EFFECTS OF PHOTOPERIOD MANIPULATION ON REPRODUCTIVE CYCLICITY IN HADDOCK (*MELANOGRAMMUS AEGLEFINUS*)

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Haddock (*Melanogrammus aeglefinus)* is an important, temperate, groundfish harvested commercially in the North Atlantic. As landings have declined over the last 40 years, haddock aquaculture is being developed to take advantage of high market prices and to diversify existing aquaculture operations. Haddock are group synchronous, serial spawners. Each female releases 8-10 batches of eggs spontaneously in communal spawning tanks over 4-6 weeks. For many temperate marine species, photoperiod, acting through the hypothalamic-hypophysial-gonadal axis, is the main environmental cue that influences endogenous, circannual, reproductive cycles. (Reviews: Bye, 1990; Bromage et al., 2001). For this reason, photomanipulation of reproductive cycles is routinely used to alter the spawning period of cultured fish for efficient hatchery production. The purpose of this study was to gain a basic understanding of haddock reproductive cycles and to determine the effects of photoperiod manipulation on gonadal development and circulating steroid hormone levels.

Wild haddock broodstock (56-73 cm FL) were tagged and held in two 6-m tanks supplied with flow-through seawater at ambient temperatures. The photoperiod

of one tank was advanced by 2 months (advanced phase-shifted photoperiod; ADV) while the other was maintained on a simulated natural photoperiod (SNP). At 6-8 week intervals, from Nov 1996 to May 1998, plasma samples, gonadal biopsies and ovarian ultrasound measurements were collected from a subset of fish in each tank. Following histological preparation, follicle diameters were measured and developmental stages assessed. Levels of estradiol-17β (E_2), testosterone (T) and 11-ketotestosterone (11-KT) were determined by radioimmunoassay.

The spawning period of haddock maintained on the ADV commenced 9 and 6 weeks ahead of the SNP broodstock in 1997 and 1998, respectively, and the duration of spawning was prolonged. Plasma E_2 levels started to increase in September and August for the SNP and ADV groups, respectively, peaking at about 3 ng/ml during spawning. Similarly, follicle size and gonad indices increased in the fall, as E_2 stimulated vitellogenesis. E_2 levels decreased abruptly during the last half of the spawning season (Fig. 1). Male testosterone levels, like E_2 in females, peaked at 1.0-1.5 ng/ml during the spawning season and dropped after spawning to low or non-detectable levels. Plasma levels of 11-ketotestosterone in males were low or non-detectable throughout the year.

Haddock exhibit similar patterns of ovarian growth and seasonal steroid production as other temperate, batch-spawning teleosts, such as Atlantic cod (*Gadus morhua*) and Atlantic halibut (*Hippoglossus hippoglossus*) (Hansen et al., 2001; Methven et al., 1992). Levels of estradiol increase around the autumn equinox when day length and temperature are declining. Estradiol promotes oocyte growth through vitellogenin incorporated into the oocytes. Peak estradiol levels correspond with spawning, and fluctuate as sequential oocyte clutches mature and ovulate (Methven et al., 1992). This study demonstrates that haddock respond readily to photomanipulation and maintain normal, phase-shifted, seasonal cycles. The extended spawning duration, characteristic of phase-shifted stocks, is likely due to individual responsiveness to environmental cues and persistent endogenous rhythms.

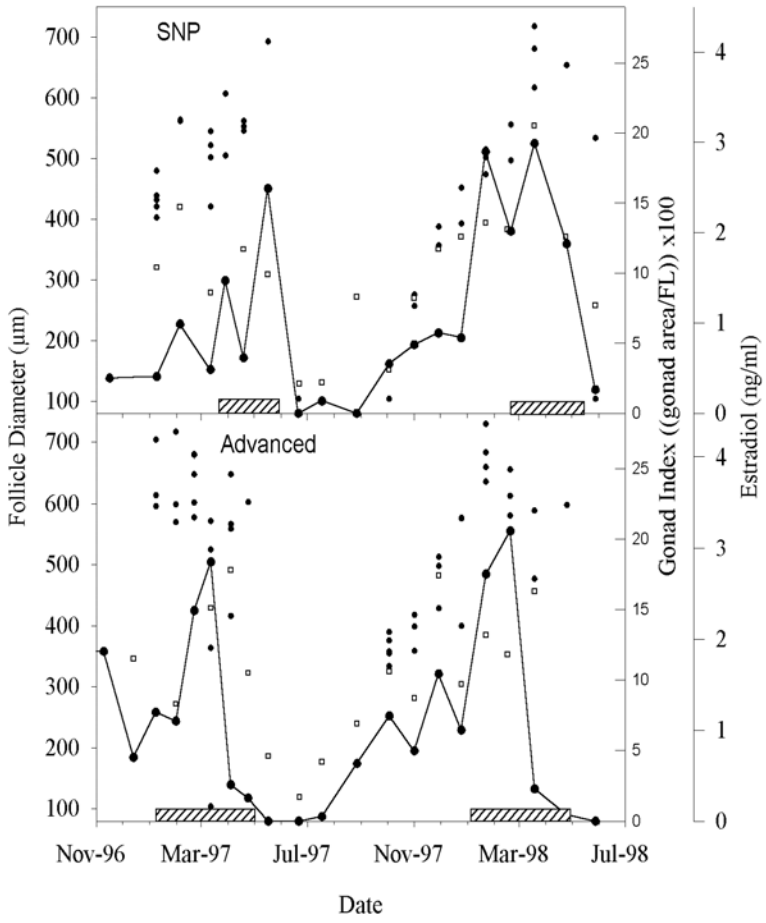

Figure 1. Seasonal profiles of mean plasma estradiol levels • (—) , follicle diameters • and ovarian indices (open squares) of haddock maintained under

SNP and 2 month advanced photoperiods. Shaded bars indicate spawning intervals.

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