

THE FISHING ACTIVITIES OF DOUBLE-CRESTED CORMORANTS ON SAN FRANCISCO BAY

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Since cormorants are an abundant, wide-ranging group of birds of conspicuous size and habits, much has been written of their behavior. Comprehensive papers, notably those by Lewis (Natural History of the Double-crested Cormorant, 1929, 94 pp.) on *Phalacrocorax auritus* in Canada and by Portielje (Ardea, 17, 1927:107-123) on *Phalacrocorax carbo* in Europe have treated the subject in detail. Most of the work on cormorants, however, has been concerned with their breeding behavior, and, with the exception of studies of food habits, there has been no adequate work on their non-breeding activities.

In the course of a study of the daily movements and distribution of cormorants in the east-central part of San Francisco Bay, California, during 1940 and 1941, frequent opportunity for the observation of the fishing activities of the Double-crested Cormorant (*Phalacrocorax auritus*) was afforded.

All the Double-crested Cormorants on the central part of San Francisco Bay roost at nighttime on a power line running from Brooks Island to the east shore of the Bay, a distance of slightly more than one and nine-tenths miles. Each morning when the birds leave the power line, virtually all fly in the same direction. Consequently on any one morning the flocks of departing cormorants pass over the same part of the Bay and large groups of them often congregate on the water and fish en masse.

From September through November, 1940, the cormorants which roosted on the Brooks Island power line were fishing in the area between the approach to the San Francisco-Oakland Bay Bridge and the Berkeley Pier. This area is enclosed on three sides by roads and accordingly offers excellent facilities for the observation of aquatic birds.

The activities of a large fishing flock, although subject to frequent variations, always follow the same basic pattern. The formation of such a flock, like all movements involving large numbers of cormorants, is gradual. Apparently there is no "prearranged" place for its formation. When the birds prepare to alight they all come down as a group without preliminary circling. The first group to alight as a rule does not begin fishing at once, but swims slowly about, with birds diving only occasionally. After the first cormorants have landed on the water, other flocks alight with them and the size of the raft of swimming birds increases rapidly. Usually only one large flock is formed in any one area, but on October 6, 1940, two fishing flocks, one of about 400 and the other of about 500 individuals, formed a mile and a quarter apart. Late arrivals joined whichever flock was the closest as they crossed the Berkeley Pier.

Cormorants which arrive after a fishing flock has begun to form probably locate it by sight. It may be that the presence of fishing cormorants is indicated to approaching flocks by the swarm of gulls flying about above them, for I have often discovered their presence in this manner. Flocks of cormorants flying away from the power line frequently alter the direction of their flight by as much as ninety degrees as soon as they have crossed the Berkeley Pier and are able to see the spot where the fishing flock is forming.

At 8:10 a.m. on October 5, 1940, a flock of approximately 450 birds had formed on the water one-half mile south of the Berkeley Pier and a quarter of a mile off shore. A flock of sixty cormorants shortly after crossing the Berkeley Pier a mile and a half from shore apparently sighted this fishing flock, for they turned abruptly and flew east

to join it. This turn of almost eighty degrees was initiated not by the birds at the apex of the flock, but by those birds which were in the part of the "V" nearest the fishing cormorants. Consequently the turn began at the east end of the formation and spread steadily westward though the rest of the flock.

The mere presence on the water of a small group of birds even of another species will sometimes attract a flock of cormorants that is flying over the area. At 7:36 a.m. on October 7, 1940, a flock of cormorants crossed the Berkeley Pier flying about forty feet in the air. After dropping down near the water, they turned sharply to the left and headed toward a loose flock of birds resting on the water approximately three-eighths of a mile to the southeast. When they reached this flock, instead of alighting they turned to the right and flew on southward. I looked through my telescope at the birds which the cormorants had approached and discovered that they were immature gulls.

Active fishing usually begins before the fishing flock is fully formed, but birds which arrive after the fishing has begun join the flock without disturbing its formation or activity. The actual method of fishing is always the same. The size of fishing flocks is highly variable. Concerted fishing activities seldom develop in groups containing fewer than ten or twelve birds, but flocks seen on the Bay range from this minimum figure up to a maximum of approximately 1900. Except for occasional groups fishing near the Brooks Island power line in the late afternoon, flocks larger than one hundred always form early in the morning before the birds have had a chance to scatter widely.

