

THE SURVIVAL OF CONFINED HADDOCK AND COD

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WASHINGTON

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ABSTRACT

Haddock (Melanogrammus aeglefinus) and Atlantic cod (Gadus morhua) maintained in aquaria and a live-car were affected differently by water temperature and other conditions in the confined areas. Haddock suffered greater mortality than cod in water warmer than about 65° F. and colder than about 35° F. Cod were unaffected by these water temperatures, and were more resistant to diseases that affected the haddock.

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INTRODUCTION

Physiological experiments, certain age and growth studies, and preliminary trials of tags are best carried out with fishes confined in aquaria or other enclosures. Our experience in such experiments, with marine fishes of the cod family, however, has been limited by high mortality rates caused by disease and, presumably, lethal water temperatures. For example, our aquarium studies with haddock (Melanogrammus aeglefinus) usually ended in the early summer when the fish died from what was suspected to be the effects of the relatively warm water in the tanks. In contrast, occasional specimens of Atlantic cod (Gadus morhua) and pollock (Pollachius virens), kept in adjacent tanks in water of the same temperature thrived, and apparently were not affected by the water temperature. These observations prompted a re-examination of data recorded during the experiments, particularly the relationship between water temperature and fish mortality.

In the former U. S. Fish Commission Hatchery at Woods Hole, cod were kept in basement tanks and remained alive as long as the water temperature did not go below 30° F. because ". . . at 29° (F.) all will die". (Carswell, 1889). In 1901, 500 to 600 cod were held in outdoor live-cars at Woods Hole, but when the water temperature fell from 31° F. to 28° F., and remained at that low level for the greater part of a month, all the cod died (Sherwood and Edwards, 1902).

McKenzie (1938) kept cod in tanks at St. Andrews, New Brunswick, and at the Eastern Passage Laboratory, near Halifax, Nova Scotia. He reported that a large proportion of the large cod will die when the water temperature rises above 59° F., but the very small cod will feed in, and survive, water of 62° F. His experience with cod at low temperatures indicated that at 31° F. the fish do not appear in distress, but rather appear quite at ease, swimming very slowly with a greatly reduced respiration rate. He reported no observations for cod in water colder than 31° F.

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About 100 cod, from 11 to 17 inches long, were kept in wooden tubs at St. Andrews for 54 weeks (Kohler, 1959). During the trip from the fishing ground to the laboratory, the fish endured a change of water temperature from 44.8° to 55.4° F., and in the laboratory endured temperatures from 57.7° to 35.1° F. with no mortality that could be attributed to water temperature (Kohler, personal communication).

In their natural habitat in the sea, cod are at home in any temperature from 32° to 50°-55° F., but large cod tend to avoid water warmer than about 50° F., although they are abundant at times in temperatures as high as 58°-59° F. on Nantucket Shoals (Bigelow and Schroeder, 1953).

Wise, (1958) made an extensive review of cod and hydrography and concluded that ". . . under appropriate circumstances some cod can survive from temperatures near the freezing point of sea water to 20° (C)"; that is, from about 28° F. to 68° F.

The temperature tolerances of haddock, on the other hand, have not been reported to the extent they have been for cod. Vladykov, (1934) kept six young haddock alive in tanks for nearly three months during which time the water temperature varied from 57.2° to 68.0° F. He noted that despite the relatively high temperature, the fish appeared in good condition even when they were sacrificed at the end of the experiment.

In nature, haddock seem to avoid water colder than 34° and warmer than 50°-55° F. (Bigelow and Schroeder, 1953).

Pollock are considered cool-water fish, and generally are not found in water warmer than 52° or cooler than 32° F. (Bigelow and Schroeder, 1953). I have seen no records of their temperature tolerances in aquaria.

The present paper reports my observations of what apparently are lethal water temperatures for haddock, with additional observations of survival of a few cod and one pollock. The observations were made incidentally, during the course of two experiments: (1) with haddock and cod in the aquarium, and (2) with haddock, cod, and one pollock, in the aquarium and in a live-car. The main purpose of the experiments was to test several kinds of tags on the fishes. It is unfortunate, therefore, that no controls were established to help determine more precisely the exact cause of death; i. e., lethal water temperature, disease, crowding, or some other factor.

EXPERIMENTAL CONDITIONS

Aquarium facilities

The laboratory aquarium contained 12 indoor tanks, each holding about 300 gallons. Flowing sea water, at the rate of four changes per day, was supplied to the tanks from Great Harbor, on which the laboratory is located. The water temperature in the tanks was recorded with a Bristol recording thermometer. We made no salinity determinations. However, the average salinity of the water in Great Harbor is 32 parts per thousand, and, because of the frequency of change, the salinity of the aquarium was presumably the same.

