Species Profile - Black Sea Bass (*Centropristis striata*)

Species range and distribution

Black sea bass range from southern Nova Scotia and the Bay of Fundy (Scott 1988) to southern Florida (Bowen and Avise 1990) and into the Gulf of Mexico.

Habitat characteristics and habitat use by life stage

Eggs and larvae: Eggs and larvae are pelagic, and were more abundant in water depths of 10-90 m and water temperatures of 15-24°C during June-September on the continental shelf from northern NJ to Cape Hatteras between 1978 and 1987 (MARMAP survey data). Berrien and Sibunka (1999) showed that in the Mid-Atlantic Bight, areas with high average egg densities were generally located on the continental shelf in the vicinity of large estuaries including Chesapeake Bay, the Delaware River, and the Hudson River. Black sea bass eggs also occur infrequently in large bays such as Buzzards Bay, MA (Stone et al. 1994), but are rare in Long Island Sound (Merriman and Sclar 1952; Wheatland 1956; Richards 1959), and absent in Narragansett Bay RI (Bourne and Govoni 1988) and Delaware Bay (Wang and Kernehan 1979).

While black sea bass larvae are collected close to shore on the continental shelf, they rarely occur within estuaries. Able et al. (1995) speculated that most larvae settle in near shore continental shelf habitats and then move into estuarine nurseries where post-settlement stage juveniles can be abundant.

Young-of-the Year Juveniles: Larvae hatch from eggs at 1.5-2.1 mm TL and settle to the bottom as early juveniles at 10-16 mm TL (Kendall 1972; Fahay 1983; Able et al. 1995) primarily in nearshore shelf areas on shells (eg surfclams) and sandy substrates, then move into estuarine nursery areas on shallow (<50 m, mostly <20 m) shellfish, sponge, amphipod habitats, also seagrass beds, cobble habitats, and man-made structures. They are rarely found on non-vegetated sandy intertidal flats and beaches and in deeper, muddy bottom. In offshore areas, recently settled fish occur in accumulations of shell on sand substrata, complex micro-topographies on exposed clay, on rocky reefs, and on wrecks (Able et al. 1995).

Juveniles appear to be most abundant in oceanic waters and polyhaline regions of many estuaries, but can occur at salinities as low as 8 ppt (Drohan et al. 2005). Juveniles can be relatively common in estuaries south of Cape Cod, and are found in estuaries such as Narragansett Bay, Long Island Sound, the Hudson-Raritan estuary, Great Bay (NJ), Delaware Bay, Chesapeake Bay and tributaries, as well as many estuaries farther south (see references cited in Drohan et al. 2005).

Within estuaries, young fish use shallow shellfish (oyster and mussel), sponge (including *Microciona prolifera*), amphipod (*Ampelisca abdita*), seagrass beds (especially *Ruppia* sp.), and cobble habitats as well as manmade structures such as wharves, pilings, wrecks, reefs, crab and conch pots (see references cited in Drohan et al. 2005). Early juveniles are rare on unvegetated sandy intertidal flats and beaches (Allen et al. 1978) as well as deeper, muddy bottoms (Richards 1963b). According to Able and Fahay (2010), YOY juveniles are more frequently collected along with large amounts of shell hash (especially surfclams). In the Great Bay estuary (NJ) they occur at a variety of sites that include shells, amphipod tubes, and deep channels with rubble, also in marsh creeks and around pier pilings. Lab studies show a preference for oyster shells over barren sand substrate (Able and Fahay 1998). There seems to be a high degree of habitat fidelity during the summer and fall in the estuary (Able and Hales 1997). Temperature and oxygen seem to be especially important components of the habitat. In the lab, they occasionally buried in sand at 6°C and below 4°C they stopped feeding (Hales and Able 1995). Mortality increased sharply at 2-3°C.

