Winter Flounder − *Pseudopleuronectes americanus*

Overall Vulnerability Rank = Very High

Biological Sensitivity = High
Climate Exposure = Very High
Data Quality = 92% of scores ≥ 2

| *Pseudopleuronectes americanus* | | Expert Scores | Data Quality | Expert Scores Plots (Portion by Category) |
|---|---|---|---|---|
| Sensitivity attributes | Stock Status | 3.4 | 3.0 | |
| | Other Stressors | 2.4 | 2.6 | |
| | Population Growth Rate | 2.2 | 2.7 | |
| | Spawning Cycle | 2.6 | 2.7 | |
| | Complexity in Reproduction | 2.4 | 2.8 | |
| | Early Life History Requirements | 3.2 | 2.9 | |
| | Sensitivity to Ocean Acidification | 1.4 | 2.4 | |
| | Prey Specialization | 1.3 | 3.0 | |
| | Habitat Specialization | 1.8 | 3.0 | |
| | Sensitivity to Temperature | 2.1 | 3.0 | |
| | Adult Mobility | 1.9 | 2.9 | |
| | Dispersal & Early Life History | 2.7 | 2.8 | |
| | Sensitivity Score | High | | |
| Exposure variables | Sea Surface Temperature | 4.0 | 3.0 | |
| | Variability in Sea Surface Temperature | 1.0 | 3.0 | |
| | Salinity | 1.4 | 3.0 | |
| | Variability Salinity | 1.2 | 3.0 | |
| | Air Temperature | 4.0 | 3.0 | |
| | Variability Air Temperature | 1.0 | 3.0 | |
| | Precipitation | 1.2 | 3.0 | |
| | Variability in Precipitation | 1.3 | 3.0 | |
| | Ocean Acidification | 4.0 | 2.0 | |
| | Variability in Ocean Acidification | 1.0 | 2.2 | |
| | Currents | 2.0 | 1.0 | |
| | Sea Level Rise | 2.2 | 1.5 | |
| | Exposure Score | Very High | | |
| Overall Vulnerability Rank | | Very High | | |

Low
Moderate
High
Very High

**Winter Flounder (*Pseudopleuronectes americanus*)**

Overall Climate Vulnerability Rank: **Very High** (64% certainty from bootstrap analysis).

Climate Exposure: **Very High**. Three exposure factors contributed to this score: Ocean Surface Temperature (4.0), Ocean Acidification (4.0) and Air Temperature (4.0). Exposure to all three factors occur during the life cycle. Two of three stocks of Winter Flounder have both obligate estuarine-dependent stocks that spawn in estuaries and a stock that spawns on the shelf. Winter flounder make seasonal onshore (winter) and offshore (summer) migrations.

Biological Sensitivity: **High**. Two sensitivity attribute scored above 3.0: Stock Status (3.4) and Early Life History Requirements (3.2). The Southern New England stock of Winter Flounder is overfished and has been so for more than a decade. Spawning occurs in the late-winter / early spring in estuaries or on Georges Bank. Eggs are benthic and larvae are planktonic.

Distributional Vulnerability Rank: **High** (74% certainty from bootstrap analysis). Two attributes indicated vulnerability to distribution shift. Adult Winter Flounder make seasonal inshore-offshore migrations and a variety of habitats are used including estuarine, coastal, and shelf.

Directional Effect in the Northeast U.S. Shelf: The effect of climate change on Winter Flounder on the Northeast U.S. Shelf is very likely to be negative (>95% certainty in expert scores). Productivity of the Southern New England stock is decreasing and this has been linked to temperature, which is expected to continue to increase in the future. The climate effect on the Georges Bank stock is more uncertain. The effect of ocean acidification over the next 30 years is likely to be minimal.

Data Quality: 92% of the data quality scores were 2 or greater.

