

NOAA
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LIFE HISTORIES OF HAMMERHEADS IN THE WESTERN NORTH ATLANTIC OCEAN

SEDAR 77

Objective

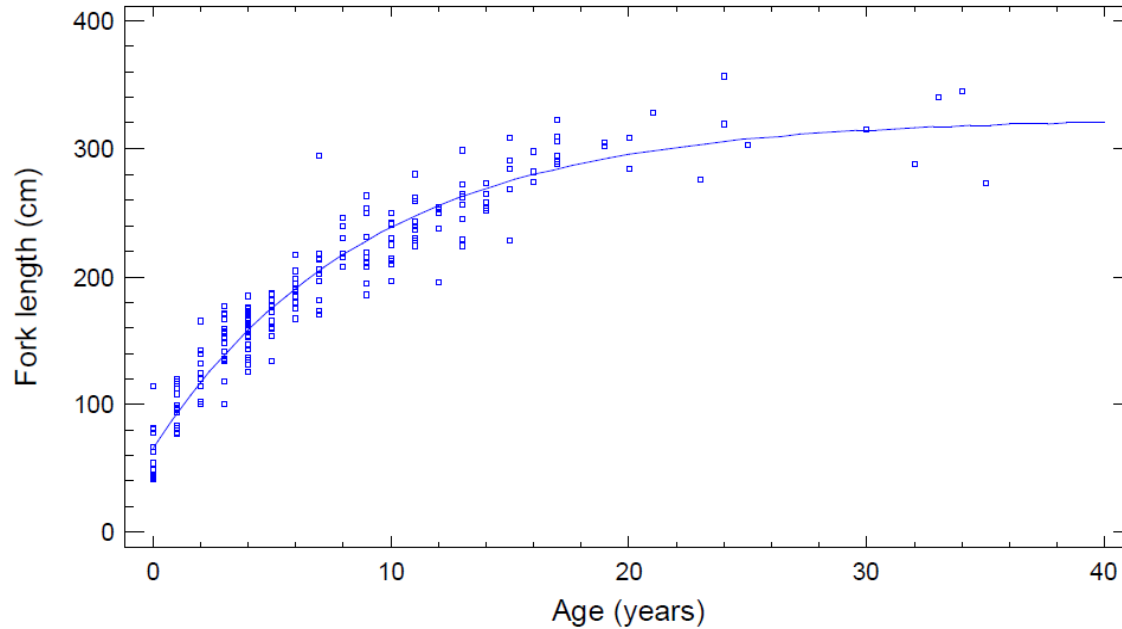
- SEDAR 77 Life History Group was tasked with gathering the most up to date and robust species-specific estimates related to:
 - Age and growth: VBGF parameter estimates, maximum observed age
 - Reproduction: size/age at maturity, reproductive cycle, brood size and sex-ratio, length of gestation, month of parturition, maternal length to brood size relationship (if any).



