A: MONKFISH (GOOSEFISH) ASSESSMENT SUMMARY FOR 2010

State of Stock

The new 2010 assessment has updated the biological reference points based on an updated yield-per-recruit analysis and the results of the SCALE length-tuned population model that incorporates multiple survey indices and catch data. Based on accepted reference points from these updated analyses, monkfish in both the northern and southern management areas are not overfished and overfishing is not occurring (Figures A1 and A2).

The existing overfishing threshold is based on Fmax, and this was retained in the 2010 assessment. The updated estimates of Fmax are 0.43 per year in the northern area and 0.46 per year in the southern area. Estimates of current F (2009) are 0.10 per year in the northern area and 0.07 per year in the southern area, both less than the respective overfishing thresholds.

The new recommended estimates of Btarget are 52,930 mt in the northern area and 74,490 mt in the southern area, and estimates of Bthreshold are 26,465 mt in the northern area and 37,245 mt in the southern area. The current (2009) estimates of total biomass are 66,062 mt in the northern area and 131,218 mt in the southern area. The total catch produced from the long-term Btarget at the respective values of Fmax (i.e., proxy for Fmsy), is 10,745 mt for the northern area and 15,279 mt for the southern area. These updated biomass reference points are based upon a new methodology.

If the previous assessment reference points had been used, both resources would have been declared not overfished and overfishing not occurring (Figure A1).

This represents our current best scientific understanding of the monkfish stock status; however, the SARC-50 panel expressed serious concerns regarding the high levels of uncertainty throughout this assessment. The assessment results continue to be uncertain due to cumulative effects of under-reported landings, unknown discards during the 1980s, uncertainty in survey indices, and incomplete understanding of key biological parameters such as age and growth, longevity, natural mortality and stock structure contributing to retrospective patterns primarily in the northern management area [see Special Comments].

Projections

Uncertainty in the current state for the northern management area makes it difficult to predict stock dynamics in that area. Keeping this in mind, SCALE model results and AGEPRO projections were used to evaluate stock trends during 2011-2016. Projections were done using Fthreshold and NEFMC-proposed Annual Catch Targets (ACTs) and Acceptable Biological Catches (ABCs). Stochastic long-term recruitment was assumed. Projections also assumed that F in 2010 would equal the estimated F in 2009 from the SCALE model.

Projections for the northern management area (NMA) are more likely to be unrealistic than for the southern area, given the relatively strong retrospective pattern in the model observed since 2002. The projections indicate that the northern area is more likely than the southern area to experience overfishing during 2011-2016 if total catches approach the proposed ABC.

Projection Tables

Northern Management Area Projection Table

Annual P relative to BRP **Catch and Biomass in Metric tons**

Basis for Projection = Proposed ACT

Year	F	Total Catch	Total Biomass	P < 0.5*Bmax	P > Fmax
2010	0.10	4,447	74,102	0%	0%
2011	0.22	10,750	81,907	0%	0%
2012	0.22	10,750	81,204	0%	0%
2013	0.22	10,750	80,225	0%	0%
2014	0.23	10,750	78,944	0%	0%
2015	0.24	10,750	77,548	0%	0%
2016	0.24	10,750	76,383	0%	0%

Basis for Projection = Proposed ABC

Year	F	Total Catch	Total Biomass	P < 0.5*Bmax	P > Fmax
2010	0.10	4,447	74,102	0%	0%
2011	0.38	17,485	81,907	0%	4%
2012	0.44	17,485	73,769	0%	52%
2013	0.54	17,485	64,796	0%	94%
2014	0.71	17,485	55,815	0%	99%
2015	1.01	17,485	46,871	0%	100%
2016	1.69	17,485	37,631	12%	100%

Basis for Projection = Fthreshold **n/a = not applicable**

Year	F	Total Catch	Total Biomass	P < 0.5*Bmax	P > Fmax
2010	0.10	4,447	74,102	0%	0%
2011	0.43	19,557	81,907	0%	n/a
2012	0.43	16,553	70,831	0%	n/a
2013	0.43	14,120	62,846	0%	n/a
2014	0.43	12,402	57,627	0%	n/a
2015	0.43	11,384	54,619	0%	n/a
2016	0.43	10,883	53,298	0%	n/a

Southern Management Area Projection Table

Annual P relative to BRP **Catch and Biomass in Metric tons**

Basis for Projection = Proposed ACT

Year	F	Total Catch	Total Biomass	P < 0.5*Bmax	P > Fmax
2010	0.07	6,235	131,344	0%	0%
2011	0.13	11,469	132,243	0%	0%
2012	0.14	11,469	126,295	0%	0%
2013	0.15	11,469	121,055	0%	0%
2014	0.16	11,469	116,674	0%	0%
2015	0.17	11,469	113,979	0%	0%
2016	0.17	11,469	113,777	0%	0%

Basis for Projection = Proposed ABC

Year	F	Total Catch	Total Biomass	P < 0.5*Bmax	P > Fmax
2010	0.07	6,235	131,344	0%	0%
2011	0.15	13,326	132,243	0%	0%
2012	0.16	13,326	124,255	0%	0%
2013	0.18	13,326	114,149	0%	0%
2014	0.20	13,326	111,160	0%	0%
2015	0.22	13,326	107,047	0%	0%
2016	0.23	13,326	105,443	0%	0%