The water intake was located about 100 yards from the aquarium, and about six feet below mean low water. The water was pumped into an outdoor, elevated wooden holding tank adjacent to the aquarium building, and from there into the building and to the individual tanks. Because of the location of the holding tank, the temperature of the aquarium water was warmer in the summer and colder in the winter than the harbor water, by about 1° to 2° F.

In the experiments described here, the fish were fed chopped frozen Atlantic herring (Clupea harengus) at the rate of about one ounce of herring per fish every other day. The larger pieces of uneaten herring were removed from the tanks while the scraps were quickly consumed by hermit crabs in the tanks.

THE EXPERIMENTS

As stated before, the two experiments were conducted primarily to study the effects of tags and tagging on the fish. Some of the results have already been published (Jensen, 1958). The results of fish survival under conditions of both high and low water temperatures, not previously documented are detailed below.

Experiment No. 1

The fish used in this experiment were captured by otter trawl on Georges Bank during Albatross III Cruise 59, April, 1955. A total of 168 haddock and 5 cod were transported to Woods Hole on board the vessel in wooden tanks supplied with running sea water.

On arrival at Woods Hole, the haddock were distributed in 11 tanks, and the cod were placed in a large tank in the basement of the building. Some haddock began to die on the second day, and the mortality continued throughout the experiment (table 1).

Table 1. --Water temperature and fish survival in the aquarium,
1955 experiment

Date	Water temp. (° F.)	Number of fish alive		Remarks
		Haddock	Cod	
April 12	44	168	5	Fish placed in tanks
April 19	46	127	5	Largest and smallest fish seem to die first
April 26	46	83	5	90% of fish diseased; began to offer food
May 3	49	59	5	Some haddock recovering from disease
May 9	53	43	5	Tagged 36 liveliest haddock
May 16	54	37	5	Decline in feeding noted
May 23	57	30	5	Pop-eye noted in many haddock
May 30	59	28	5	Fish feeding well again
June 6	60	26	5	-----
June 13	62	25	5	50% of haddock affected with pop-eye
June 20	67	22	5	-----
June 27	69	22	5	More than 2/3rd of haddock not feeding
July 4	70	20	5	One cod dead, cause unknown
July 12	70	All dead	4	Surviving cod sacrificed

The greatest mortality occurred in the first four weeks when 125 haddock, nearly 75 percent of the total, died. No doubt many of these fish were unable to acclimate to the artificial environment of the aquarium. Disease, however, also added to the high death rate. Many of the fish became covered with whitish spots, believed to be a fungus, although the pathogen was not identified. Others became affected with a generalized fin-rot in which the tissue between the fin rays became reddened and sloughed off. This condition was particularly noticeable on the caudal fin, although the dorsal fins also were involved.

By the third week about 90 percent of the haddock were affected with the fin-rot. Although the acute symptoms of the disease cleared up on most of the surviving fish, a few exhibited some fin-rot throughout the experiment.

After about 2 weeks in the tanks, the haddock became interested in food and began to feed actively on the herring offered to them. They continued to feed throughout May and into part of June.

As the water continued to warm, the haddock lost interest in the food, and by June 30, with the water at 69° F. less than one-third of the fish were feeding. By July 5, with the water temperature at 70° F., the haddock had ceased to feed, and during the week of July 4-12, the 20 remaining haddock died. I suspect that 70° F. is about the upper lethal limit for haddock.

The five cod were unaffected by the water temperatures and disease. They continued to feed, and maintained themselves well throughout the experiment. One died from unknown causes on July 5, but the four remaining fish were in good condition when they were sacrificed on July 12.

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Experiment No. 2

From November 1955 to June 1956, haddock, cod, and one pollock were tagged and kept under observation to determine how well the fishes tolerated tags of various design; and to determine changes in fish length and pattern of scale markings. Because of some technical difficulties, explained later, only part of the experimental objectives were achieved. However, some interesting observations were made of fish survival under conditions of both high and low water temperatures and extreme crowding.

The experimental fish were captured by otter trawl on the Highland Grounds, about 10 miles north-northeast of Provincetown, Massachusetts, during a cruise of the chartered commercial fishing vessel Priscilla V. On November 19, 1955, a total of 71 haddock, 8 cod, and 1 pollock were transported to Woods Hole on board the vessel in wooden tanks supplied with running sea water.

At the laboratory, 36 haddock and the pollock were placed in four indoor tanks. The remaining 35 haddock and the 5 cod were placed in a floating live-car in Great Harbor. The surface water temperature in the live-car was measured daily with a pocket thermometer graduated in whole degrees, Fahrenheit. A few observations were missed when I was away on field work and to fill these gaps data were taken from surface water temperatures reported at the adjacent Woods Hole Oceanographic Institution (Bumpus, 1957).