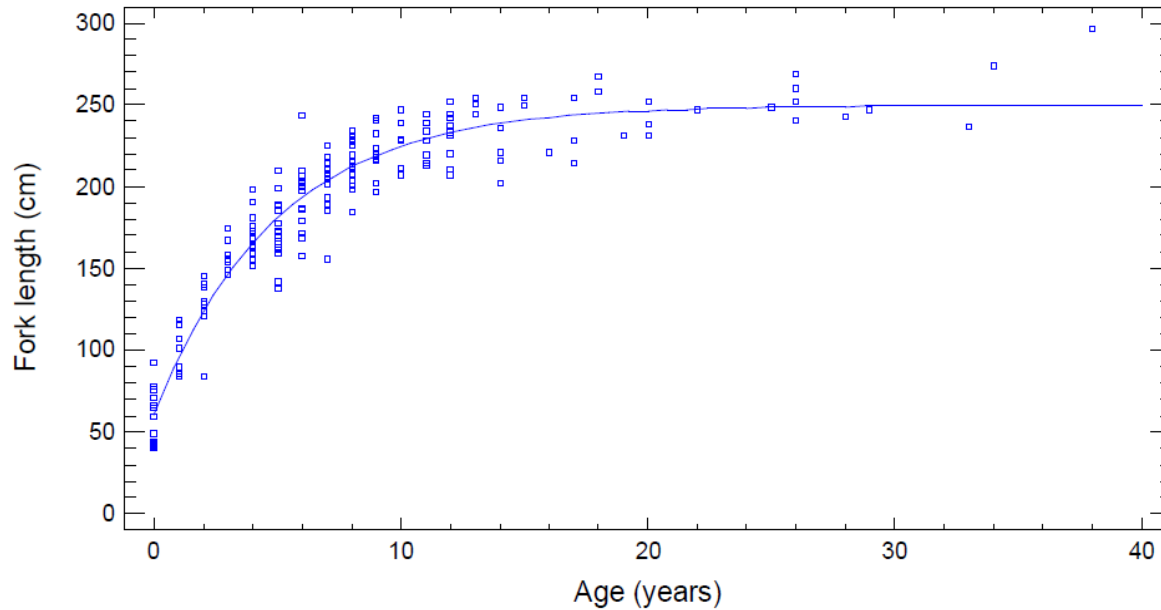
Age and growth: Great hammerhead

- Treated as single stock
- 388 vertebral samples aged (179 male, 204 female, 5 sex unknown)
- Most samples from observer program
- Based on high between-reader agreement (84% in agreement, 96% within one year, 100% within 2 years) and low IAPE(0.92%) and CV(1.30%) ages were considered accurate and reliable.
- Oldest directly aged sharks was a 38 year old male
- Based on bomb radio carbon dating of sample unavailable to us for direct ageing, the maximum age was determined to be 42 years.

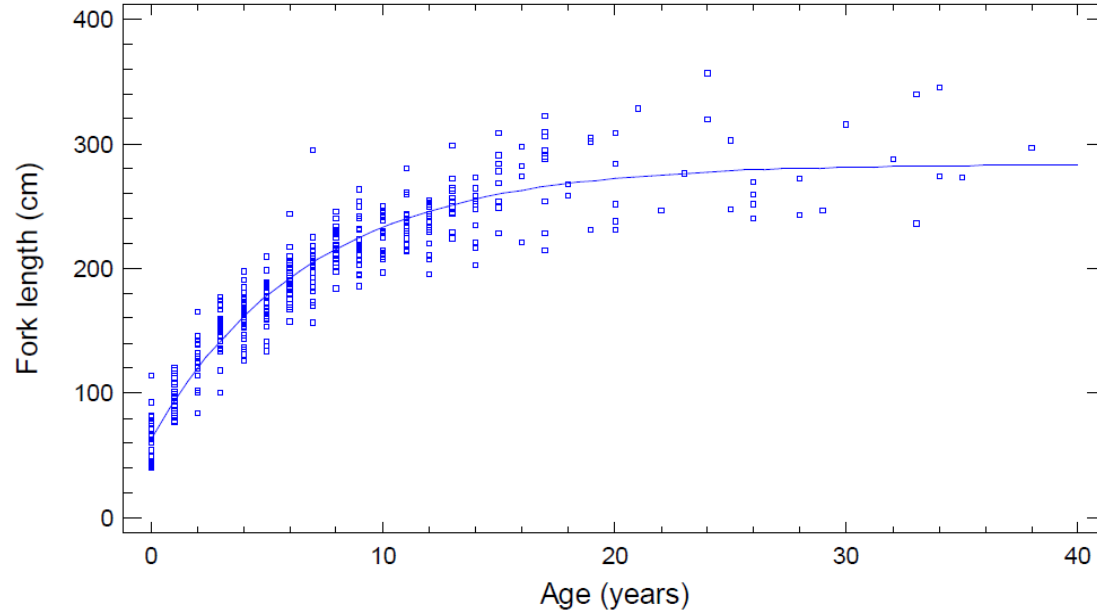
Great hammerhead (females)



Great hammerhead (males)



Great hammerhead (combined sexes)