Basis for Projection = Fthreshold **n/a = not applicable**

Year	F	Total Catch	Total Biomass	P < 0.5*Bmax	P > Fmax
2010	0.07	6,235	131,344	0%	0%
2011	0.46	36,245	132,243	0%	n/a
2012	0.46	25,171	99,182	0%	n/a
2013	0.46	18,484	80,735	0%	n/a
2014	0.46	15,033	72,167	0%	n/a
2015	0.46	13,857	69,597	0%	n/a
2016	0.46	13,878	69,949	0%	n/a

Catches

Reported total landings (live weight) increased from an average of 2,500 mt in the 1970s to 8,700 mt in the 1980s, 23,000 mt in the 1990s, 22,000 mt from 2000-2005 and 11,600 mt during 2006-2009 (Figure A5). Total landings have declined since 2003 due to management regulations including TACs during 2007-2009 of 5,000 mt in the northern region and 5,100 mt in the southern region. Landings in 2009 were 3,255 mt in the northern region and 5,302 mt in the southern region. Landings in the early part of the time series are thought to be under-reported. The accuracy of landings data has likely improved with mandatory reporting beginning in 1994.

During 1990-1999, 53% of USA monkfish landings were taken in otter trawls, 28% in scallop dredges, and 18% in gill nets (Figure A6). During 2000-2009, 50% of USA monkfish landings were taken in otter trawls, 6% in scallop dredges, 36% in gill nets, and 8% other gear. While trawl gear accounts for most of the landings in the northern area (75% during 2000-2009), gillnets now account for the majority of the landings in the southern area (54% during 2000-2009).

Estimated total discards of monkfish have ranged between 1,600 mt (1992) and 7,500 mt (2001) per year, with a long-term discard/kept ratio of 0.15 (1989-2009, northern and southern areas combined). Discard rates have been highest in the scallop dredge fisheries in the southern area, and lowest in gillnets in both areas. Discard ratios and discard levels (mt) increased in both areas after 2000, and have since declined somewhat (overall discard/kept ratio for 2000-2004 =0.20; for 2005-2009=0.17).

Catch and Status Table (weights in '000 mt): Monkfish (Goosefish)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Max[1]	Min[1]	Mean[1]
USA Commercial landings													
Northern area	10.7	13.3	14.0	15.0	13.2	10.3	6.7	4.9	4.0	3.3	15.0	3.2	7.6
Southern area	10.1	10.0	8.9	11.1	8.0	8.8	7.9	7.3	6.9	5.3	19.3	3.7	9.1
Total	20.9	23.3	22.9	26.1	21.2	19.1	14.6	12.1	11.0	8.6	28.2	7.3	16.7
USA Commercial discards													
Northern area	1.0	2.9	1.4	1.3	0.9	0.9	0.5	0.4	0.4	0.5	2.9	0.4	1.0
Southern area	1.5	4.6	3.4	3.2	2.7	2.5	1.8	1.8	1.1	0.8	4.6	0.6	2.0
Total	2.5	7.5	4.8	4.5	3.6	3.4	2.3	1.2	1.5	1.3	7.5	1.6	3.0
Foreign landings[2]	0.2	0.1	0.3	0.3	0.2	0.2	0.3	0	0	0	0.3	<0.1	0.4
Total Catch	23.6	30.9	28.0	30.9	24.9	22.7	17.2	13.3	12.5	9.9	31.0	9.9	24.1
Northern area													
Total Biomass[3]	56.0	63.2	65.5	65.5	57.1	50.6	47.9	51.4	58.2	66.1	100.4	41.2	62.0
F	0.46	0.68	0.82	1.13	0.96	0.71	0.38	0.22	0.14	0.10	1.13	0.10	0.56
Age-1 recruitment[4]	44,137	29,071	18,412	18,771	19,798	14,750	25,032	18,373	17,459	16,147	44,137	14,750	22,195
Southern area													
Total Biomass[3]	102.2	108.5	111.9	117.1	119.2	123.0	125.7	129.2	131.1	131.2	146.7	99.2	121.3
F	0.17	0.21	0.20	0.22	0.16	0.16	0.13	0.12	0.10	0.07	0.22	0.07	0.15
Age-1 recruitment[4]	33,286	16,235	32,177	41,825	24,292	16,460	14,451	13,113	17,880	18,988	41,825	13,113	22,871

[1]Landings data based on 1980-2009 ('000 mt). Commercial fishery discard means from 1989-2009.

[2] Foreign landings are for NAFO Areas 5 and 6.

[3] Estimates from SCALE model ('000 mt)

[4] Estimates from SCALE model (thousands of fish)

Stock Distribution and Identification

The monkfish resource in US waters is distributed from the Gulf of Maine through Cape Hatteras, NC. Current management practice divides US waters into two areas north and south of Georges Bank to accommodate differences in fishery practices. Information on growth, maturity, and genetics tends to support the hypothesis of a single biological stock. Information from recent and ongoing tagging studies is equivocal, but indicates limited movement of fish from the northern management area to the southern area. Patterns in recruitment tend to support the hypothesis of two biological stocks. In the past, fishing practices and estimated fishery selectivity also tended to support management and assessment for two areas; however, the current mix of removals by gear provides model estimates indicating very similar average fishery selectivity in the two areas.