The formation assumed by a large flock is a long, narrow, but closely packed, line which may be curved or indented at various points but is generally at right angles to the direction of movement of the flock as a whole (see fig. 7). The exact dimensions of the flock depend on the number of birds involved, but the relative proportions are constant and independent of the size of the flock. All the birds swim in the same direction and nine-tenths of them are in the narrow line. In a flock of fifty or sixty birds, this leading line rarely contains more than a single rank of cormorants, but in a flock of 500 or more it may be three or four birds deep. The few birds that are not in this line are scattered loosely behind the main part of the flock. Active fishing is confined almost entirely to the front line.

The movement of the flock as a whole is divisible into several components (see fig. 7). All the cormorants swim along the surface in one direction. When they dive, they are of course headed in this same direction and they continue to swim straight forward while they are beneath the water. The birds beneath the water and those on the surface move at about the same speed so that when a cormorant appears at the surface after a dive, it is either close to or actually in the line of birds swimming there. Perhaps one bird in seven, however, returns to the surface behind the main group. These laggards do not attempt to overtake the others by swimming; instead they take off and fly over the flock and land in front of the main line and allow it to overtake them. This flying from the rear to the front imparts to the flock a constant rolling movement which materially increases its speed. Flying is rarely seen in flocks smaller than twenty-five and it becomes more and more conspicuous as the size of the flocks increases.

A group of cormorants that is fishing appears to be considerably smaller than it really is because one-quarter to one-half of the birds are usually beneath the water. The direction of movement often changes. In groups of fifty or less, turns of 90 or even 180 degrees are not infrequent, because such relatively small flocks are readily and quickly reorganized. A group larger than 500 usually pursues a relatively straight course and when it does turn, since it may be 80 or 100 yards long, considerable time and much flying about are required before it can reorganize itself and head off in the new direction.

When a large flock turns sharply, it is apparently because of an alteration in the direction of movement of the school of fish which it has been pursuing, for such a turn is almost always preceded by a cessation of fishing. After drifting aimlessly for from a few seconds to two or three minutes, the birds at one end or the other of the flock will resume their diving. Soon other near-by birds join in and almost immediately a short new fishing line forms and begins to move off. At first this newly formed fishing group contains only those birds which were near the spot where the fishing was resumed, but as soon as the new line is definitely established, birds in distant parts of the flock take off and fly over to join it. This movement is not en masse; first one individual and then another takes off, and in flocks larger than 1000, a continuous, but straggling, stream of birds passing from the non-fishing to the fishing flock will be formed. So gradual is

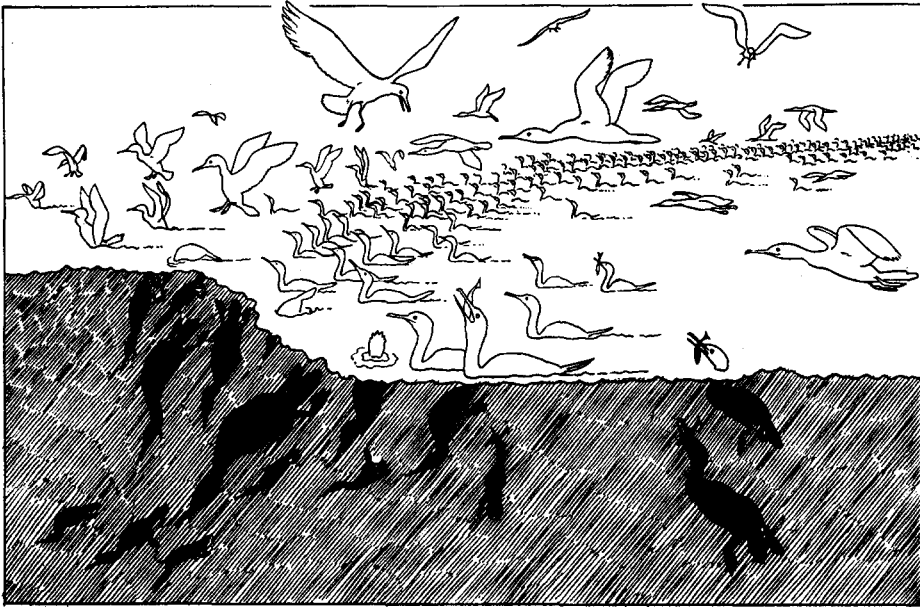


Fig. 7. Drawing showing arrangement and activity of a large fishing flock of Double-crested Cormorants.