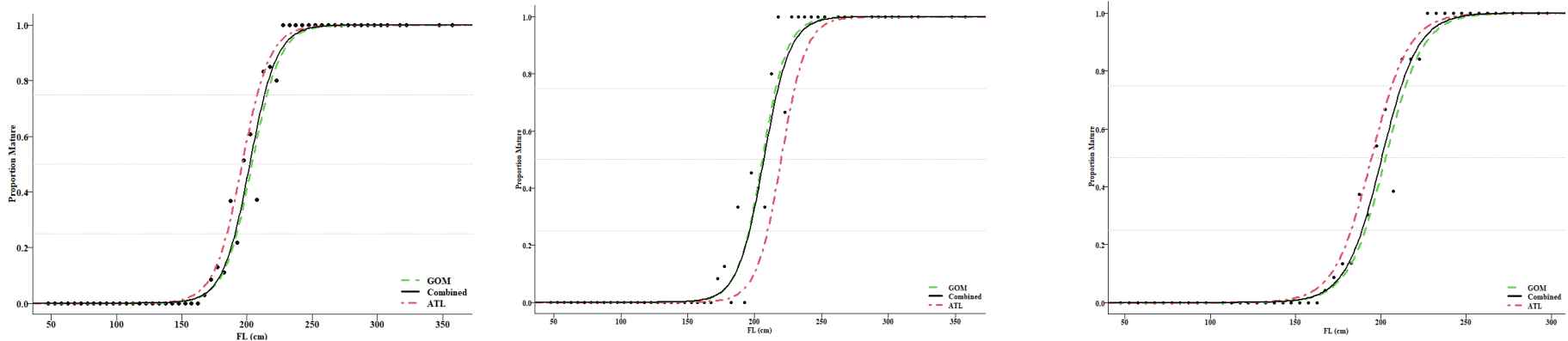
Great hammerhead VBGF summary table

Study	Sex	L_{∞} (cm)	k	t_o (year)	n
Piercy et al. 2010	Male	264.2 (5.61)	0.16 (0.01)	-1.99 (0.20)	111
	Female	307.8 (11.23)	0.11 (0.01)	-2.86 (0.44)	105
	Combined	286.9 (5.99)	0.13 (0.01)	-2.51 (0.15)	216
Current	Male	249.4 (3.36)	0.20 (0.01)	-1.37 (0.14)	179
	Female	323.9 (7.49)	0.11 (0.01)	-2.06 (0.20)	204
	Combined	283.8 (3.96)	0.15 (0.01)	-1.72 (0.14)	388

Reproduction: Great hammerhead

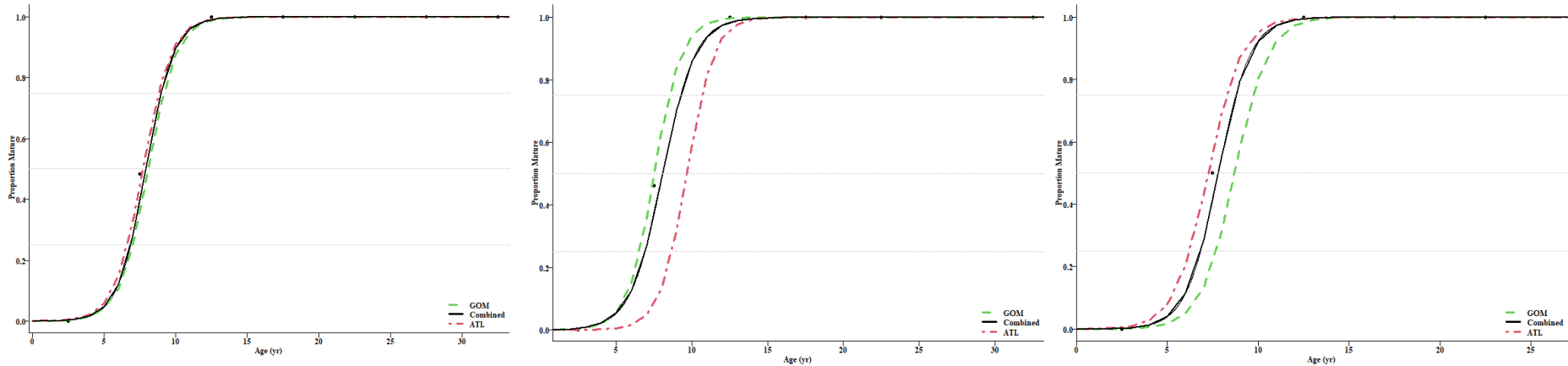
- Length and maturity data were available for 751 individuals (primarily GOM) from fishery dependent and independent sources.
- Age and maturity data were available for 86 individuals.
- The largest immature male was 225.0 cm FL, and the smallest mature male was 170.0 cm FL. Largest immature female was 222.0 cm FL and smallest mature female was 173.0 cm FL.