Data and Assessment

Data used in the 2010 assessment include data from NEFSC surveys, ME/NH surveys, and cooperative monkfish surveys conducted in 2001, 2004 and 2009 (see below) as well as commercial fishery data from vessel trip reports, dealer landings records and on-board fishery observers through 2009. The assessment assumed a natural mortality rate (M) = 0.3. Fishing mortality rates and stock sizes were estimated using the SCALE statistical catch-at-length model.

A cooperative monkfish survey was conducted during February-April 2009 using two industry trawlers and 3 nets (2 flat, 1 rockhopper). The survey design differed slightly from previous cooperative surveys (in 2001, 2004) because sampling effort was allocated proportional to stratum area (with extra sampling in strata designated by industry) rather than proportional to spatial patterns of fishing effort. A total of 204 successful survey tows and 91 gear experiment tows were completed in USA waters from Cape Hatteras through the Gulf of Maine. Absolute estimates of biomass, abundance and length composition were developed using catch and area swept by each tow and net efficiency estimates from depletion experiments. Proportion at length from the cooperative surveys was used in the SCALE model; however, the estimates of absolute population biomass and abundance were not included in the final model runs due to poor model fit.

The model for the northern area exhibited retrospective patterns in fishing mortality and stock size that were strongest for the 2002-2006 terminal years and weaker for the 2007-2008 terminal years (Figure A3). The retrospective underestimation of fishing mortality averaged -66% for the 2002-2008 terminal years, ranging from -21% for the 2008 terminal year to -84% for the 2003 terminal year. The retrospective overestimation of total biomass averaged +108% for the 2002-2008 terminal years, ranging from +17% for the 2008 terminal year to +163% for the 2003 terminal year. The retrospective estimation error in recruitment at age 1 averaged +36% for the 2002-2008 terminal years, ranging from -2% for the 2008 terminal year to +89% for the 2003 terminal year.

The model for the southern area exhibited moderate retrospective patterns in fishing mortality and stock size since 2002 (Figure A4). The retrospective underestimation of fishing mortality averaged -13% for the 2002-2008 terminal years, ranging from -9% for the 2008 terminal year to -21% for the 2006 terminal year. The retrospective overestimation of total biomass averaged +16% for the 2002-2008 terminal years, ranging from +8% for the 2008 terminal year to +22% for the 2006 terminal year. The retrospective overestimation of recruitment at age 1 averaged +48% for the 2002-2008 terminal years, ranging from +12% for the 2008 terminal year to +130% for the 2006 terminal year.

Biological Reference Points

Previous monkfish biomass targets and thresholds (NEFSC 2007) were based on long-term average biomass and a low point in the biomass time series from which the stock recovered, respectively. The current assessment recommends using a different approach that is used for New England groundfish stocks based on the long-term projected biomass corresponding to Fmsy or its proxy. For monkfish this proxy is Fmax. Based on the new approach, total biomass targets (i.e., Bmax at Fmax) and thresholds (0.5*Bmax) were calculated for monkfish for the northern and southern management areas. Btarget is 52,930 mt in the northern area and 74,490 mt in the southern area, and Bthreshold is 26,465 mt in the northern area and 37,245 mt in the southern area. The total catch produced from the long-term Btarget at the respective values of

Fmax (i.e., proxy for Fmsy), is 10,745 mt for the northern management area and 15,279 mt for the southern management area.

The existing overfishing threshold is based on Fmax, and this was retained in the 2010 assessment, with updated estimates of Fmax = 0.43 per year in the northern area and Fmax = 0.46 per year in the southern area.

The following table summarizes biological reference points for monkfish from the 2007 and 2010 assessments. These were calculated using different methods as indicated in the 'Basis' column.

Management Area		**Biomass BRPs in metric tons**		
North	**BRP**	**Basis**	**NEFSC 2007**	**SAW 2010**
	Fmax	YPR	0.31	0.43
	Bthreshold	Bloss 1980-2006	65,200	
	Bthreshold	Bloss 1980-2009		41,238
	Bthreshold	0.5*Bmax Projected		26,465
	Btarget	Bavg 1980-2006	92,200	62,371
	Btarget	Bavg 1980-2009		61,991
	Btarget	Bmax Projected		52,930
	MSY	Fmax Projected		10,745
South	**BRP**	**Basis**	**NEFSC 2007**	**SAW 2010**
	Fmax	YPR	0.40	0.46
	Bthreshold	Bloss 1980-2006	96,400	
	Bthreshold	Bloss 1980-2009		99,181
	Bthreshold	0.5*Bmax Projected		37,245
	Btarget	Bavg 1980-2006	122,500	120,292
	Btarget	Bavg 1980-2009		121,313
	Btarget	Bmax Projected		74,490
	MSY	Fmax Projected		15,279

Fishing Mortality

Fishing mortality estimated for 2009 from the SCALE model (assuming M=0.3 per year) was F = 0.10 per year in the northern area, and F = 0.07 per year in the southern area (Figure A1). Fishing mortality has declined in both areas since 2003.

Recruitment

Northern area SCALE model results (Figure A3) indicate that the strongest year classes were produced in 1997-1999. Recruitment was generally below average in the 1980s, and has been about average since 2001. The time series average recruitment is about 20 million age 1 fish. Southern area results (Figure A4) indicate that the strongest year classes were produced in 1992, 1997, and 2002, with the weakest year class produced in 1987. Recruitment has been below average since 2004. The time series average recruitment is about 23 million age 1 fish.

