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# Effect of alternate-day feeding on growth and feed conversion in Atlantic cod

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**Results show feeding costs can be drastically reduced without affecting performance**



Results of this study to evaluate the effect of alternate-day feeding compared with daily feeding in Atlantic cod demonstrated that feeding costs can be drastically reduced while maintaining or improving fish performance. Photo by © Hans Hillewaert / CC BY-SA 4.0.

The Atlantic cod (*Gadus morhua*) has been a promising candidate for marine aquaculture in Norway. The commercial culture production of cod increased rapidly for several years (1990 to 2000), but biological (low growth rates, early maturation in captivity, poor disease control) and economical (high production costs, increased wild catches putting pressure on prices) factors resulted in the downfall of the industry. The number of farmers was reduced from 2005 onwards, and most of the industry was closed down.

Despite this, there has ever since been an ongoing work aiming at improving the quality of the fish through the National Breeding Program for Cod at **Nofima** (<https://nofima.no/en/>), in Tromsø, Norway. The cod available for farming today is the fifth generation since the beginning of the program, and through breeding efforts fish growth has increased by 9 to 10 percent per generation; early maturation of males reduced from 95 percent to 5 percent, and larval survival has increased significantly. Based on these encouraging results, there is a growing optimism again for cod farming in Norway, and a few companies started stocking juvenile cod into the sea for farming during 2019 and 2020.

Growth in fish is regulated by factors such as access to food, water temperature and photoperiod. Manufactured feeds normally make up 50 to 70 percent of the expenses in fish farming. In general, farmed fish are fed every day, but several studies have investigated how different feeding regimes may affect growth and feed conversion ratio. Cyclic starvation/re-feeding regimes have been applied to induce compensatory growth in several species, such as Atlantic cod, gilthead sea bream, Atlantic halibut, turbot and Atlantic salmon (*Salmo salar*). Such restricted feeding and cyclic starvation/re-

feeding regimes have documented an improved feed conversion ratio (FCR) in fish following a starvation period. But there is less information available on how growth in large Atlantic cod could be affected by alternate-day feeding compared with daily feeding.

This article – adapted and summarized from the [original publication](https://doi.org/10.1111/anu.13260) (<https://doi.org/10.1111/anu.13260>). (Marit Bjørnevik, M. et al. 2021. The effect of alternate-day feeding on growth and feed conversion in Atlantic cod, *Gadus morhua*. *Aquaculture Nutrition*) – investigated the effect of alternate-day feeding compared with daily feeding on growth and feed utilization in on-growing Atlantic cod over a 15-month period.



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## Study setup

The juvenile Atlantic cod ( $n = 400$ ) used in our study came from a commercial hatchery (Sagafjord AS). From 320 to 530 days posthatch, the fish were reared at the research facility of the University of Nordland (Mørkvedbukta) and thereafter moved by truck to the production site of Fjord Marine Cod in Brønnøysund, where the feeding trial took place. The fish (mean weight  $\pm$  SD;  $704 \pm 277$  grams) were stocked into two sea cages ( $5 \times 5 \times 5$  meters) where 296 out of the total of 400 fish were tagged intraperitoneally using a Biomark MK25 implant gun and Biomark GPT 12 12.5-mm needle tags (Biomark Inc.).

Two feeding regimes were used: One cage was fed daily at 100 percent ration (control, Con) according to a commercial growth table (Biomar AS), and the other cage was fed every second day (alternating, Alt), both under natural light (Brønnøysund,  $65^{\circ}28'30$  N). The experiment lasted for 444 days. The fish were hand-fed either daily or once every second day with a commercially formulated feed (Classic Marine, containing 15 to 20 g/kg fat, 48 to 54 g/kg protein) from Biomar, Myre). The pellet size was gradually increased from 5 to 12 mm according to producer recommendations. The fish were reared at ambient temperatures (annual mean temperature, 7.7 degrees-C, max 13.9 degrees-C in September, min 3.8 degrees-C in March).

All tagged fish (198 fish in Con and 98 in Alt) were anaesthetized and sampled for individual weight and length measurements on six occasions over a 15-month period during the experiment. For detailed information on the experimental design and fish husbandry; growth and feed consumption; and statistical analyses, refer to the original publication.

## Results and discussion

Fish density in the cages was low and under 4 kg per cubic meter during the whole experimental period. The total mortality throughout the experiment was significantly higher ( $p < .05$ ) in the Con group (20.3 percent) compared with the Alt group (4.3 percent). The Alt group was significantly heavier throughout the trial period ( $p < .05$ ) and grew from (mean  $\pm$  SE)  $758 \pm 27$  to  $3,041 \pm 68$  grams, compared with  $628 \pm 20$  to  $2,635 \pm 85$  grams for the Con group (Fig. 1). No differences were found in the length of the fish in the two groups ( $p > .10$ ). The condition factor, CF [relates fish length to weight] varied between the two feeding groups, with the fish in the Alt group having a higher CF ( $p < .05$ ) throughout the trial period.