Length at maturity ogives: great hammerhead



Proportion mature at length for great hammerhead (*Sphyrna mokarran*) for Left) sexes combined, Middle) females, Right) males. Combined region analysis is represented by the solid black line, Gulf of Mexico (GOM) as green dashed line, and Atlantic (ATL) as red dashed line.

Age at maturity ogives: great hammerhead



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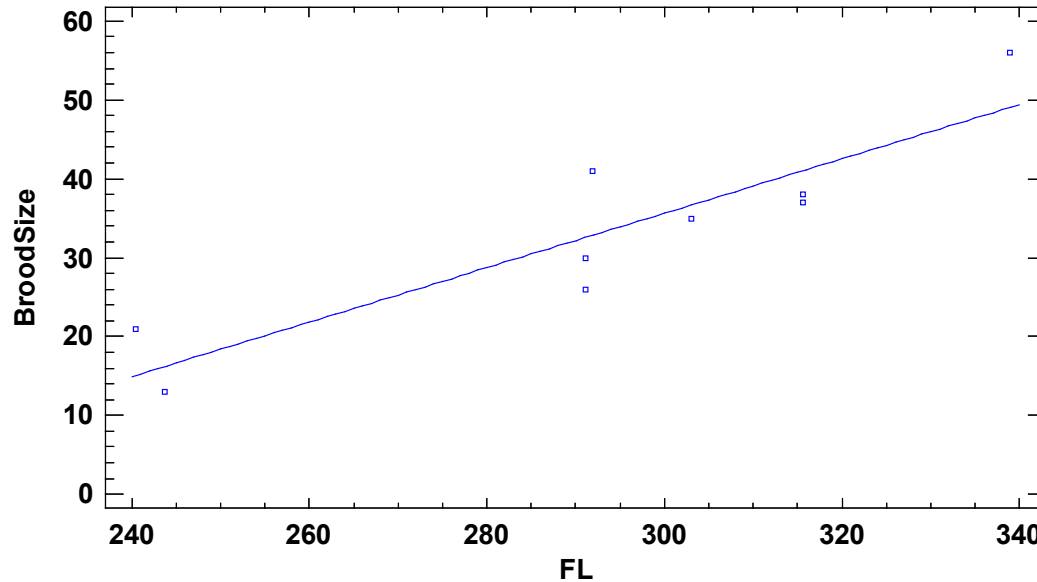
Reproduction (cont.): great hammerhead

- Limited published information so exhaustive data search conducted. All references and sources listed in Table 3 of life history section in Data Workshop Report.
- Biennial cycle based on gravid females with inactive ovaries.
- Limited published fecundity data (n=14). Available data were combined with unpublished data.
- Gestation based primarily on the development of embryos and comparisons of months associated with mating times and presence of postpartum females reported in three published documents.
- Maternal length-brood size relationship based on nine published and unpublished records.
- All other parameters (i.e. birth month, size at birth, embryo sex-ratio) similarly determined.

Reproductive characteristics: great hammerhead

- Reproductive cycle: biennial
- Fecundity: 30.93 pups/brood (13-56)
- Gestation: 10-11 months
- Pupping month: late spring/early summer
- Size at birth: 50 cm FL
- Pupping month: late spring/summer

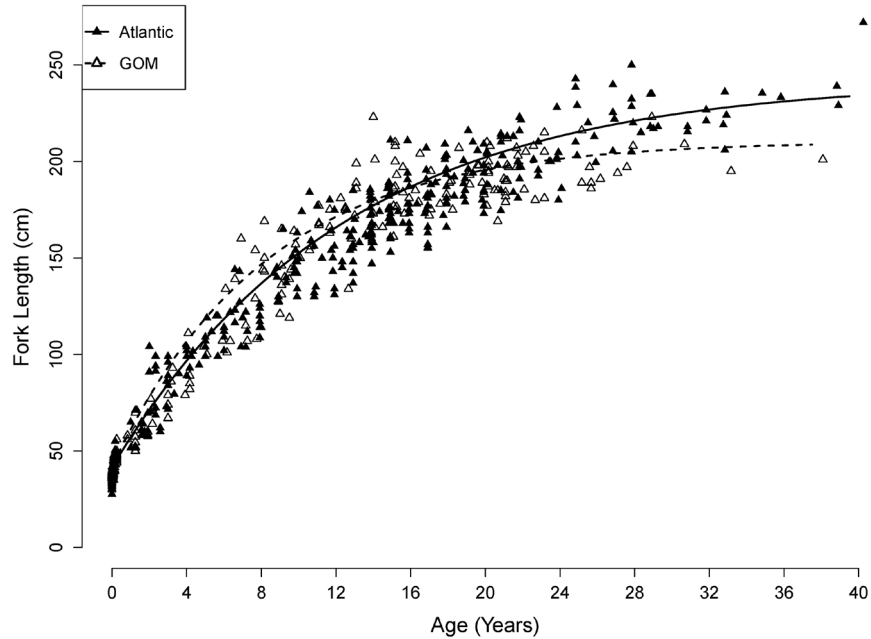
Maternal length-brood size relationship: GHH



