

FEEDING BEHAVIOR AND FOOD-CONSUMPTION RATES OF A CAPTIVE CALIFORNIA MURRE

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Detailed studies of the underwater feeding behavior of Common Murres (*Uria aalge californica*) do not appear to have been reported. We had the opportunity to make such a study beginning in September 1964, when school children found an apparently uninjured murre on the beach near Humboldt Bay, California, and brought him to Humboldt State College. The bird was a nearly full-grown young male in juvenal plumage with fully developed flight feathers.

Throughout the study, from 16 September 1964 to 19 January 1965, the murre was housed in a 620-gallon, indoor salt-water aquarium in the Wildlife Building at Humboldt State College. The aquarium tank is 66 inches long, 48 inches wide, and 45 inches deep and is constructed of concrete with a glass window in front 60 inches wide and 44 inches high through which detailed observations of the murre's underwater activities were made. The water was aerated with an air pipe, and filtering and refrigeration systems maintained the water temperature at 11° C. An overflow pipe opened at the surface, allowing the bird's fecal material to settle to the bottom where it could be collected for analysis. All pipes were near the tank walls and did not interfere with the murre's activities. During most of the study period the aeration system was kept at a low enough level so that there was essentially no surface turbulence.

The murre was fed live cull rainbow trout (*Salmo gairdnerii*) from the college hatchery. These fish averaged 25 per pound at the beginning and 10 per pound at the end of the study. Twice daily, the bird was placed in a paper bag and weighed to the nearest 5 g. Weights were usually taken about 0800 and in the late afternoon.

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SURFACE BEHAVIOR

While on the surface of the water, the murre maintained his position more or less in the center of the aquarium, never touching the walls. The aeration and circulation-filtration systems set up current patterns that forced the bird into constant swimming activity in order to avoid hitting the walls. All surface swimming was accomplished by alternately stroking with the feet. The bird was never observed to stroke with both feet simultaneously.

During the first month of the study, a platform approximately 9 inches square was provided at the surface of the water for perching. The platform was frequently awash and seldom allowed the bird to dry off completely. Later, he learned to jump up 6 inches onto a narrow wooden ledge at the edge of the tank which he quickly came to use exclusively for perching.

FEEDING BEHAVIOR

Head-dipping. Head-dipping (Storer, A comparison of variation, behavior, and evolution in the sea bird genera *Uria* and *Cepphus*. Univ. Calif. Publ. Zoöl., 52: 121-222, 1952) was observed. The murre placed his eyes just below the surface of the

water, occasionally moving his head from side to side about 20 degrees from center. While head-dipping, he did not rotate his body nor did he look under his own body. Head-dipping appeared closely associated with locating prey beneath the surface, and the frequency of this behavior appeared to increase as the time since the last feeding increased.

Pursuit and capture of fish. Only about 1 per cent of the fish were caught on the surface as they happened to swim within the murre's reach. Most fish were caught underwater as a result of a deliberate pursuit.

Diving was accomplished by simultaneously moving the wings forward to take a scoop of water, moving the head below the water, extending the neck, and alternately kicking with both feet, thereby moving the center of gravity forward and tipping to a head-down position. This was done quickly as one graceful movement. A single wing beat forced the bird beneath the surface.

Swimming under water was accomplished by "flying" with half-folded wings. Although Tuck (The Murres; Queens Printers, Ottawa, 1960) reported that the murre's feet were used for underwater swimming, our murre was never observed to use foot movements for propulsion while below the surface. As a sharp turn began, the foot on the inside of the turn was placed out to drag and act as a pivot, and, at that instant, the bird banked into the turn exactly as he might if he were flying.

The trapped air in the murre's feathers gave the appearance of a silver sheen covering the bird's body. This created added buoyancy, and the bird was forced to swim downward in order to avoid being forced to the surface. A high forward velocity was needed to remain below the surface; once the murre stopped movement, he popped up to the surface. The murre was observed to remain submerged as long as 60 seconds.

The murre was most successful in making a capture when he obviously selected a single fish and deliberately pursued that one until the fish was either caught or escaped even though other fish may have passed between the murre and the one being pursued. In the few instances where the murre appeared to change targets in the middle of a dive, he was usually unsuccessful in making that capture.

All fish were swallowed head first. The bird had no difficulty in turning fish 3 to 4 inches long around to a head-down position even when they originally had been caught by the tail. This manipulation of a caught fish to a head-down position was accomplished by a series of very rapid, short, biting-striking movements of the head and bill. The bird could successfully manipulate fish of the 5- to 9-inch size to a head-down position only if he had originally seized them behind the gills and forward of the pectoral fins. Nearly all fish of this size seized behind the pectoral fins escaped as the bird tried to manipulate them to a head-down position.