Stock Biomass

Total stock biomass in the northern area declined steadily from the early 1980s through the early 1990s, remained at a relatively low level during the 1990s and then began to increase after 1999 (Figure A2). Biomass in the northern area has been relatively stable since 2003, and was estimated to be 66,062 mt in 2009. In the southern area, total biomass increased until the late 1980s and then declined throughout the 1990s. Biomass has increased in the southern area since 1999, and was estimated to be 131,218 mt in 2009 (Figure A2).

Ecosystem Considerations

Monkfish is potentially one of the dominant piscivores in the ecosystem. The amount of food consumed by monkfish is 0.005-0.02% of all energy flows in the ecosystem, and monkfish account for 2-6% of the total consumption by all finfish in the ecosystem (1-4 % in the northern area, 2-8% in the southern area). The amount of food eaten and per capita consumption peaked in the early 1980s for both stocks, driven by larger fish. Monkfish consumption of mackerel and herring is equivalent to 20-50% of landings, and they consume the same magnitude of squid as the landings of squid, and potentially consume more than the landings of silver hake and skates.

Special Comments

- Without knowing the reason(s) for the retrospective pattern in the model, it is not possible to know if the 2010 assessment is biased. In the north, if the 2010 assessment suffers from a retrospective bias equal to that seen on average over the past 7 years, a projection at the proposed ACT = 10,750 mt using retrospective adjusted 2009 stock sizes indicates a 65% chance that total biomass will fall below the adjusted Bthreshold by 2016. This is a very different result from the unadjusted analyses (see Projections).
- The assessment is uncertain for a number of reasons, including uncertainty due to cumulative effects of under-reported landings, unknown discards during the 1980s, uncertainty in survey indices, distribution of monkfish outside the survey areas, and incomplete understanding of key biological parameters such as age and growth, longevity, natural mortality and stock structure contributing to retrospective patterns primarily in the northern management area. The model results are sensitive to the assumed value of natural mortality (M) of 0.3 per year, adopted by NEFSC (2007). This value was adjusted in 2007 as a compromise between the observed longevity of males (~7 yr) and females (at least age 13); however, both sexes may potentially have longer lifespans. Uncertainties in key life history parameters and historical catches are unlikely to be resolved in the short term.
- The SCALE model allows integration of a wide variety of input information and facilitates estimation of uncertainty of fishery selectivity and stock sizes; these estimates can then be used in stochastic projections to provide measures of uncertainty of future trends of the monkfish populations in the management areas. However, these projections are subject to the same uncertainties that are of concern regarding the assessment model.
- The higher monkfish catch efficiency of the new NOAA vessel *Henry Bigelow* is expected to improve our ability to monitor trends in abundance.