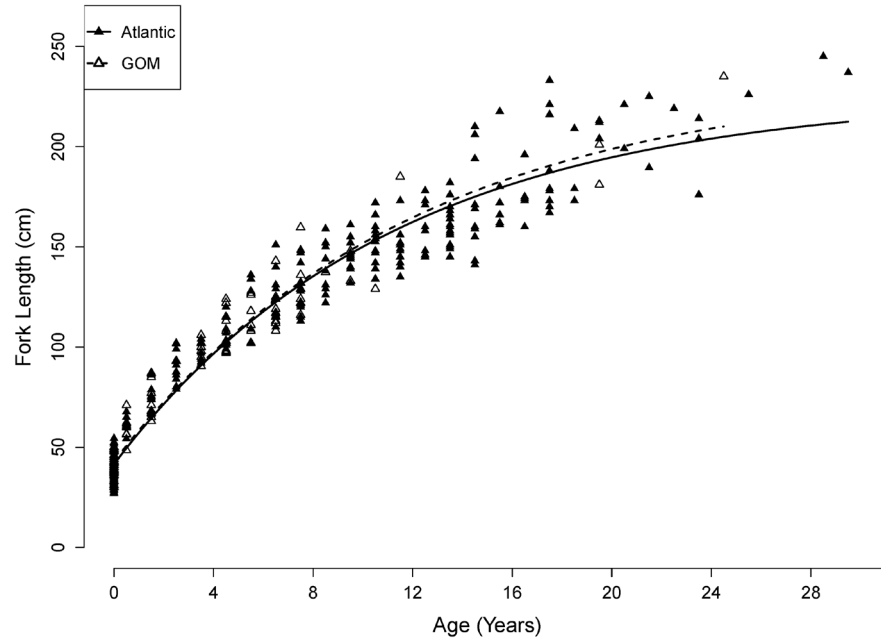
Age and growth: scalloped hammerhead

- Treated as two stocks due to presence of Carolina hammerhead off east coast.
- 1,026 scalloped hammerheads (403 females and 623 males).
- Between reader agreement 70.8% and 92.8% of age estimates within ± 1 band. Low IAPE (5.5%) and CV (7.6%).
- Oldest observed individuals in the Atlantic and Gulf were both males and 39.5 year old male and 37.5 year old male, respectively. Oldest aged female was 29.5 years.

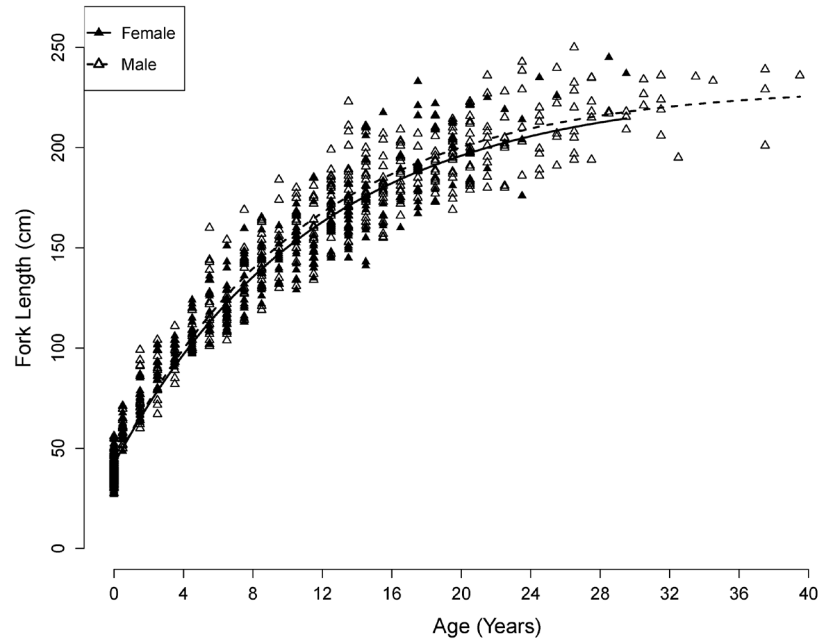
Scalloped hammerhead (males)