Most commonly, the bird surfaced with the fish in its mouth and maneuvered it to a head-down position and swallowed it. With larger fish the murre often remained submerged and swam rapidly around the tank, using the water's resistance to help in maneuvering the fish to a head-down attitude. In such cases swallowing was accomplished either below the surface or immediately after the bird came to the surface.

After swallowing a fish the murre always surfaced, paddled quickly while standing up in the water and beat his wings several times. This probably helped to arrange the fish in his gullet.

Fish 5 to 9 inches long often were bill-marked where the murre had seized them and rubbed off some scales in the attempt to eat them. The fish were most often

bill-marked on the posterior half of the body. Certain fish escaped repeatedly and became more difficult to catch thereafter. Fish that eluded the murre for several days were badly bill-marked. One 9-inch trout eluded the murre for 13 days. This fish became so weakened that it finally floated to the surface and was caught. The murre took 90 seconds to swallow this fish, 85 seconds more than the usual time. It appeared that this 9-inch fish was near the upper size-limit that a murre could eat. On one occasion the murre escaped into an adjacent tank that contained salmon 14 to 18 inches long. Although some of these salmon were bill-marked, none had been eaten. Tuck (*op. cit.*) presented data that indicate that most of the fish eaten by murre are less than 8 inches long. Latta and Sharkey (J. Wildl. Mgmt., 30:17-23, 1966) found that American Mergansers (*Mergus merganser americanus*) took smaller trout first in preference to larger ones when they were offered trout ranging from 4 to 8 inches long. They also concluded that girth was more important than length in determining the maximum size of fish that a merganser could swallow.

Several trials demonstrated that our murre could not successfully catch fish in total darkness. These trials were conducted by withholding fish for at least one day and then turning out the lights over the aquarium and in the adjacent room, making the aquarium approximately as dark as on a moonless night. Fish were added to the tank in the dark, but the murre made no recorded attempt to dive as long as the lights remained off, even though he was observed to head-dip occasionally. The murre immediately dove and made pursuits whenever the lights were turned on. The murre was left in darkness in the tank with known numbers of fish for up to eight hours, and at no time did any fish disappear from the tank until the lights were turned on.

As the murre missed some trout and caught others, a school of fish, made up of those that had escaped, congregated near the surface where the murre seemed to be relatively inefficient at catching fish. The school of fish maintained its position under the murre's perch or behind the murre in the water. These fish, dorsal fins barely beneath the surface, dove and scattered only as the murre approached them. When new fish were added to the tank, while a school of old fish remained, the murre always attacked the new and ate one or two during the first few minutes. The school of fish at the surface was always consumed last, particularly the larger fish.

FOOD-CONSUMPTION RATES

Three trials were made to determine the number and weight of fish the murre needed to maintain his body weight. In each trial a surplus of fish was kept in the tank at all times so the murre could feed at will. Data for the three trials, conducted in late September, early December, and late December, respectively, are shown in table 1.

For the three trials combined, the murre ate an average of 184 g of fish per day while maintaining an average body weight of 650 g. This relatively inactive murre required an average intake of 28 per cent of his body weight in fish each day. Latta and Sharkey (*op. cit.*) found that American Mergansers had an average daily intake equal to 17.9 to 26.8 per cent of their body weight, but five of eight birds studied lost weight continually. White (Fish. Res. Bd. Canada. Bull. 116, 1957) found that three subadult mergansers ate the equivalent of 28 per cent of their body weight per day over a 219-day period, but also lost weight continually, and a fourth bird held for 19 days consumed 38.5 per cent of his body weight per day.

TABLE 1
VOLUNTARY FOOD CONSUMPTION OF A CAPTIVE COMMON MURRE

Trial no.	1	2	3
No. days in trial	10	10	6
Body weight of murre			
Mean	616 g	699 g	639 g
Range	590-640 g	680-735 g	620-665 g
Mean no. fish available per day	23.9	8.3	4.7
Mean no. fish eaten per day	10.6	3.4	4.0
Mean weight of fish eaten per day	208 g	146 g	197 g

WEIGHT LOSS DURING STARVATION

Seven trials were made to determine the rate of weight loss in the absence of food. Food was withheld from the murre for periods ranging from 24 to 87.5 hours, and the weight at the beginning and end of each starvation period was recorded (table 2). In the seven trials, weight loss ranged from 2.8 to 5.7 per cent (17 to 46 g) of the original weight per 24 hours. Although there was some variability, generally there was a tendency for the murre to lose weight faster when the original weight had been high than when the original weight was lower. For all seven trials there was an average weight loss of 28 g or 4.3 per cent of original body weight per day.