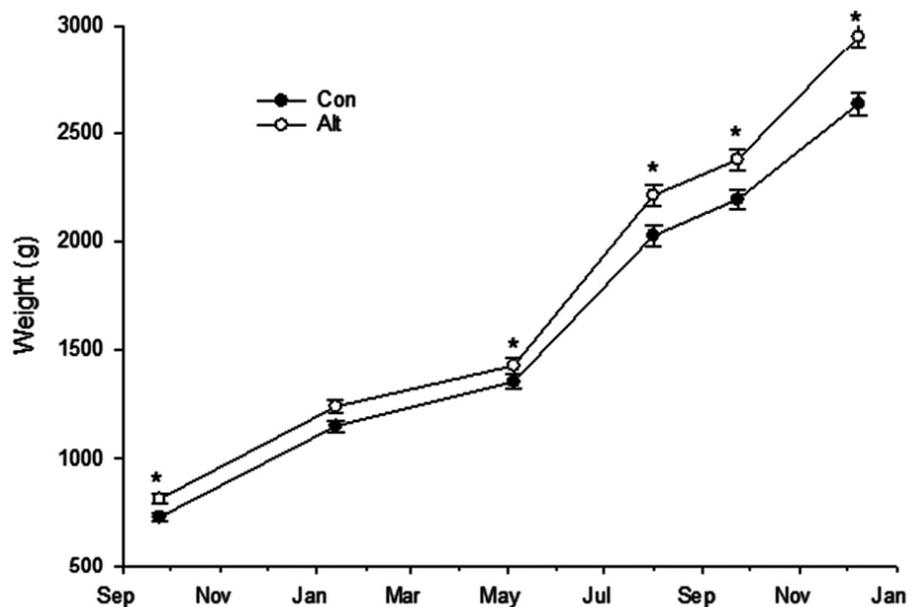


Fig. 1: Mean body weight (grams) of Atlantic cod reared under either daily (Con) or alternative days (Alt) feeding. Values represent means  $\pm$  SE. \* indicates significant differences ( $p < .05$ ) between the two experimental groups.

In general, zero to two fish died per month in each cage. But on random occasions, the mortality was higher in the control group. With the relatively low number of fish per cage, even small increases in mortality will have a large effect on the mortality rate. There were no specific health issues that could explain the increased mortality in the control group. As the mortality was irregular, it is unlikely to be caused by the feeding regime itself.

Overall, the current findings indicate that Atlantic cod can deal well with short fasting periods (here Alt) during the whole on-growing period. The mean individual growth trajectories differed between the two groups, and the Alt group gained 13 percent more mean weight compared with the Con group but was fed 27 percent less feed. Our results show that Atlantic cod fed on alternate days have similar or higher growth rate as fish fed every day, in agreement with other studies on other cod species. Similar results – showing better or no different results in terms of fish performance and production cost for intermittent feeding regimes – have been reported for other fish species, including Nile tilapia and juvenile longfin yellowtail. The Alt group consumed significantly less feed (27 percent) compared with control. From an economic perspective, a lower FCR is of vital importance due to feed costs.

Previous studies have shown that growth in Atlantic cod (>400 grams) was not influenced by the intervals between the feeding (ad libitum), when fed five times a week or two times a week. A previous trial by our research group investigated the effect of different feeding regimes (fasting/re-feeding and reduced feeding) for Atlantic cod juveniles between 132 and 400 grams. Results showed that short fasting – that is, 50 percent feeding for two weeks and 100 percent for four weeks, and 100 percent every second day and 0 percent the following day (i.e. Alt), resulted in similar body mass increment compared with the control (fed 100 percent according to a commercial growth table every day), but consumed significantly less feed (42.9 and 37.5 percent less feed, respectively) compared with control.

These findings from this previous trial are in line with our results here, and both studies demonstrate that feeding costs can be drastically reduced without compromising biomass growth by using feeding on alternate days.

It has been demonstrated that Atlantic cod freely skips feeding on a daily basis. In an earlier study where cod were fed once per day, 23 percent of the individuals frequently skipped meals. Information of this nature will prove important in fine-tuning daily feeding regime and indicate that a combination of large- and small-scale studies is required to adequately assess feeding behavior in cod. Also, previous studies have shown that Atlantic cod displays hierarchical aggressive feeding behavior in the laboratory directed towards smaller conspecifics, so the selection of alternative feeding strategies may also reduce potential competition between conspecifics in sea pens.

## Perspectives

The results of this study to investigate the effect of alternating feeding on growth of juvenile Atlantic cod showed that feeding on alternating days over a 15-month period resulted in higher weight gain, improved growth and lower feed conversion ratio. Our research demonstrates that feeding costs can be drastically reduced without compromising biomass growth by using feeding on alternate days during the on-growing period of Atlantic cod.

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