Scalloped hammerhead (females)



Scalloped hammerhead (combined areas)



Scalloped hammerhead VBGF summary table

Region	Sex	L_{∞} (cm FL)	k	t_0	n	MOA
Atlantic	Female	225.8 (219.6-240.8)	0.089 (0.077-0.096)	-2.290 (-2.579 · -2.143)	285	29.5
	Male	242.1 (235.5-249.8)	0.081 (0.074-0.087)	-2.33 (-2.551 · -2.129)	423	39.5
GOM	Female	234.5 (213.6-266.8)	0.084 (0.067-0.101)	-2.407 (-2.778 · -2.100)	107	24.5
	Male	210.5 (203.9-219.6)	0.122 (0.106-0.139)	-1.818 (-2.214 · -1.501)	184	37.5
Combined	Female	229.2 (219.6-240.8)	0.086 (0.077-0.096)	-2.352 (-2.579 · -2.143)	403	29.5
	Male	230.1 (225.1-236.0)	0.092 (0.086-0.099)	-2.166 (-2.356 · -1.986)	623	39.5
	Combined	232.2 (227.7-237.6)	0.088 (0.083-0.092)	-2.262 (-2.416 · -2.132)	1026	39.5
Piercy et al. 2007 [#]	Female	233.1 ± 11.5	0.09 ± 0.01	-1.62 ± 0.24	116	30.5
	Male	214.8 ± 4.2	0.13 ± 0.01	-2.22 ± 0.20	191	30.5
	Combined	219.8 ± 4.1	0.12 ± 0.01	-1.84 ± 0.15	307	30.5

[#]Standard error is reported for Piercy et al. (2007), and estimates are for the Atlantic and GOM combined.

Reproduction: Scalloped hammerhead

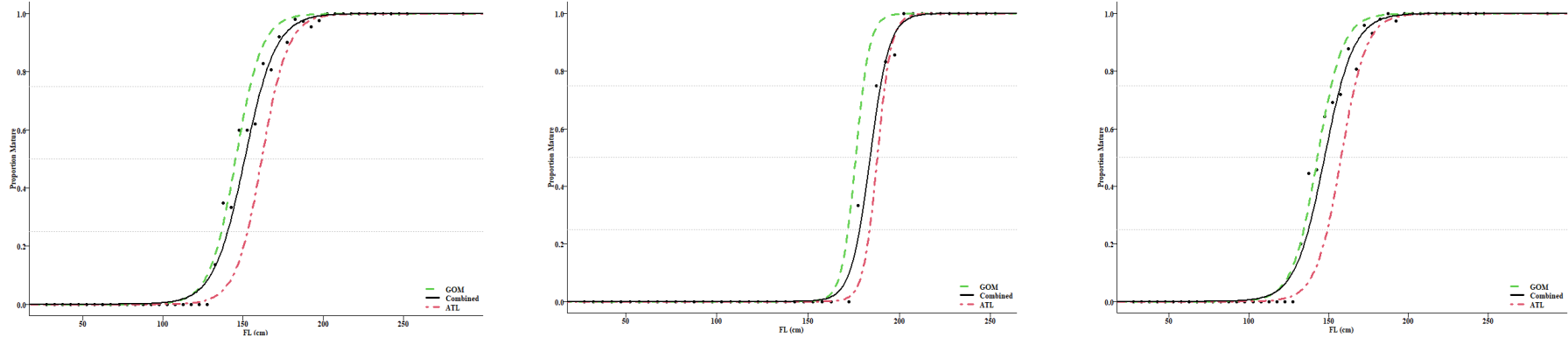
- Limited published information so exhaustive data search conducted. All references and sources listed in Table 1 of life history section in Data Workshop Report.
- Annual cycle based on gravid females with active ovaries.
- Limited published fecundity data (n=11 broods). Available data were combined with unpublished data from observers and fisheries-independent surveys.
- All other parameters (i.e. birth month, gestation period, size at birth, embryo sex-ratio, maternal length-brood size relationship) similarly determined.