this flight that the stream of flying birds may persist for five or six minutes. While the shift is going on, the fishing birds move rapidly away and the amount of flying necessary to overtake them increases continually.

Occasionally when an extremely large flock which has been fishing for a long time changes direction, it splits and one part swims away and continues to fish while the other part remains behind resting quietly on the water. After the fishing birds have moved a quarter of a mile or so away, members of the resting group sometimes fly over and join them. This too is a gradual movement, carried out by individuals or at most groups of three or four. When it is well under way, a continuous, but irregular line of flying birds all moving in the same direction connects the two flocks. Such a flight often lasts for ten or fifteen minutes.

The birds in a fishing flock are more active than those which fish by themselves. When fishing is good, a cormorant flock presents a scene of almost frenzied activity and the screaming gulls hovering in the air overhead heighten the impression of unlimited energy. The only noise made by the cormorants themselves is a continuous splashing,

swishing sound caused by their movement through the water and through the air. On calm days, this sound is audible when the birds are 200 yards away. The large number of birds swimming, taking off and alighting roils the water and creates a conspicuous disturbed area around the flock. When fishing in a large flock, it is not unusual for cormorants to leap completely out of the water as they dive, but this almost never occurs in small flocks. Birds of a flock often send vertical splashes two to three feet into the air as they dive, whereas solitary birds make such a slight disturbance that they seem to slide beneath the water.

All cormorants in a fishing flock swim continuously and rapidly at a uniform speed. There is no pause in their forward motion even while they are shifting a fish about in their bills or swallowing.

When a lone cormorant is fishing, it appears to search beneath the water for individual fish, but large fishing flocks undoubtedly pursue whole schools of fish. The reasons for this assumption are several. The large number of fish caught could only be captured if the birds had access to a school. The changes in direction of the flocks can best be explained as maneuvers to allow them to follow the flight of a school. The entire flock of cormorants will take off and fly to some other part of the Bay when fishing is poor. The activity of a large fishing flock, which is much more intense than that of a small one, suggests that the birds are stimulated to their maximum intensity of effort by the presence of large numbers of easily caught fish. If a large flock of cormorants were driving a school of fish before it, there would be no need for the birds to zigzag back and forth searching for a fish; they could merely dive beneath the water and swim straight ahead until they sighted a fish, seize it and return to the surface. Thus the fact that the birds reappear at the surface headed in the same direction as when they dived, together with the fact that birds swimming under water do not lag behind those on the surface, bears out the premise that members of large fishing flocks do not search for scattered individual fish.

There are several reasons why the formation here described should be assumed by large flocks of fishing cormorants. When the birds form a long thin line stretching at right angles to the direction of the movement of the flock as a whole, the extended front serves to drive the school of fish before it, while the length of the line tends to keep the fish from escaping off to the side. The fish undoubtedly flee from the flock and if the birds were in a dense compact formation, only those individuals on the leading edge of the flock would have much chance of catching anything, whereas when the cormorants swim side by side, all are fishing in water from which the fish have not yet been chased.

Mass fishing is an efficient way of obtaining food and a surprising number of cormorants return to the surface with fish in their bills. Because of the great activity and the many birds, it is almost impossible to estimate the average number of dives necessary to catch one fish in mass fishing. Purely as a guess, but a guess based on many hours of observation, I would suggest that one in every six or seven birds returning to the surface has a fish. The fish (possibly anchovies) caught in mass fishing seldom exceed five inches in length and many are required to furnish an adequate meal.

