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Population biology of a data poor species, offshore hake (*Merluccius albidus*) in the northwest Atlantic, United States

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ABSTRACT

Offshore hake (*Merluccius albidus*) is a data-poor stock and very little is known about its biology and life history. This paper provides a general synopsis of the data acquired during the National Marine Fisheries Service bottom trawl surveys between 1963 and 2008 for offshore hake in the northeast United States and is limited to those fish found in the northwestern Atlantic. Offshore hake are commonly distributed from southern Georges Bank through the Mid-Atlantic Bight, at depths of 160–550 m and temperatures ranging between 11 and 13 °C. They are known to co-occur with silver hake (*Merluccius bilinearis*) on the outer continental slopes of the Atlantic Ocean and are easily confused with silver hake because of their strong morphological resemblance. Spawning generally occurs between April and July. Maximum observed size was approximately 43 cm for males and 56 cm for females, and fish greater than 40 cm consist mainly of females, suggesting that they are sexually dimorphic. Length at 50% maturity (L_{50}) also differed significantly between sexes with females maturing at larger sizes (28 cm) relative to males (23 cm). This basic life history information is critical to conserving the offshore hake population and managing sustainable fisheries.

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1. Introduction

Offshore hake, *Merluccius albidus* belongs to one of the twelve hake species of the genus *Merluccius*, inhabiting the northern and southern hemisphere of the world's oceans (Pitcher and Alheit, 1995; Helser, 1996). Like other species of the *Merluccius* genus, they are considered to be a 'true hake' species and are morphologically distinct from other gadoid-like hakes (e.g. red and white hake; Helser, 1996). Offshore hake are known to be distributed off the continental slope of the northwest Atlantic to the Caribbean and the Gulf of Mexico (Chang et al., 1999). They are commonly located off southern Georges Bank through the Mid-Atlantic Bight at depths ranging from 160 to 550 m (Bigelow and Schroeder, 1953; Klein-MacPhee, 2002), though they have been found in depths up to 1000 m in the Gulf of Mexico (Rohr and Gutherz, 1977). Offshore hake and silver hake (*M. bilinearis*) are sympatric species, and they co-exist over a considerable range of the continental slope, but are often separated by depth preferences (Helser, 1996). The most distinguishing morphological characteristics between these species are the number of gill rakers and lateral line scales (Chang et al., 1999). Due to the similar morphological features and spatial areas where they co-exist, they have been commonly misidentified for many years. The fishing industry did not separate the commercial landings of the two species until 1991, but the extent to which they are still landed as a single species is unknown (Helser, 1996).

Spawning usually occurs between April and July in the New England area, at depths ranging from 330 to 550 m (Cohen et al., 1990). Offshore hake eggs are usually bigger than silver hake eggs and are pelagic and both spherical and transparent (Chang et al., 1999; Marak, 1967). The larvae usually hatch relatively undeveloped between 6 and 8 days after fertilization (Marak, 1967). Juveniles tend to stay along the outer shelf, as the eggs and adults do. The NEFSC categorizes juveniles as any individual <30 cm and adults >30 cm. The maximum observed adult length is 40 cm for males and 70 cm for females (Chang et al., 1999).

They are also the most concentrated in the fall and winter, within temperatures ranging from 11 to 12 °C. The concentration of juveniles ranges from 70 to 440 m, however the distribution tends to vary by season (Reid et al., 1999). Depth and concentrations of adult distribution tend to be very similar to the patterns of juvenile offshore hake. Though they are found as far south as French New Guinea (Cohen et al., 1990; Rohr and Gutherz, 1977), they are predominantly found from the southern tip of Georges Bank to the mid-Atlantic region (Chang et al., 1999).

Offshore hake is currently included in the New England Fishery Management Council's (NEFMC) small mesh multi-species fishery management plan. Offshore hake nominal commercial landings peaked at 120 mt in the early 1990s, then declined sharply to less than 5 mt in 2001, the lowest in the time series (Fig. 1). Otter trawl

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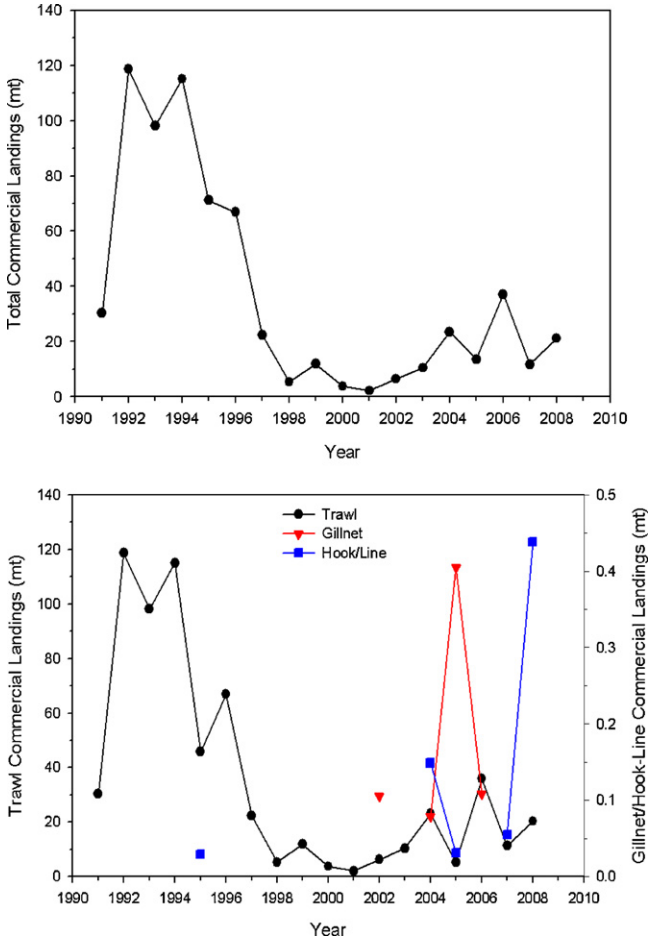

Fig. 1. Total nominal commercial landings from 1991 to 2008 (top plot) and by gear type (bottom plot).