Reproduction (cont.): Scalloped hammerhead

- Reproductive cycle: annual
- Fecundity: 18 pups/brood (7-30)
- Gestation: 10-12 months
- Pupping month: May-June
- Size at birth: 35.2 cm FL
- No relationship between maternal size and brood size

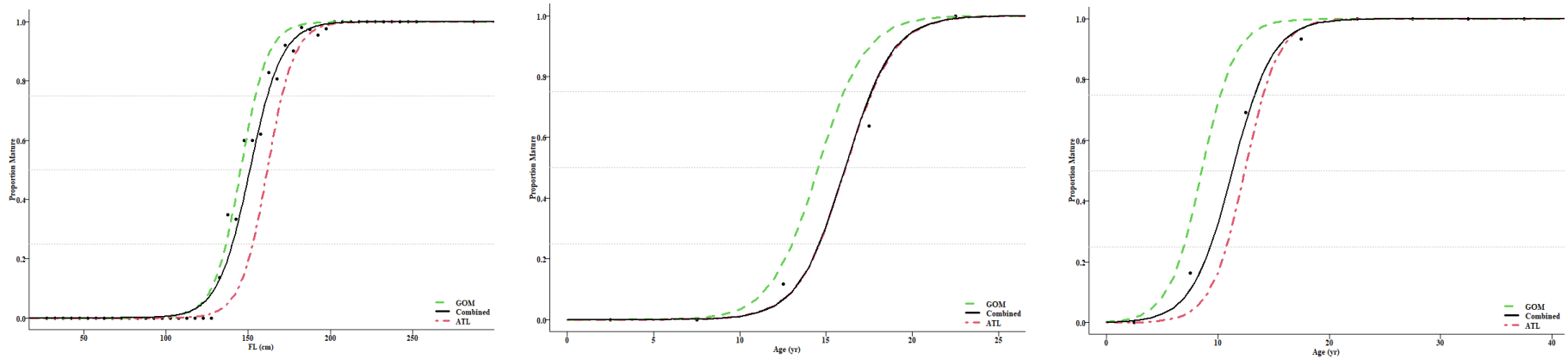
Length at maturity ogives: scalloped hammerhead



Proportion mature at length for scalloped hammerhead (*Sphyrna lewini*) for Left) sexes combined, Middle) females, Right) males. Combined region analysis is represented by the solid black line, Gulf of Mexico (GOM) as green dashed line, and Atlantic (ATL) as red dashed line.

* Atlantic region also includes Carolina hammerhead (*Sphyrna gilberti*) and hybrid individuals.

Length at maturity ogives: scalloped hammerhead

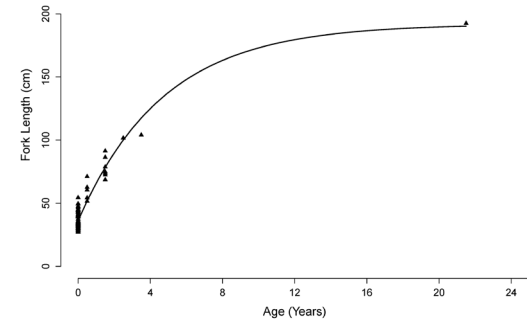


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*Atlantic region also includes Carolina hammerhead (*Sphyrna gilberti*) and hybrid individuals.

Carolina hammerhead

- Because the Carolina hammerhead was only recently described (i.e., 2013) and it is morphologically indistinguishable from the scalloped hammerhead, there has been very limited targeted sampling of the species and almost nothing is known about its basic biology.
- Based on samples from genetically verified specimens, our knowledge of the species is limited to:
- Growth: Vertebrae have been aged from juveniles and an incomplete, and thus unreliable, growth model has been generated.
- Reproductive biology: parturition occurs during June off SC and mean size at birth is 31.53 cm FL



Carolina hammerhead

- Due to extremely limited knowledge of the basic biology of the species we were able to generate or locate no additional information.
- Data from *S. gilberti* are almost certainly included within data related to *S. lewini* and cannot be untangled. In cases where genetic verification of *S. gilberti* occurred, those samples were removed from *S. lewini* dataset.