The following is a detailed account of YOY juvenile growth, and inshore-offshore movements in New Jersey as reported by Able et al. (2005). “In New Jersey coastal waters larvae first appear in July but can occur into November. Recently settled individuals (15-24 mm total length [TL]) were collected at an inner continental shelf site and an adjacent estuary from July through October. By fall, fishes from these areas were 18-91 mm TL, and many had moved offshore from New Jersey estuarine waters and other estuaries to inner continental shelf waters between southern Massachusetts and Cape Hatteras. Subsequently, they continued to move offshore and during their first winter, they were concentrated near the shelf or slope break in the southern portion of the mid-Atlantic Bight. Some age 0+ individuals moved back into New Jersey estuaries in early spring, at sizes approximating those of the previous fall (150-96 mm TL). Thus, black sea bass reach relatively small sizes after 12 months of growth partly because little or no growth occurs during their first winter. This year class reached sizes of 78-175 mm TL by midsummer and 134-225 mm TL by the following fall.”

Older Juveniles: Similar to YOY juveniles and adults, older juveniles are associated with structurally complex bottom habitats, display high site fidelity, use shallow estuarine habitats at age 1+ (<10 m) and are also found in deeper estuarine channels. Juveniles <19 cm T are common on the shelf at depths of 100-140 m in the spring at bottom temperatures between 9-12°C and at 5-50 m and 15-21°C in the fall (NEFSC survey data reported in Drohan et al. 2005). Juvenile black sea bass have been collected at temperatures as high as 27°C in Chesapeake Bay (Geer 2002). Growth is faster at intermediate salinities, suggesting that most suitable habitats are in lower reaches of estuaries (Berlinsky et al. 2000). In laboratory studies, 100% mortality was recorded at 2-3°C, increased use of shelter and burial at temperatures below 6°C, and reduced feeding at 4°C (Able and Hales 1997).

Adults: Adults are strongly associated with structured habitats such as rocky reefs, cobble/rock fields, stony coral and sponge patches (in the South Atlantic), exposed stiff clay, and mussel beds (Drohan et al. 2005). They use shelters, appear to remain near complex structures during the day, and move to adjacent soft-bottom habitats to feed at night (Steimle and Figley 1996). Juveniles and adults migrate to over-wintering habitats on the outer shelf in the fall and return inshore in the spring (see below). Primary summer habitats on the nearshore shelf are <60 m deep; black sea bass may also occupy complex habitats in lower reaches of large estuaries (~5 m depth). At temperatures near 6°C adults become inactive and rest in holes and crevices (Adams 1993). They are also known to burrow into soft sediments during especially cold winters off NC/SC coast (Parker 1990). Based on NEFSC trawl survey data, depth and temperature preferences on the shelf in spring are 70-140 m and 9-14°C, and 10-40 m/16-28°C in the fall (Drohan et al. 2005).

Migrations

In the Mid-Atlantic Bight juvenile and adult black sea bass migrate from nearshore continental shelf habitats to outer shelf over-wintering areas as bottom temperatures decline in the fall. Juveniles begin to move into deeper warmer offshore water as temperatures decline below 14°C, and few individuals are collected in shallow areas when temperatures fall below 6°C (Able and Fahay 1998; Klein-MacPhee 2002). During warmer winters, juveniles may successfully over winter in deeper waters of lower Chesapeake Bay (MAFMC 1996; Chesapeake Bay Program 1996). In the Mid-Atlantic Bight, juveniles return to nearshore and estuarine habitats in the spring and are collected as early as March in the Chesapeake Bay region (Kimmel 1973). Larger fish appear to migrate earlier than smaller fish (Kendall 1977).

Tag returns from fish tagged in Nantucket Sound (Massachusetts) suggest that fish migrate south to the outer shelf near Block Canyon (south of Rhode Island) and then move southwest along the outer shelf toward Norfolk Canyon off Virginia (Kolek 1990). Acoustically tagged fish east of Sandy Hook, NJ, remained in the study area for 1-6 months and dispersed from the area in greater numbers in early summer (early June) and late fall (October-December) (Fabrizio et al. 2013a). Dispersal in early summer may have been larger males going to nearby spawning and feeding areas.

In a more recent tagging study, fish tagged in SNE moved south along the shelf break as far as Virginia, reaching the outer shelf in 4-9 weeks (Moser and Shepherd (2009). In the central MAB (middle of Long Island to Chesapeake Bay), tagged fish reached the shelf break in 3 weeks. In both cases, winter habitats were 140-150 m deeper than shelf areas occupied in the summer. Movement was initiated when bottom temperatures were between 10 and 12°C. Return migration in the spring is faster and more directed. Despite mixing among local groups during winter on the outer shelf, fish generally return to the area of previous summer residence, but degree of site fidelity was lower for fish that travel farther, i.e., the fish did not display strict "homing behavior."