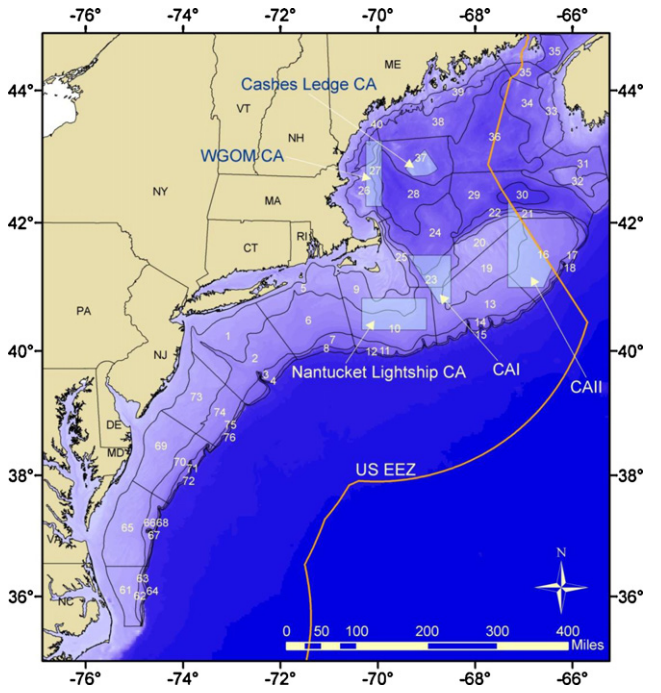

Fig. 2. NEFSC survey strata map. Offshore hake survey catches are based on the two outermost bands in the southern region, defined by strata 3–4, 7–8, 11–12, 14–15, 17–18, 63–64, 67–68, 71–72, 75–76.

is the dominant fishing gear for offshore hake, accounting for 95% of the total catch in the commercial fishery. Other gears such as gillnet or hook and line were very minimal, contributing less than 1% in offshore hake catches, while approximately 5% of the total landings are from unknown gear sources (NEFSC, 2011).

Unfortunately, very little is known about the biology and population dynamics of offshore hake. Therefore, this study summarizes and builds upon the current information available on this species, based on the Northeast Fishery Science Center's resource survey information since 1963 in the US territory to support stock assessment and fishery management. For the sake of this paper, the survey information used is from 1967 onward, which reflects when all the strata were consistently sampled.

2. Methods

The primary sources of biological information for offshore hake are based on the annual fishery independent surveys conducted by the Northeast Fisheries Science Center (NEFSC). The surveys were conducted using a random stratified sampling design which allocates samples relative to the size of the strata, defined by depth. The NEFSC have conducted both spring and fall bottom trawl surveys off the US continental shelf annually since 1963. The surveys extend from the Gulf of Maine to Cape Hatteras, in offshore waters at depths 27–365 m, and have been conducted in the fall since 1963 and in the spring since 1968. The winter bottom trawl survey began in 1992 and was specifically designed for flatfish; however, the deeper survey strata were not sampled until 1998 (Fig. 2). The winter trawl survey does not cover the Georges Bank area because the survey was designed specifically for flatfish in the southern region. Details on the stratified random survey design and biological sampling methodology may be found in Grosslein (1969), Azarovitz (1981) and Sosebee and Cadrin (2006).

Offshore hake survey trends were calculated based on the delta estimator described by Pennington (1983). Survey strata sets were restricted to the two outermost band of the Continental shelf as this is considered primary habitat for offshore hake. If a strata set which includes southern Georges Bank through the Mid-Atlantic (Strata 1–19, 61–76; Fig. 2) was used, the stratified mean weight catches per tow are lower by an order of magnitude, however, the variance estimates remained similar.

Habitat association preferences for offshore hake were evaluated by examining catch distributions relative to bottom temperature and depth from data collected during each of the NEFSC bottom trawl surveys using methods developed by Perry and Smith (1994). Analyses were based on a cumulative distribution of catch numbers calculated for each depth and temperature profile, binned at every 50 m and 1 °C respectively for each season, for both sexes.

Gonadal development was staged by dissection and gross visual inspection using a 6-stage classification system (immature, developing, ripe, ripe and running, spent, and resting) based on gonad size, color, texture and presence of milt or ova (Burnett et al., 1989). Post-spawning condition was considered by aggregating spent and resting stages while ripe conditions included fish that were both 'ripe' and 'ripe and running'. Due to limited biological samples available for offshore hake, gonad observations were pooled across the entire geographical range using the entire time series (1995–2008), but separated by gender. Fish with unknown reproductive state were excluded from the analyses. Rates of sexual maturity were estimated for males and females using length and maturity stages collected from the spring survey when spawning is at its peak. The proportion mature at length was estimated using