Smooth hammerhead

- No age and growth information available from US waters.
- Used growth models from Rosa et al. 2017.

Sample collection and model from Rosa et al. 2017

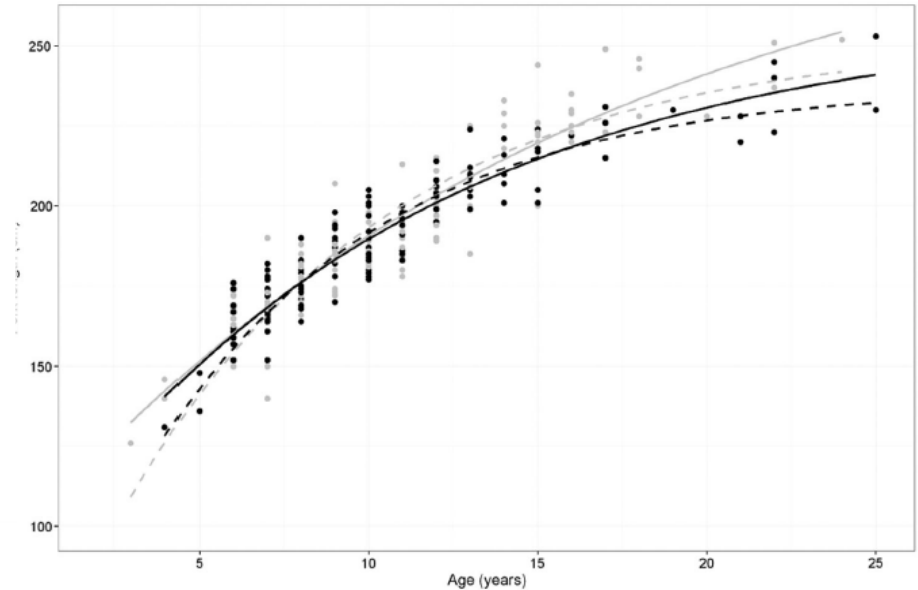
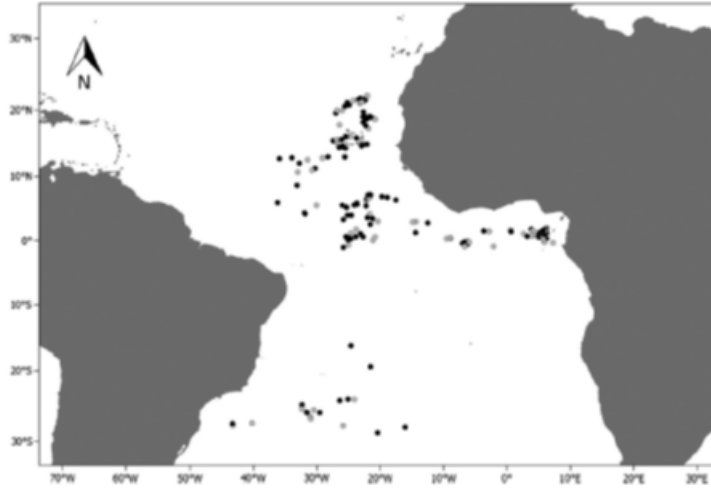


Figure 5 . The von Bertalanffy growth function (VBGF) for *Sphyrna zygaena* based on age estimations by vertebrae growth marks. Circles represent observed data and line represents VBGF. Black represents males and grey represents females.

Reproduction: Smooth hammerhead

- No data available from US waters.
- All reproductive information gathered from primary literature and from studies conducted off Central America, South America and Africa (except cycle).

Reproduction: Smooth hammerhead

- Reproductive cycle: biennial based on examination of two gravid females and absence of appendiculae on umbilical cords.
- Fecundity: 33.5 pups/brood (29-37)
- Gestation: 10-11 months
- Pupping month: summer
- Size at birth: 50.3 cm FL
- No information on maternal size and brood size relationship available.