Climate Effects on Abundance and Distribution: There is strong evidence for climate effects on Winter Flounder productivity in the southern part of its range. A number of studies have indicated that various vital rates and ecological processes are temperature dependent (see Bell 2009). Manderson (2008) hypothesized that increasing temperatures caused recruitment synchrony across multiple spawning units of winter flounder in the Mid-Atlantic region with increasing temperatures decreasing recruitment. Bell et al. (2014a) modeled the stock recruitment relationship and concluded that population productivity has been decreasing and this decrease was linked to increasing temperature. Despite climate effects on productivity, climate effects on distribution have not been identified. Bell et al (2014b) found that the distribution of the southern stock of Winter Flounder has changed little over the past decades while other species have shifted north. Spawning site fidelity is one possible explanation that keeps Winter Flounder form shifting distribution.

Life History Synopsis**:** Winter Flounder is a benthic, marine flatfish species that ranges from Labrador to Georgia (Pereira et al., 1999). Winter Flounder reach maturity after 2-5 years (NEFSC, 2011), however, females may not spawn annually, complicating age at maturity calculations (Pereira et al., 1999). Most spawning occurs in cold, shallow, estuarine waters over sand, muddy-sand, mud, and gravel substrate (Pereira et al., 1999; Klein-MacPhee, 2002), but the Georges Bank population spawns offshore and there may be limited offshore spawning in other areas (Able and Fahay, 2010). Spawning season varies latitudinally and is effected by temperature, but in general, Winter Flounder move inshore and into estuaries in fall and early winter and spawn in late winter and spring (Pereira et al., 1999; Able and Fahay, 2010). Eggs are demersal and adhesive, forming clumps (Pereira et al., 1999). Hatching occurs

after 2-3 weeks, but the incubation period is temperature dependent (Pereira et al., 1999). Larvae are briefly planktonic, but gain the ability to swim and sink vertically through the water column early and are mostly bottom oriented by metamorphosis (Pereira et al., 1999; Klein-MacPhee, 2002; Able and Fahay, 2010). Larvae are zooplanktivorous, primarily consuming invertebrate eggs and nauplii during the pelagic phase and polychaetes and copepods when larger (Pereira et al., 1999). Sarsia medusae and Atlantic Mackerel are likely predators of larval Winter Flounder (Periera et al., 1999). Metamorphosis begins after 5-6 weeks and settlement occurs approximately 8 weeks after hatch (Pereira et al., 1999). Juveniles occur in shallow waters with mud or vegetated substrates, and probably aggregate where food is abundant (Klein-MacPhee, 2002). Early juveniles primarily consume polychaetes and amphipods, but the diversity of prey increases with growth (Pereira et al., 1999). Young Bluefish, gulls, cormorants, Summer Flounder, sea robins, and Windowpane Flounder prey on juvenile Winter Flounder (Pereira et al., 1999). Emigration from estuaries to the ocean occurs in late fall or early winter of the following year (Able and Fahay, 2010). Except for the Georges Bank population, which does not migrate, adult Winter Flounder migrate back to deeper, cooler waters in summer after spawning (Pereira et al., 1999). Rising bottom water temperature and food availability drive the migration pattern (Pereira et al., 1999; Klein-MacPhee, 2002). Adult Winter Flounder are opportunistic, visual predators that eat mostly annelids, amphipods, capelin eggs, bivalves, and small fish (Pereira et al., 1999). A variety of benthic predators prey on adult Winter Flounder, including: humans, Striped Bass, Bluefish, Oyster Toadfish, cormorants, Blue Herons, seals, and Ospreys (Pereira et al., 1999). Winter Flounder are managed as three stocks: Gulf of Maine, southern New England and mid-Atlantic, and Georges Bank (Pereira et al., 1999). The Atlantic States Marine Fisheries Commission (Fishery management plan for inshore stocks of Winter Flounder) and the New England Fishery Management Council (Northeast Multispecies Fishery Management Plan) jointly manage the southern New England-mid-Atlantic and Gulf of Maine stocks. Based on the 2010 assessment, the southern New England-mid-Atlantic stock was overfished, but overfishing was not occurring; the Gulf of Maine stock was not undergoing overfishing, but the overfished status was undetermined (NEFSC, 2011). The New England Fisheries Management Council manages the Georges Bank stock, which was neither overfished nor was overfishing occurring based on the 2010 assessment (NEFSC, 2011).

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