The dissolution of a large fishing flock is caused by one of two factors: escape of the school of fish, or satisfaction of the hunger of the cormorants. The behavior of the birds in the two cases is distinctly different. When the cessation of fishing is the result of the escape of the school of fish, diving stops abruptly; the flock loses its formation and the birds drift about slowly and aimlessly or dive haphazardly. If any of the birds find the lost fish again or discover another school, fishing is resumed and the flock assumes the usual formation. If no fish are found in the vicinity, the flock flies away. The birds do

not take to the wing all together, but rather gradually, so that a straggling line is formed. If the birds fly more than a half-mile, the continuous line breaks up into flocks which adopt asymmetrical "V" or single-line formations. The birds all fly in the same direction and alight on the water in a compact raft to form another fishing flock. Sometimes a flock that has lost its school of fish will take off and alight on three or four different parts of the Bay before beginning to fish again.

When the cessation of fishing is the result of satiation, the fishing of the birds stops slowly rather than abruptly. This type of break-up of a flock can be described by quoting from my field notes concerning a group of cormorants observed south of the Berkeley Pier on the morning of October 7, 1940: "9:45.—The fishing flock is beginning to break up. Some of the birds in the rear of the flock instead of alighting in front of the other birds after taking off are leaving the flock and flying away in the direction of the Brooks Island power line. 10:00.—Many of the cormorants are lagging behind to form a wake of scattered birds flapping their wings, drying their feathers or resting quietly on the water behind the actively fishing birds. When these scattered laggards are resting quietly on the water, they are relatively inconspicuous, but when they flap their wings to shake the water off, they blossom forth like small black explosions. 10:05.—The fishing flock continues to decrease in size, more and more birds are dropping behind and an increased number of small flocks are taking to the wing and flying away northward. 10:12.—Fishing has stopped completely. Instead of a compact raft of birds, there is now a loose flock scattered over an area half a mile square. 10:20.—Whereas forty-five minutes ago there was an organized group of 1500 to 2000 cormorants, now only 200 birds are in sight and these are scattered so widely that they must be considered as solitary individuals rather than as a flock."

Small flocks of fishing cormorants are more common than large ones and the flocks most frequently seen on the Bay contain fewer than twenty birds. These small flocks form at any time of day, usually in the vicinity of the daytime roosting sites. The organization of these small flocks is much more flexible than that of the larger ones. As a rule the birds form a fairly compact group, perhaps one bird to each square yard of water surface, but instead of making a long narrow line at right angles to their direction of movement, they tend to assume a roughly circular formation. All of the birds in the flock face in the same direction as they swim steadily along. Birds in the trailing edge of the flock dive just like those on the leading edge. It is noticeable that in small flocks there is no flying. Those birds that lag behind or come to the surface some distance to the rear of the flock do not take to the air to catch up with the others; they simply swim faster. The speed of movement of small flocks is about one-third less than that of large ones. The reduced speed is due to two things, the slower swimming and the absence of flying. The slower swimming allows the birds that lag behind to overtake the main group by swimming and this of course does away with the necessity for flying. Small flocks as a rule apparently do not pursue schools of fish. The birds do not always swim along beneath the water parallel to the direction of the main part of the flock, for individuals often come to the surface headed 90 or even 180 degrees away from the line of movement followed by the rest of the birds. These individuals, however, immediately turn and swim after the others. All the members of a small fishing flock dive in the direction of movement of the group as a whole, and in order to be facing some other way when they reappear at the surface, they must reverse directions while under the water looking for or pursuing fish. The small flocks change direction more readily and frequently than large ones. Even when an entire flock completely reverses direction, none of the birds takes to the wing.

There is no synchronization of diving in either large or small flocks. As a result, the number of cormorants visible at one time is highly variable. In a flock that was fishing about 150 yards off shore in the bay opposite the Berkeley Aquatic Park, the number of birds on the surface at any one time varied all the way from three to twenty. The only time that it is possible to determine accurately the size of a fishing group is when it reverses direction, for then most of the cormorants stop diving for a few seconds.