References

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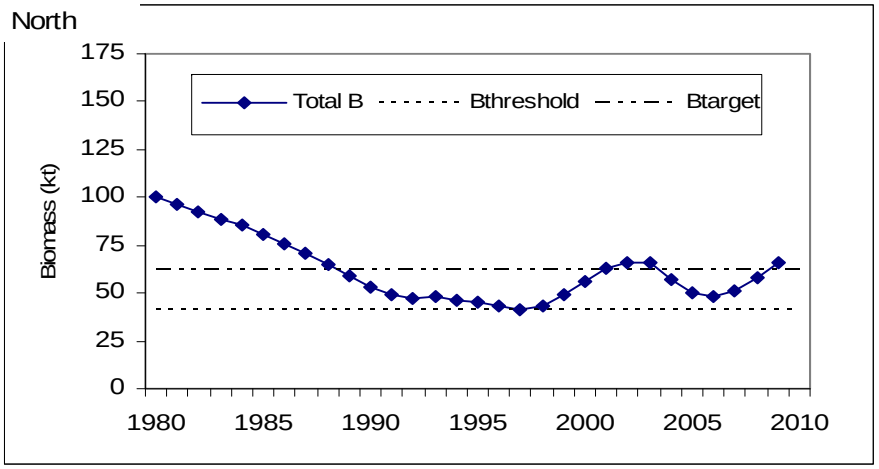
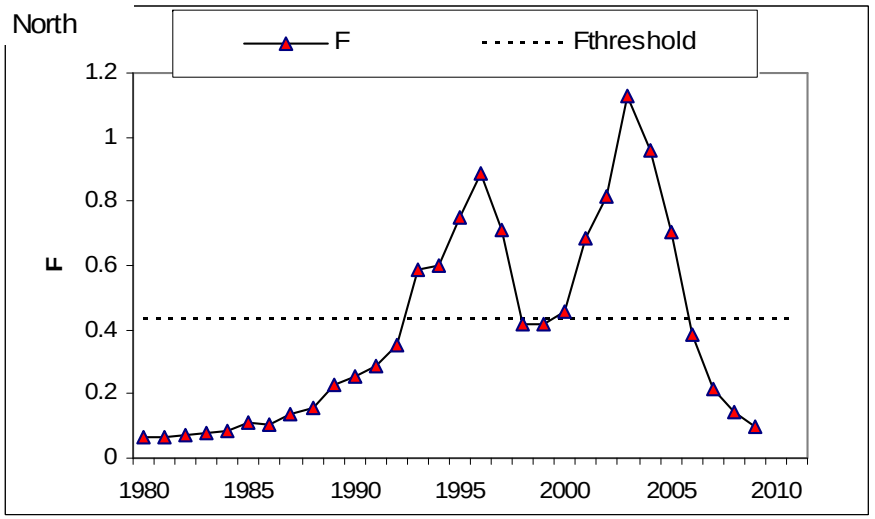
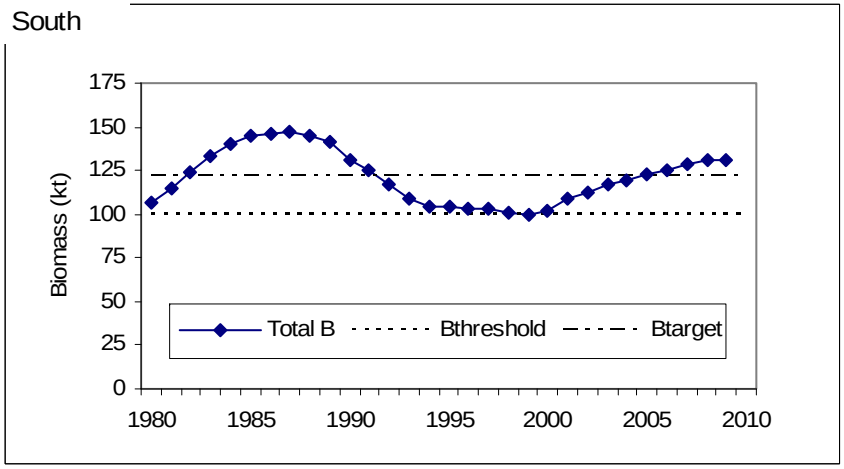
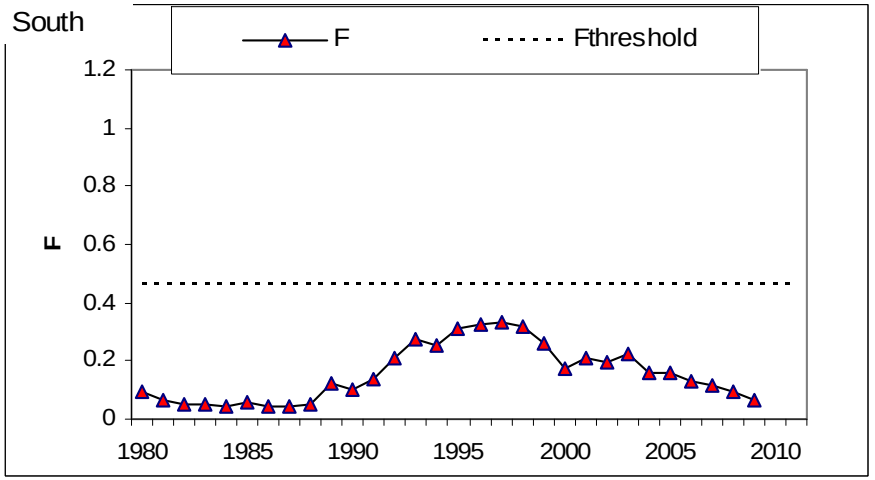
Figures:

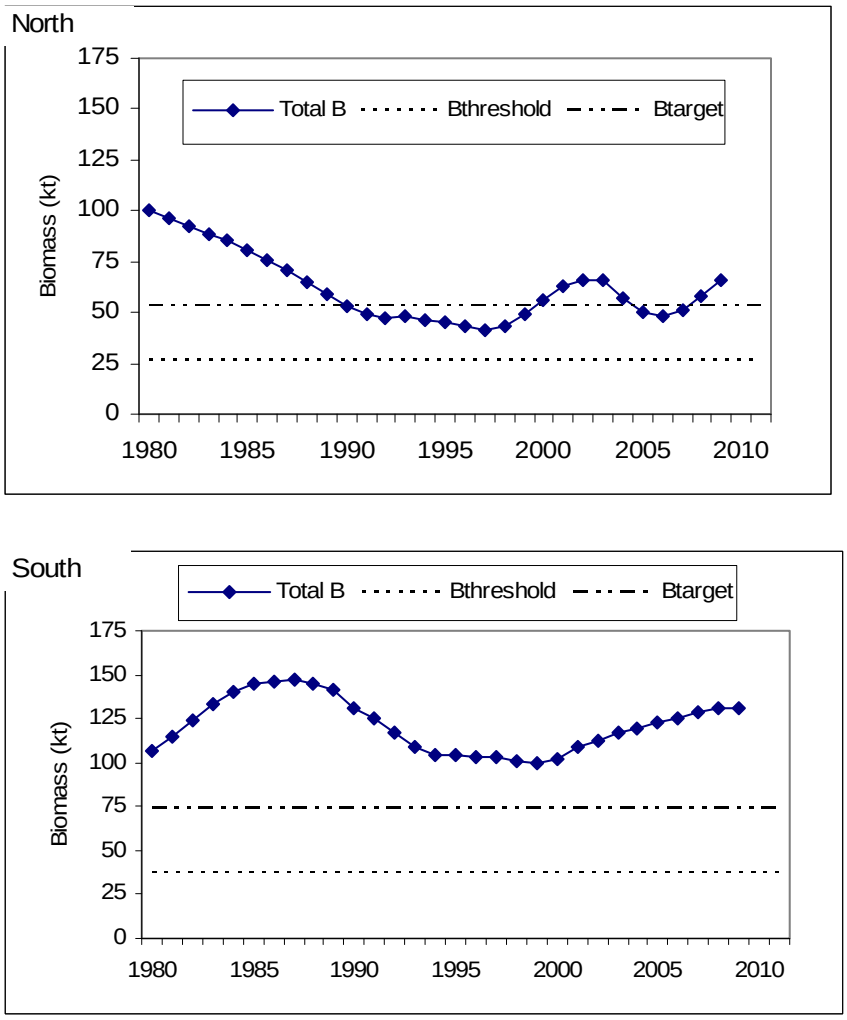




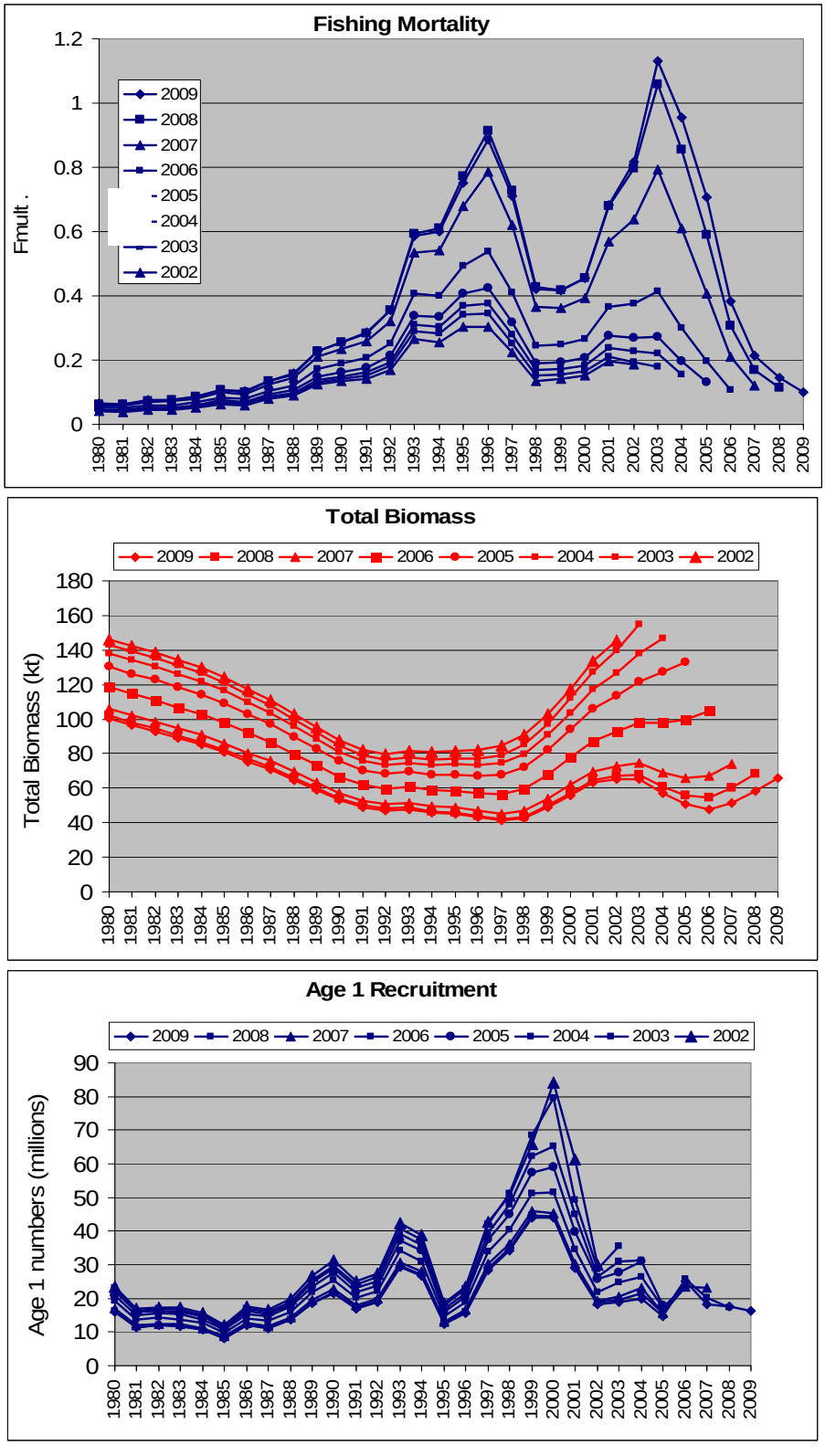




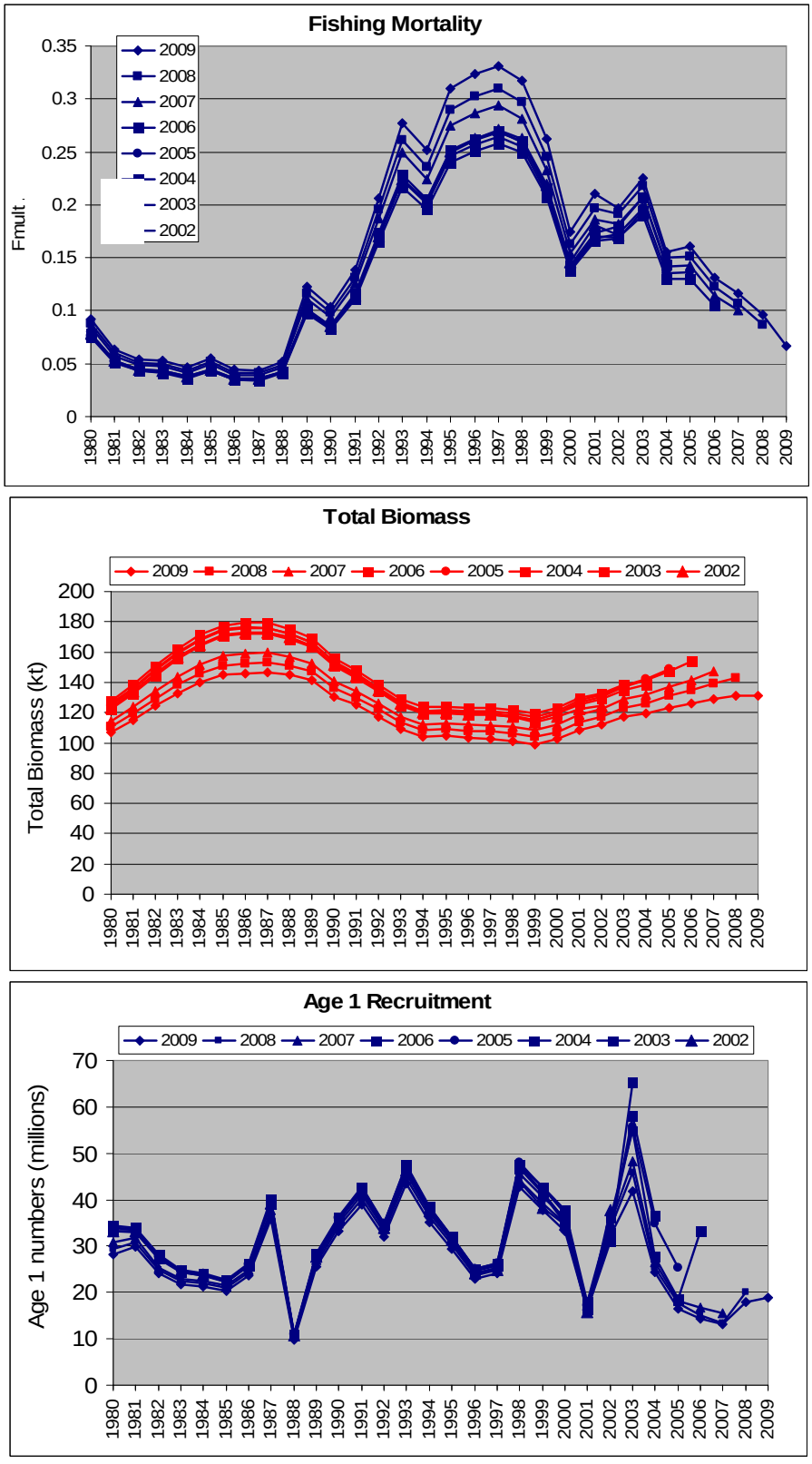
A1. Trends in total biomass and fishing mortality rate (F) from the 2010 assessment model (SCALE) relative to updated biological reference points using previous (NEFSC 2007) definitions in the monkfish fishery management plan for northern and southern