The initial mortality of haddock (table 2) was much less than in Experiment 1. Fla-rot disease affected haddock both in the aquarium and in the live-car, but the cod and pollock showed no evidence of the disease. A few haddock died each week in the tanks, but the heaviest mortality occurred in the live-car. Twelve haddock died during the first week in the live-car, and 17 more died during the month of January when temperatures in the low 30's prevailed. Temperatures in the aquarium were similar to those in the live-car and reached a low of 31° F. on January 2, 1956.

In live car tanks

Table 2.--Water temperature and fish survival in the aquarium and in the live-car, 1955-1956 experiment

Date	Aquarium <i>In live car tanks</i>			Live-car		
	Water temp. (° F.)	No. of haddock alive	Remarks	Water temp. (° F.)	No. of haddock alive	Remarks
Nov. 20	49	36	Fish placed in tanks	49	35	Fished placed in live-car
Nov. 28	45	30	Fin-rot showing up	45	23	Fin-rot same as in aquarium
Dec. 5	44	27	Fed fish, very hungry	43	23	Fed fish, very hungry
Dec. 12	39	26	-----	40	23	-----
Dec. 19	38	24	-----	39	21	Decline in feeding
Dec. 26	34	23	-----	33	21	-----
Jan. 2	31	19	Water stoppage in one tank killed 4 fish	30*	--	No observations made
Jan. 9	34	19	-----	32*	--	No observations made
Jan. 16	36	14	Tagged all fish	33	8	-----
Jan. 23	34	14	Decline in feeding	33	6	Decline in feeding
Jan. 30	33	13	-----	32*	--	No observations made
Feb. 6	35	13	-----	37	4	Tagged all fish
Feb. 13	35	13	-----	36	3	-----
Feb. 18	35	12	Pump broke down, transferred to live-car	37	2	-----
Feb. 21	--	--	-----	37	14	Additional fish from aquarium
Feb. 27	--	--	-----	36	14	Feeding improving
Mar. 5	--	--	-----	36	13	Fish feeding actively
March 12	--	--	-----	37	13	-----
Mar. 19	--	--	-----	37	13	-----
Mar. 26	--	--	-----	39	12	Fish active, alert and feeding
Apr. 2	--	--	-----	39	12	-----
Apr. 9	--	--	-----	42	12	-----
Apr. 16	--	--	-----	43	12	Fish actively feeding
Apr. 23	--	--	-----	46	12	Removed 4 live haddock
Apr. 30	--	--	-----	46	8	Removed 8 live haddock
May 7	--	--	-----	47*	--	5 cod and 1 pollock alive
May 14	--	--	-----	49	--	5 cod and 1 pollock alive
May 21	--	--	-----	55	--	5 cod and 1 pollock alive
May 28	--	--	-----	55	--	5 cod and 1 pollock alive
June 4	--	--	-----	58	--	Removed 3 cod
June 11	--	--	-----	65	--	Removed 2 cod and 1 pollock

* From Bumpus (1957)

This should be on this table

The fishes' interest in food seemed to be affected by the water temperature. Early in December, all the fish appeared hungry and interested in the food offered to them and began to feed actively, but, by the end of January, following the prolonged cold spell, neither the fish in the aquarium nor in the live-car showed an active interest in the food. The lack of interest in food continued until about the middle of March when the fish began to feed actively again.

On February 18, the aquarium water-pump system became inoperative and could not be repaired, and the 12 surviving haddock and the pollock were transferred to the live-car. At this time only two haddock remained alive of the number originally placed in the live-car, but the five cod were still alive, active, and, to all appearances, quite healthy.

During the next two months haddock mortality in the live-car was almost nil; only two fish died. The 12 surviving haddock were removed alive from the car during the last week in April, transferred to a large outdoor pool, and used in a test of underwater television. Because of the physical limitations of the pool, we were able to recapture only one fish for further study; the others were lost to the experiment.

The five cod and the pollock continued to thrive in the live-car, even into June when the water temperature reached 65° F. The study ended in June when, on two separate days, the survivors were removed from the live-car and sacrificed. They were sleek and healthy looking, and appeared to have adapted well to confinement in the live-car.

DISCUSSION

Any conclusions drawn about lethal water temperatures and the survival of haddock must be tempered by a consideration of the effects of disease and the lack of experimental controls. Most of the haddock were affected by fin-rot and other disease that undoubtedly made them more sensitive to temperature changes. The data shown here, however, strongly suggests that the upper lethal water temperature for haddock is probably 70° F. and the lower lethal temperature is probably 31° F.

Cod and pollock were not visibly affected by disease and seemed better able to adjust to captivity. Cod were able to tolerate temperatures as high as 70° F. and as low as 31° F., while the one pollock was able to tolerate temperatures as high as 65° F. and as low as 31° F.

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