Miller et al. (2016) performed a GAM analysis of spring NEFSC bottom trawl survey data from the MAB in relation to bottom temperatures, salinity, and shelf water volume and concluded that all three factors were significant features of over-wintering habitats. North of Hudson Canyon, temperatures >8°C had a positive effect on catch; south of Hudson Canyon the preferred temperature range was 7.9-15.7°C, with a peak at 12.5°C. Spring bottom temperatures in the north never get high enough to limit offshore migration. A temperature/salinity fronts on the outer shelf limits the extent of offshore migration and is preferred habitat, presumably due to upwelling, surface convergence and high productivity.

Within the stock area, distribution changes on a seasonal basis and the extent of the seasonal change varies by location. In the northern end of the range (New York to Massachusetts), black sea bass move offshore crossing the continental shelf, then south along the edge of the shelf (Moser and Shepherd 2009). By late winter, northern fish may travel as far south as Virginia, but most return to the northern inshore areas by May (NEFSC 2017). Black sea bass originating inshore along the Mid-Atlantic coast (New Jersey to Maryland) head offshore to the shelf edge during late autumn, traveling in a southeasterly direction. They return inshore in spring to the general area from which they originated (NEFSC 2017).. Black sea bass in the southern extent of the stock (Virginia and North Carolina) move offshore in late autumn/early winter. Given the proximity of the shelf edge, they transit a relatively short distance, due east, to reach over-wintering areas (NEFSC 2017).

Climate change

A GAM analysis of NEFSC trawl survey data by Bell et al. (2015) showed that the center of biomass (COB) of BSB and scup in spring when fish are offshore moved north by 150-200 km between 1972 and 2008 and remained in north during 2008-2012. Fish size was a significant variable in the fall, but not temperature. BSB were spatially segregated in the fall, with larger individuals located further north. The COB is further south when the number of juveniles in survey catches is high, further north when more adults are caught.

Food habits

Black sea bass are generalist carnivores. Primary prey are arthropods (45%) with 19% Cancer crabs and 16.5% other decapod crabs (Byron and Link 2010). Geographic region and fish size are important variables. Larger fish consume more sand lance and other fish, smaller ones eat more polychaetes, amphipods, miscellaneous arthropods, and mollusks. As reported by Drohan et al (2005), juveniles <20 cm consume almost exclusively crustaceans. YOY (<10 cm) eat amphipods and decapods, e.g. sand shrimp and rock crabs. Older juveniles eat euphausiids and decapods (hermit crabs, rock crabs). Adults consume mostly crustaceans, but they make up a smaller component of diet than for juveniles.

Reproduction and maturity

Black sea bass are protogynous hermaphrodites, with some fish changing sex from female to male as they increase in age and size. Age of sexual transition varies with latitude with females maturing and undergoing sexual transition at greater ages in northern latitudes (McGovern et al. 2002). Fish in the Mid-Atlantic Bight begin to mature at age 1 (8-17 cm TL) and 50% are mature at 2-3 yrs and ~19 cm SL (O'Brien et al. 1993). The majority of fish less than 19 cm are females, while larger fish are transitional individuals or males (Mercer 1978).

Primary spawning habitats appear to be located in the nearshore continental shelf at depths of 20-50 m (Breder 1932; Kendall 1972; Musick and Mercer 1977; Wilk and Brown 1980; Eklund and Targett 1990; Berrien and Sibunka 1999). Gravid females are common on the continental shelf and generally not found in estuaries (Allen et al. 1978). Fish may spawn on sand bottoms broken by ledges and move to structurally complex habitats in deeper water after spawning (Kolek 1990; MAFMC 1996). Kolek (1990) showed that some tagged black sea bass return to the spawning grounds in Nantucket Sound and suggested that the animals may home to spawning grounds. Fabrizio et al. (2013b) reported that the home ranges of tagged black sea bass in the MAB were large, but highly variable, ranging from 0.14 to 7.36 km2. Mature males are territorial and have smaller home ranges than females, sub-ordinate males, and fish in transition. In the Mid-Atlantic Bight, black sea bass spawn from April through October (Able and Fahay 1998; Reiss and McConaughay 1999).