The cessation of fishing in small flocks differs from that in large flocks in that it follows a constant pattern, probably because the break-up almost invariably occurs in the immediate neighborhood of one of the roosts on which the cormorants spend their days. Small fishing flocks break up gradually. First one bird and then another, having caught all the fish it wants, will take off, fly back to the roosting site, alight and begin to preen and dry its feathers. The movement back to the roost continues until the flock has disappeared. Often one or two birds, probably because of poor fishing, continue to dive long after the others have returned to the roost. As a rule relatively fewer fish are caught by the members of the small flocks than by the members of the larger groups. This is probably because the former have to hunt for their prey while the latter need merely to swim into a school and seize a fish.

The small number of fish caught by the small flocks of cormorants may explain why they are so seldom accompanied by flocks of gulls. The gulls cannot obtain enough fish to make it worth their effort.

Cormorants do not always fish in flocks. It is a common sight to see solitary individuals or groups of two or three fishing by themselves. There is not even a hint of organization in a group of less than four or five cormorants.

The fish caught by cormorants on San Francisco Bay are seldom more than five or six inches long. When a cormorant returns to the surface after a successful dive, its prey is usually held crossways in its bill. At first it apparently is held in the same position in which it was caught, for sometimes it is grasped near the head and other times near the tail, but before being swallowed it is shifted so that it will go down head first. Lewis (*op. cit.*: 72) says that small soft fish are swallowed in any position, but I have never seen fish swallowed other than head foremost. A cormorant shifts a fish to a position suitable for swallowing by shaking its head from side to side and executing chewing movements with its mandibles. Since I have been able to watch large flocks of fishing cormorants, there has been opportunity to see literally thousands of fish caught, and only once have I seen a fish tossed into the air before being swallowed. On this occasion, the fish could very easily have flipped itself into the air by a sudden flirt of its tail. Once caught, fish are seldom lost, but the large number of gulls which habitually accompany flocks of fishing cormorants testifies to the fact that some fish escape.

As Lewis points out, cormorants swallow in a series of jerks in which the head is thrust forward and slightly upward. Smaller fish are swallowed with one forward movement of the head, but with larger fish, four or five thrusts may be necessary. Swallowing distends the neck and gular pouch. If the fish is a large one, the lashing back and forth of its tail as it passes down the neck of its captor is clearly visible. After swallowing, a cormorant invariably shakes its head vigorously from side to side.

When a small fish is caught, the other cormorants in the flock pay no attention, but when a large fish that is difficult to swallow is captured, two or three near-by birds occasionally give chase and attempt to rob the captor. A bird which captures an unusually large fish appears to realize that others will attempt to rob it, for instead of swimming along with the flock as it normally would, it turns and moves directly away from the other birds. On November 11, 1940, at 7:30 a.m., a flock of twenty-five cor-

morants was fishing in the bay just west of the Berkeley Yacht Harbor. Twice within three minutes exceptionally large fish were caught and both times similar but unsuccessful attempts at robbery were made. A cormorant came to the surface with a flounder about eight inches long. Due apparently to the excessive width of the fish, the bird had difficulty in swallowing it. Instead of swimming along the surface in the customary manner, the cormorant turned, stretched out its neck, and using both wings and feet simultaneously, fled in the opposite direction, half swimming and half hopping along the surface of the water. As soon as it started to flee, two near-by birds turned and gave chase. In spite of the efforts of its assailants the bird finally managed to swallow the fish, and the would-be robbers returned to the flock and resumed their fishing. The fish made a conspicuous bulge in the neck of its swallower. Fully fifteen seconds elapsed before the fish reached the base of the neck where it formed a lump so large that it looked as if the bird had a broken neck. After swallowing, the bird swung its head strongly from side to side, stuck its head beneath the water, shook it, and then swam away shuffling its wings back and forth and splashing water over its back. After this, it reared back and flapped its wings for six or eight seconds as if trying to adjust the position of the fish. It did not again rejoin the flock but remained floating quietly on the water.