areas. Panels on the right can be used to determine status with respect to overfishing.



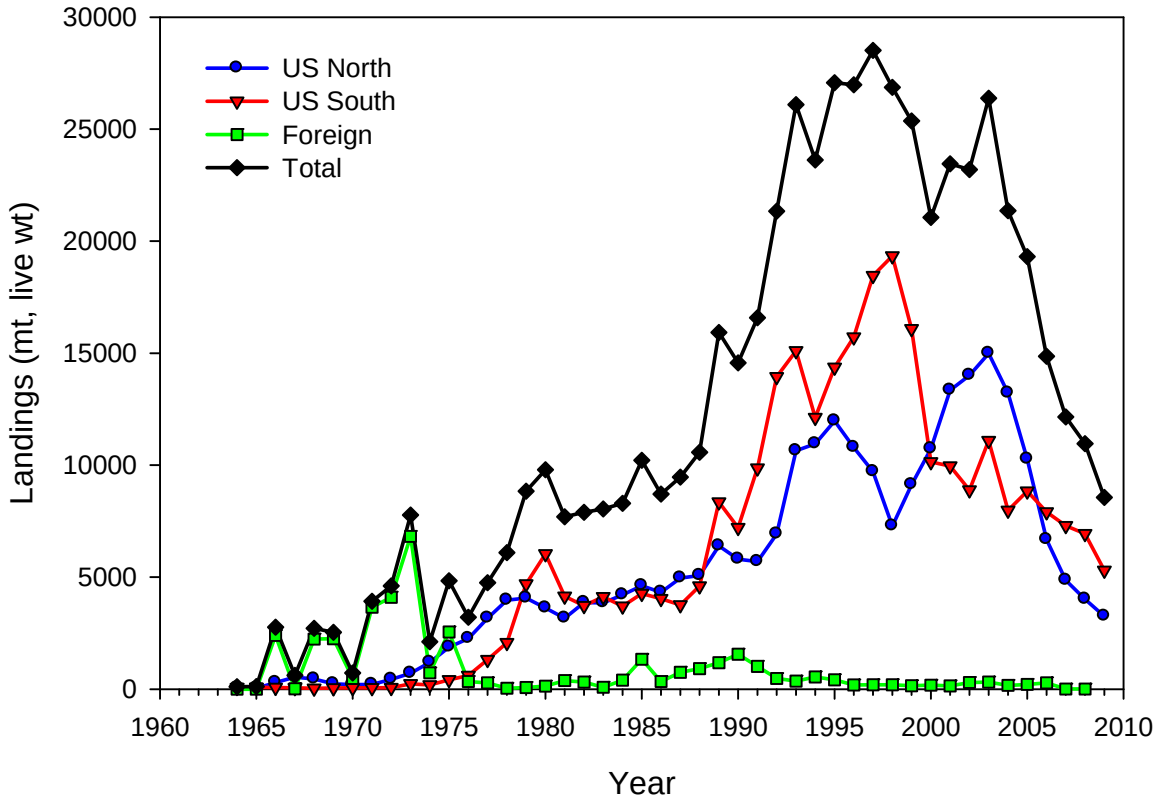
A2. Trends in total biomass from the assessment model (SCALE) relative to new recommended biomass reference points for the northern and southern management areas. This figure can be used to determine status with respect to whether stocks are overfished.



