose dolphin that feed on fish such as white croaker which are known to have elevated contaminant concentrations had much higher contaminant levels than offshore feeders such as the baleen whale that feed principally on zooplankton--although the Minke whale, which is a baleen whale that feeds on fish and zooplankton, also had high contaminant levels. Conclusive reports on the effects of chlorinated hydrocarbon contamination on marine mammals have been difficult to find. De Long et al. (1973) reported a significant correlation between premature sea lion births and DDT concentrations, but pointed out that the correlation did not indicate a cause-effect relationship and that other causes were possible. Helle et al. (1976) correlated PCB concentrations with increased uterine lesions and reduced reproductive success in ringed seals from the Baltic Sea, but the PCB concentrations were higher than those found in California animals.

CONCLUSIONS

We conclude that some species of marine mammals in the southern California Bight have very high chlorinated hydrocarbon levels, although our estimate may be biased because 1) we know so little about their natural history and 2) we have in most cases analyzed only stranded animals. Improvements in determining the age of marine mammals, studying their movements, and analyzing their diet have recently been made which will help us interpret their contaminant levels. Several years of studies should be undertaken to produce an accurate estimate of degree of contamination and enable trends in the decrease or increase of concentrations to be detected. Histological studies should be made to provide information on the effects of synthetic organic accumulation at the tissue level (cf: Perkins and Rosenthal, this volume); and toxification/detoxification studies are needed to show cause and effect (cf: Brown et al., this volume). We know of no investigations which have been conducted or are presently planned that will attempt to measure the effects of contamination on marine mammals.

Although the studies described above require extremely fresh samples which are difficult to obtain, we believe it is important to take advantage of any opportunity to do so. Since these animals are long-lived and many feed high in the food web, they are most likely to show chronic effects from the accumulation of organic contaminants--and are therefore the most likely candidates for study in our effort to understand the long-term effects of exposure to contaminants in the natural environment.

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