FOOD-CONSUMPTION RATES FOLLOWING STARVATION

Fish were added to the tank immediately after completion of a starvation trial. The murre always ate one to four fish within the first two minutes. By the fourth hour he had consumed the equivalent of approximately one-third of his body weight in fish (table 3). By the end of the first day he consumed an average of 62 per cent of his body weight (average of 7 trials) compared with an average consumption rate of 28 per cent of body weight during the normal weight-maintenance trials (tables 1 and 3).

The rate of food consumption declined somewhat during the second day, and by the third day the consumption rate had declined to essentially the same level (24 to 29 per cent) as during the weight-maintenance trials (tables 1 and 3).

In the seven trials the murre gained an average of 12 per cent (range, 5 to 17 per cent) in excess of his starvation weight within 24 hours after the resumption of feeding (table 3). This compares with an average weight loss for the seven starvation trials of about 10 per cent. Undoubtedly a portion of the gain was represented by food material contained in the digestive tract, but in two trials for which detailed

TABLE 2
WEIGHT LOSS IN A CAPTIVE COMMON MURRE DURING STARVATION

Trial no.	1	2	3	4	5	6	7
Hours food withheld	24	39	39	48	67	76	87.5
Initial body wt., g	620	565	690	660	595	625	700
Final body wt., g	600	530	625	600	520	570	565
Per cent of initial wt. lost	3.2	6.3	9.3	9.1	12.6	8.8	19.3
Per cent lost per day	3.2	3.9	5.7	4.5	4.5	2.8	5.3
Grams of weight lost per day	20	21	46	30	27	17	37

TABLE 3

FOOD CONSUMPTION AND WEIGHT CHANGES EXPRESSED AS PER CENT OF BODY WEIGHT AT THE START OF EACH OF THE FIRST FOUR DAYS FOLLOWING STARVATION TRIALS IN A CAPTIVE COMMON MURRE

Elapsed time in hours since resumption of feeding	Food consumption during preceding 24-hour period (percentage of body weight consumed)	Percentage change in body weight during preceding 24-hour period	Number of observations
24	62	+12	7
48	40	-3	1
72	24	+3	1
96	29	-2	2

records up to 96 hours are available, the murre did not gain additional weight after the first 24 hours (table 3).

GRIT RETENTION

The murre was in captivity 126 days. No gravel or stones were available in the aquarium. However, twice he was observed pecking at the bottom on what could have been a search for gravel. Dissection of the gizzard revealed 23 pieces of gravel and 7 otoliths. The gravel had a volume of 2.5 ml and was mostly chert and quartz. The largest piece had a volume of 0.3 ml. The otoliths were apparently obtained from the perch that had been ingested 16 hours before death. An analysis of the fecal material collected during the study revealed clean, undamaged fish bones, but no gravel or rock of any kind. Examination of the digestive tracts of a sample of the trout fed to the murre revealed no rocks. This might indicate that a wild murre would seldom need to seek gravel to replenish the grit in the grizzard.

SUMMARY

A captive California murre was fed rainbow trout 3 to 9 inches long, while housed in an indoor salt-water aquarium. All surface swimming was by alternately stroking with the feet, and all subsurface propulsion was by wing action, the feet being used only in making turns. Nearly all fish were caught underwater after a deliberate pursuit. All fish were swallowed head first, and most were swallowed on the surface. After swallowing the bird always "stood up" in the water and beat his wings several times. Fish 9 inches long appeared to be the maximum size the murre could successfully swallow. The murre did not attempt to dive after fish in darkness even when he had not eaten in more than 24 hours. In three trials the murre consumed an average of 28 per cent of his body weight in fish per day while maintaining an average body weight of 650 g. In seven starvation trials ranging from 24 to 87.5 hours, the murre lost 2.8 to 5.7 per cent of the original body weight per day. Following starvation trials the murre ate an average of 62 per cent of his body weight in fish in the first 24 hours, and 40 per cent of his body weight in the second 24 hours. By the third day the consumption had declined to the "normal" weight-maintenance rate of 24 to 29 per cent. Following starvation the murre regained an average of 12 per cent of the "starvation" weight within 24 hours and failed to gain any additional weight during the next three days.

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