Stock structure and status

The black sea bass population is currently managed as three separate stocks: Mid-Atlantic, South Atlantic,and the Gulf of Mexico. The geographic dividing line for the Mid- and South Atlantic stocks is located at Cape Hatteras, North Carolina. An operational assessment that incorporated new recreational harvest estimates was peer reviewed in August 2019. The assessment found that the black sea bass stock north of Cape Hatteras, NC was not overfished and overfishing (2021). For current details on stock status: https://www.fisheries.noaa.gov/national/status-stocks-reports

Fishery

Black sea bass are highly sought by both commercial and recreational fishermen throughout the Mid-Atlantic. Fisheries change seasonally with changes in fish distribution. Fish pots and handlines are more common inshore and in the more southern commercial fisheries. When fish move offshore, they are primarily caught in trawl fisheries targeting summer flounder, scup, and *Loligo* squid. Recreational fisheries generally occur during the period that sea bass are inshore (May to September), but season duration varies among the states.

Management

The black sea bass population is currently managed as three separate stocks by the Mid-Atlantic, South Atlantic, and Gulf of Mexico fishery management Councils..The management unit for the northern stock of black sea bass (*Centropristis striata*) is U.S. waters in the western Atlantic Ocean from Cape Hatteras, North Carolina northward to the U.S.-Canadian border. Since the fishery management plan's approval in 1997, the black sea bass commercial fishery has operated under a quota. The recreational fishery is restricted by a coastwide recreational harvest limit. NOAA Fisheries, the Mid-Atlantic Fishery Management Council, and the Atlantic States Marine Fisheries Commission cooperatively manage the black sea bass fishery north of Cape Hatteras. Annual catch limits are divided between the commercial and recreational fisheries. The commercial catch limit is further divided among the states based on historical harvests. Specific management measures for the commercial fishery include minimum size limits, minimum mesh requirements for trawls, a moratorium on entry into the fishery, and closed seasons.

References

Able, K.W. and M.P. Fahay. 1998. The first year in the life of estuarine fishes in the Middle Atlantic Bight. New Brunswick, NJ: Rutgers Univ. Press. 342 p.

Able, K.W. and M.P. Fahay 2010. Ecology of estuarine fishes: Temperate waters of the western North Atlantic. John Hopkins University Press, Baltimore, Maryland. ISBN 0-8018-9471-9 (hardcover). 566 p.

Able, K.W., M.P. Fahay, and G.R. Shepherd. 1995. Early life history of black sea bass, Centropristis striata, in the Mid-Atlantic Bight and a New Jersey estuary. Fish. Bull. (U.S.) 93: 429-445.

Able, K.W. and L.S. Hales, Jr. 1997. Movements of juvenile black sea bass *Centropristis striata* (Linnaeus) in a southern New Jersey estuary. J. Exp. Mar. Biol. Ecol. 213: 153-167.

Adams, A.J. 1993. Dynamics of fish assemblages associated with an offshore artificial reef in the southern Mid-Atlantic Bight. M.A. thesis, Coll. William and Mary, Williamsburg, VA. 98 p.

Allen, D.M., J.P. Clymer, III, and S.S. Herman. 1978. Fishes of Hereford Inlet estuary, southern New Jersey. Lehigh Univ., Dept. Biol. and Cent. Mar. Environ. Stud. and Wetlands Instit. 138 p.

Bell, R.J. et al. 2015. Disentangling the effects of climate, abundance, and size on the distribution of marine fish: an example based on four stocks from the Northeast US shelf. ICES J. Mar. Sci. 72(5):1311-1322.

Berlinsky D., M. Watson, G. Nardi, and T.M. Bradley. 2000. Investigations of selected parameters for growth of larval and juvenile black sea bass *Centropristis striata* L. J. World Aquacult. Soc. 31: 426–435.

Berrien, P. and J. Sibunka. 1999. Distribution patterns of fish eggs in the United States northeast continental shelf ecosystem, 1977-1987. NOAA Tech. Rep. NMFS 145. 310 p.

Bourne, D.W. and J.J. Govoni. 1988. Distribution of fish eggs and larvae and patterns of water circulation in Narragansett Bay, 1972-1973. In: Weinstein, M.P., editor. Larval fish and shellfish transport through inlets. American Fisheries Society Symposium 3. Bethesda, MD: American Fisheries Society. p. 132-148.