The cormorant normally is not a scavenger, but on occasion it will resort to this means of obtaining food. Lewis (p. 71) quotes Frank L. Farley as saying that at Miquelon Lakes, Alberta, he has seen adult Double-crested Cormorants picking up pieces of fish lying near the nests of White Pelicans (*Pelecanus erythrorhynchos*). Although this species of cormorant has never been seen scavenging on San Francisco Bay, on April 13, 1941, Dr. S. B. Benson saw four or five Brandt Cormorants (*Phalacrocorax penicillatus*) eating bait that was being discarded by a fisherman in a rowboat in the Richmond Channel. On April 20, Dr. Benson and I attempted to attract cormorants in a similar manner in the same place. Although there were six or eight Brandt Cormorants roosting on the breakwater within fifty yards of us, only Western Gulls (*Larus occidentalis*) and Brown Pelicans (*Pelecanus occidentalis*) were attracted by the bait. In the morning we saw a commercial fishing boat moving slowly out the channel. Behind it was a dense flock of birds containing about 150 gulls, ten Brown Pelicans and a group of about eight Brandt Cormorants. The cormorants remained together and did not approach as close to the boat as the other birds, but like the others they were presumably feeding on fish or scraps which the fishermen were discarding.

Because of the large concentrations of aquatic birds on San Francisco Bay during the fall, winter, and spring, other species of birds often associate with cormorants while they are fishing. The most persistent and conspicuous association is that between Farallon Cormorants and gulls. The largest number of gulls that I have seen with any single flock of cormorants is about 250. When relatively small groups of cormorants are fishing near a favorite roosting place of the gulls, the latter may outnumber the former two to one. Gulls which have been seen with flocks of cormorants on the bay include Western (*Larus occidentalis*), Glaucous-winged (*Larus glaucescens*), Bonaparte (*Larus philadelphia*), California (*Larus californicus*), and Ring-billed (*Larus delawarensis*). Western and Glaucous-winged gulls are the ones most commonly associated with the cormorants. The gulls fly about above the fishing cormorants calling noisily and occasionally dropping to the water to pick up a fish. Frequently, they alight on the water in the midst of the cormorants who ignore them completely. The gulls cannot swim fast enough to keep up with the cormorants and a few seconds after alighting they drop behind and then take to the wing again. As soon as the fishing stops, the gulls scatter,

but if the flock of cormorants should fly away, the gulls do not follow them. Gulls do not ordinarily accompany individual cormorants or groups of less than twenty-five. Only once have I seen a gull attempt to rob a cormorant other than those with a fish too large to swallow readily, and this attempt was unsuccessful.

I am indebted to Mr. Herman V. Leffler, of Oakland, California, for the account of an interesting relationship between gulls and cormorants. On February 8, 1941, while watching birds in the Berkeley Aquatic Park, Mr. Leffler saw about ten Double-crested Cormorants, with a number of Bonaparte Gulls flying about above them, fishing in the water flowing into the lagoon from the bay through a culvert which runs underneath the Bayshore Highway. The cormorants were catching perch (size unspecified), some of which were pregnant. As the cormorants shifted the fish about preparatory to swallowing them, either the shock of being caught or the pressure of the birds' bills caused the perch to give birth to young which were spewed forth into the water. The gulls then dropped down and picked up the new born fish, but the cormorants made no attempt to eat the baby perch.

In the spring and fall when Forster Terns (*Sterna forsteri*) are abundant on the Bay, they frequently dive into the water in front of small groups of fishing cormorants. Even though a tern may strike the water within thirty inches of a cormorant, the splash evokes no response. Brown Pelicans also often dive in the vicinity of fishing cormorants without disturbing them. On one occasion three pelicans which were flying over a flock of about twenty cormorants dived into the water simultaneously. One hit the water about a yard in front of the flock and the other two came down about the same distance behind the flock, but the big splashes seemed to have no effect on the activities of the cormorants who continued their fishing as though nothing had happened.

When cormorants are fishing, they usually ignore any and all species of birds which may be in the vicinity. On various occasions I have seen Pacific Loons (*Gavia arctica*), Red-throated Loons (*Gavia stellata*), Pied-billed Grebes (*Podilymbus podiceps*), Western Grebes (*Aechmophorus occidentalis*), Eared Grebes (*Colymbus nigricollis*), American Egrets (*Casmerodius albus*), American Mergansers (*Mergus merganser*), and Red-breasted Mergansers (*Mergus serrator*), all of which are fish eaters, fishing within less than a yard of Double-crested Cormorants without either species paying any attention to the other.