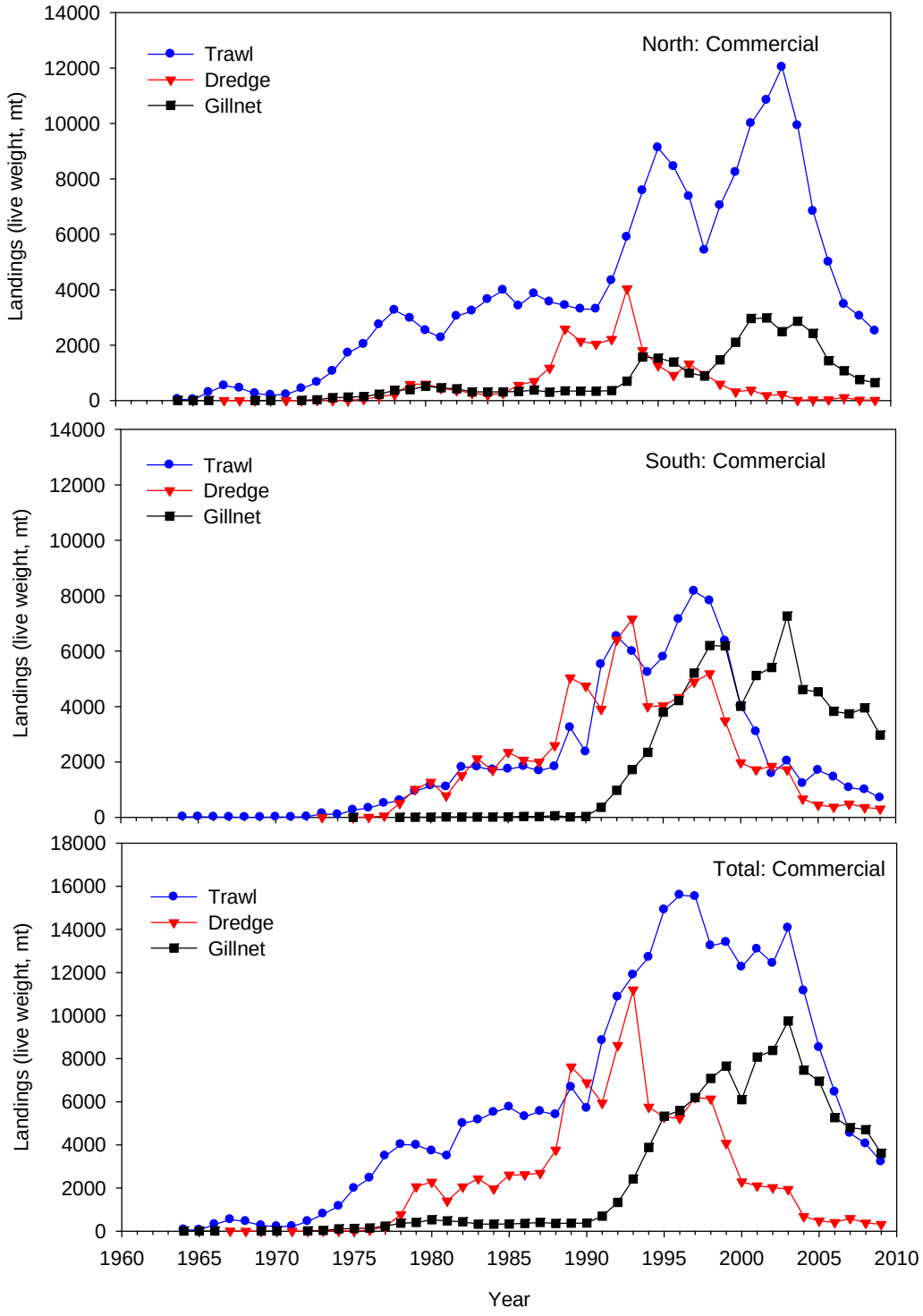
A3. Retrospective patterns in estimated monkfish fishing mortality, biomass and recruitment from the SCALE model for the **northern** management region.



A4. Retrospective patterns in estimated monkfish fishing mortality, biomass and recruitment from the SCALE model for the **southern** management region.



A5. Monkfish commercial fishery landings, by management region and total, 1964-2009.



A6. Monkfish commercial fishery landings by major gear type, northern, southern and combined management regions.