Bowen, B.W. and J.C. Avise. 1990. Genetic structure of Atlantic and Gulf of Mexico populations of sea bass, menhaden, and sturgeon: influence of zoogeographic factors and life-history patterns. Mar. Biol. 107: 371-381.

Byron, C.J. and J.S. Link 2010. Stability in the feeding ecology of four demersal fish predators in the US northeast shelf large marine ecosystem. Mar. Ecol. Progr. Ser. 406:239-250.

Chesapeake Bay Program. 1996. Chesapeake Bay and Atlantic coast black sea bass fishery management plan. U.S. Environ. Prot. Agency Rep. 903-R-96-009 (CBP/TRS 151a/96). 57 p.

Drohan, A.F., J.P. Manderson, and D.B. Packer 2007. Essential Fish Habitat Source Document: Black sea bass, *Centropristis striata*, life history and habitat characteristics, 2nd edition. NOAA Tech. Memo. NMFS-NE-200, 68 pp.

Eklund, A.-M. and T.E. Targett. 1991. Seasonality of fish catch rates and species composition from the hard bottom trap fishery in the Middle Atlantic Bight (US east coast). Fish. Res. 12: 1-22.

Fabrizio, M.C., J.P. Manderson, and J.P. Pessutti 2013a. Habitat associations and dispersal of black sea bass from a mid-Atlantic Bight reef. Mar. Ecol. Progr. Ser. 482:241-253.

Fabrizio, M.C., J.P. Manderson, and J.P. Pessutti 2013b. Home range and seasonal movements of black sea bass (*Centropristis striata*) during their inshore residency at a reef in the mid-Atlantic Bight. Fish. Bull. 112:82-97.

Fahay, M.P. 1983. Guide to the early stages of marine fishes occurring in the western North Atlantic Ocean, Cape Hatteras to the southern Scotian Shelf. J. Northwest Atl. Fish. Sci. 4: 1-423.

Geer, P.J. 2002. Summary of essential fish habitat description and identification for Federally managed species inhabiting Virginia waters of Chesapeake Bay 1988-1999. Virginia Mar. Res. Rep. VMRR 2001-03, Jan. 2001, Revised June 2002. 169 p.

Hales, L.S., Jr. and K.W. Able. 1995. Effects of oxygen concentration on somatic and otolith growth rates of juvenile black sea bass, *Centropristis striata*. In: Secor, D.H., Dean, J.M., Campana, S.E., editors. Recent developments in fish otolith research. Univ. South Carolina Press. p. 135-153.

Kendall, A.W., Jr. 1972. Description of black sea bass, *Centropristis striata*, (Linnaeus), larvae and their occurrence north of Cape Lookout, North Carolina. Fish. Bull. (U.S.) 70: 1243-1259.

Kendall, A.W., Jr. 1977. Biological and fisheries data on black sea bass, *Centropristis striata* (Linnaeus). U.S. Natl. Mar. Fish. Serv., Northeast Fish. Cent. Sandy Hook Lab. Tech. Ser. Rep No. 7. 29 p.

Kimmel, J.J. 1973. Food and feeding of fishes from Magothy Bay, Virginia. M.S. thesis, Old Dominion Univ., Williamsburg, VA. 190 p.

Klein-MacPhee, G. 2002. Black sea bass/*Centropristis striata* (Linnaeus 1758). In: Collette, B.B., Klein-MacPhee, G., editors. Bigelow and Schroeder's fishes of the Gulf of Maine. 3rd Edition. Washington, DC: Smithsonian Institution Press. p. 392-395.

Kolek, D. 1990. Homing of black sea bass, *Centropristis striata*, in Nantucket Sound with comments on seasonal distribution, growth rates, and fisheries of the species. Massachusetts Div. Mar. Fish. Pocassett, MA. 12 p.

[MAFMC] Mid-Atlantic Fishery Management Council. 1996. Amendment 9 to the summer flounder Fishery Management Plan: Fishery Management Plan and draft environmental impact statement for the black sea bass fishery. June 1996. MAFMC. Dover, DE. 152 p. + appendices.