During the winter immense flocks of ducks congregate on San Francisco Bay and in the early morning it is not unusual to see a flock of several thousand Ruddy Ducks (*Erismatura jamaicensis*), or an equally large mixed flock of White-winged Scoters (*Melanitta deglandi*) and Surf Scoters (*Melanitta perspicillata*) resting on the water in a loose raft. I have never seen any large flocks of cormorants come in contact with one of these rafts of ducks, but flocks of fifteen or twenty frequently do. They move along as if there were not a duck within miles. The ducks, however, swim leisurely aside as the cormorants approach and leave a temporary lane of open water for them to swim through. In this manner a small flock of fishing cormorants may pass completely through a flock of ducks.

Only once in the scores of times that I have seen ducks and cormorants swimming within a foot or less of each other has there been any antagonism. A dozen Surf Scoters and three Double-crested Cormorants were swimming about among some old pilings in the east end of the Berkeley Yacht Harbor. An immature cormorant and a female scoter approached each other swimming in opposite directions and passed less than eight inches apart. For no apparent reason, when the two were side by side, the cormorant opened its bill and thrust out vigorously at the duck which scurried away for about a yard. The cormorant made no attempt to follow it.

Wetmore (Condor, 19, 1927:273-274) states that individuals of *Phalacrocorax auritus floridanus* confined to a cage 158×50×56 feet in the National Zoological Park in Washington, D.C., remained in excellent health when fed three-quarters of a pound to one pound of fish daily, six days a week. Since the cormorants on San Francisco Bay probably do more flying and swimming than the caged specimens mentioned by Wetmore, their consumption of fish must be about one pound per day per bird. Since during most of the fall and winter of 1940-41 the number of cormorants in the central part of San Francisco Bay was about 2000, they caught and ate approximately one ton of fish daily. Nevertheless, it seems improbable that these birds have any economic importance, for little commercial fishing is done on the Bay. Cormorants do not compete with sport fishermen because the only important game fish on the Bay is the introduced striped bass, and this fish is usually too large for the birds to handle.

No effort was made to determine by an examination of stomach contents the kinds of fish eaten, but cormorants on San Francisco Bay have been seen catching smelt, flounder, and pipe fish, and they probably will eat any fish of a reasonable size that they can catch.

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SUMMARY

All the Double-crested Cormorants on the central part of San Francisco Bay, California, roost at night on a power line running from Brooks Island to the east shore of the Bay. In departing from the power line in the morning, all fly in one direction and they often congregate on the water in rafts containing as many as 1800 or 2000 birds to engage in mass fishing activities. In flocks containing more than forty or fifty birds, the cormorants form a long narrow line at right angles to their direction of movement. The forward movement of the flock is divisible into three components, swimming on the surface, swimming beneath the water, and flying from the front to the rear of the flock.

Large fishing flocks of cormorants pursue entire schools of fish; small flocks hunt for individual fish.

The break-up of a large flock of cormorants results either from the escape of the school of fish or the satisfaction of the hunger of the birds. In the former case, fishing stops abruptly; in the latter, it stops gradually.

Large flocks (500 or more) form only in the morning before the birds have had a chance to scatter widely over the Bay. Small flocks (50 or less) are more commonly seen than large ones and they form at any hour of the day, usually in the vicinity of the various roosts on which the birds spend their time when they are away from the night-time roost. Small flocks form compact, roughly circular groups in which all the birds move through the water in the same direction. The movement of small flocks is dependent solely on swimming, for their members never take to the wing during the fishing activities.

The break-up of small flocks is always gradual. Each bird stops fishing when its hunger is satisfied.

Flocks of as many as 250 gulls may accompany large groups of fishing cormorants, but they rarely follow small fishing flocks. Fishing cormorants ignore other species of birds with which they may be associated.

Because of the small amount of commercial fishing done on San Francisco Bay, cormorants can hardly be of any economic importance there.

Museum of Vertebrate Zoology, Berkeley, California, September 15, 1941.