[MAFMC] Mid-Atlantic Fishery Management Council. 1999. Amendment 12 to the summer flounder Fishery Management Plan: Fishery Management Plan and draft environmental impact statement for the black sea bass fishery.

McGovern J.C., M.R. Collins, O. Pashuk, and H.S. Meister. 2002. Temporal and spatial differences in life history parameters of black sea bass in the southeastern United States. N. Am. J. Fish. Manage. 22: 1151-1163.

Mercer, L.P. 1978. The reproductive biology and population dynamics of black sea bass, *Centropristis striata*. Ph.D. dissertation, Coll. William and Mary, Williamsburg, VA. 195 p.

Merriman, D. and R.C. Sclar. 1952. The pelagic fish eggs and larvae of Block Island Sound. In: Riley, G.A., et al., editors. Hydrographic and biological studies of Block Island Sound. Bull. Bingham Oceanogr. Collect. 13. p. 165-219.

Miller, A.S., G.R. Shepherd, and P.S. Fratantoni 2016. Offshore habitat preference of overwintering juvenile and adult black sea bass, *Centropristis striata*, and the relationship to year-class success. PLoS ONE 11(1):e0147627.doi:10.1371/journal.pone.0147627, 19 pp.

Moser, J. and G.R. Shepherd 2009. Seasonal distribution and movement of black sea bass (*Centropristis striata*) in the Northwest Atlantic as determined from a mark-recapture experiment. J. Northw. Atl. Fish. Sci. 40:17-28.

Musick, J.A. and L.P. Mercer. 1977. Seasonal distribution of black sea bass, *Centropristis striata*, in the Mid-Atlantic Bight with comments on the ecology and fisheries of the species. Trans. Am. Fish. Soc. 106: 12-25.

[NEFSC] Northeast Fisheries Science Center. 2017. 62nd Northeast Regional Stock Assessment Workshop (62nd SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 17-03; 822 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/publications/

O'Brien, L., J. Burnett, and R.K. Mayo. 1993. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990. NOAA Tech. Rep. NMFS 113. 66 p.

Parker, R.O., Jr. 1990. Tagging studies and diver observations of fish populations on live-bottom reefs of the U.S. southeastern coast. Bull. Mar. Sci. 46: 749-760.

Reiss, C.S. and J.R. McConaugha. 1999. Cross-fronted transport and distribution of ichthyoplankton associated with Chesapeake Bay plume dynamics. Continent. Shelf Res. 19: 151-170.

Richards, S.W. 1959. Pelagic fish eggs and larvae of Long Island Sound. In: Riley, G.A., et al., editors. Oceanography of Long Island Sound. Bull. Bingham Oceanogr. Collect. 17. p. 95-124.

Richards, S.W. 1963a. The demersal fish population of Long Island Sound. II. Food of the juveniles from a sand-shell locality (Station 1). Bull. Bingham Oceanogr. Collect. 18: 32-72.

Richards, S.W. 1963b. The demersal fish population of Long Island Sound. III. Food of the juveniles from a mud locality (Station 3A). Bull. Bingham Oceanogr. Collect. 18: 73-93.

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219: 731 p.

Steimle, F.W. and W. Figley. 1996. The importance of artificial reef epifauna to black sea bass diets in the Middle Atlantic Bight. N. Am. J. Fish. Manage. 16:433-439.

Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jury, M.E. Monaco, and L. Andreasen. 1994. Distribution and abundance of fishes and invertebrates in Mid-Atlantic estuaries. ELMR Rep. No. 12. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 280 p.

Wang, J.C.S. and R.J. Kernehan. 1979. Fishes of Delaware estuaries: a guide to the early life histories. Towson, MD: EA Communications, Ecological Analysts, Inc. 410 p.

Wheatland, S.B. 1956. Pelagic fish eggs and larvae. In: Riley, G.A., et al., editors. Oceanography of Long Island Sound, 1952-1954. Bull. Bingham Oceanogr. Collect. 15. p. 234-314.

Wilk, S.J., and B. E. Brown. 1980. A description of those fisheries, which take place in the western North Atlantic between the US-Canadian border and North Carolina, that presently have or potentially could have user group allocation conflicts. In: Grover, J. H., editor. Proceedings of the technical consultation on allocation of fishery resources, Vichy, France, April, 1980. Rome: FAO. p. 502–518.