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TECHNICAL DOCUMENTATION OF A US GULF OF MEXICO ECOPATH WITH ECOSIM MODEL

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NOTICE

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Executive summary

This technical report details the data inputs and methods applied to develop an ecosystem model for the US Gulf of Mexico (GoM). The goal of the project is to support ecosystem-based fisheries management in the GoM through integration of biological and fishery information on species of commercial, recreational, and ecological importance. Of particular importance is the ability of the model to capture trade-offs associated with trophic interactions as well as fisheries bycatch. Accounting for such tradeoffs that occur across taxa, habitats, and fishing fleets is necessary for effective and sustainable ecosystem-based management of the GoM. The model was developed in Ecopath with Ecosim with a spatial domain including all state and federal waters (through 400 meters deep) of the northern GoM continental shelf and coastline. The GoM food web model includes 78 trophic groups, including three marine mammal groups, an aggregate seabird group, an aggregate sea turtle group, eight elasmobranch groups, 52 fish groups (18 of which are sub-divided into multiple life stages), nine invertebrate groups, three primary producers, and one detritus. Twelve commercial fishing fleets are modeled (bottom trawl (shrimp), bottom trawl (other), purse seine (menhaden), purse seine (other), pots and traps, handline, dredge, nets, pelagic longline, reef fish longline, shark longline, and other), and four recreational fleets (private angling, charter, headboat, and shore). Trophic interactions were defined according to a meta-analysis of 568 diet studies, many of which were conducted in the GoM. Nutrient forcing is based on the Mississippi-Atchafalaya River nutrient input. Time series of predicted biomass and catch from Ecosim were calibrated to estimates of stock biomass from Southeast Data Assessment and Review (SEDAR) and International Commission for the Conservation of Atlantic Tunas (ICCAT) stock assessments and relative abundance indices calculated from NOAA biological monitoring programs in the GoM, including the groundfish trawl survey from the Southeast Area Monitoring and Assessment Program (SEAMAP) and Pelagic Longline Observer Program. Model predictions generally agree with most reference time series and with single species stock-assessment F_{MSY} estimates (fishing mortality that results in maximum sustainable yield) obtained from SEDAR assessments of reef and pelagic fishes. We provide information about the calibration and diagnostics of the mass-balanced (Ecopath) and time-dynamic (Ecosim) components of the model, as well as various model outputs and results describing key system aspects related to fisheries dynamics, biomass flow, ecological indices, and network analysis. This model can be used to compare top-down (fishing and predation) and bottom-up (nutrients, environmental drivers) processes in the GoM, evaluate potential effects of proposed harvest policies on the community, provide data products to support stock assessments (e.g., time series of natural mortality), and identify policy trade-offs between populations and the ecosystem. The model detailed here therefore provides a quantitative tool to support ecosystem-based fisheries management in the Gulf of Mexico.

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Table of Contents

List of Figures

List of Tables

Abbreviations and Acronyms

CV	Coefficient of Variation
EBFM	Ecosystem-based Fisheries Management
ESA	Endangered Species Act
EwE	Ecopath with Ecosim
FIM	Fisheries Independent Monitoring
FMP	Fishery Management Plan
F_{MSY}	The rate of fishing mortality that results in maximum sustainable yield
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	(FWC) Fish and Wildlife Research Institute
GDAR	Gulf Data Assessment and Review
GoM	Gulf of Mexico
HMS	Highly Migratory Species
ICCAT	International Commission for the Conservation of Atlantic Tunas
LME	Large Marine Ecosystem
MMPA	Marine Mammal Protection Act
MRFSS	Marine Recreational Fisheries Statistics Survey
MRIP	Marine Recreational Information Program
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
SEAMAP	SouthEast Area Monitoring and Assessment Program
SEDAR	SouthEast Data Assessment and Review
SEFSC	SouthEast Fisheries Science Center
SRHS	Southeast Region Headboat Survey
TL	Trophic Level
TPWD	Texas Parks and Wildlife Department
US	United States

Introduction

The US Magnuson–Stevens Fishery Conservation and Management Reauthorization Act (MSFCMA) aims to prevent overfishing and recover overfished stocks to maximize long-term fisheries yield and other benefits to stakeholders (MSFCMA 2007). Global fisheries stocks, as well as those in the US, are largely assessed and managed on a single-species basis via peer-reviewed stock assessments. The dynamics of marine ecosystems are complex with multiple interactions among species, the environment, and fishing fleets, any of which can effect stock productivity and sustainable catch projections. The MSFCMA also contains a number of provisions related to the integration of ecosystem considerations into fisheries management, ultimately setting the stage for Ecosystem-Based Fisheries Management (EBFM) (Pikitch *et al.*, 2004).

EBFM is critically important for the Gulf of Mexico (GoM), which is rich in natural resources such as fisheries and petroleum (Karnauskas *et al.*, 2013). At the same time, this ecosystem has been under immense environmental and anthropogenic pressures such as harmful algal blooms (HABs) (Sagarese *et al.*, 2017; DiLeone and Ainsworth, 2019; Perryman *et al.*, 2020), chemical pollution (Berenshtein *et al.*, 2020; Lewis *et al.*, 2020) and overfishing (Cowan *et al.*, 2011; O'Farrell *et al.*, 2017). In support of EBFM, ecosystem modeling can complement stock assessments and address questions related to marine pollution, hypoxia, HABs, climate change, invasive species, bycatch reduction, restoration efforts, marine protected areas, and management tradeoffs (O'Farrell *et al.*, 2017; Chagaris *et al.*, 2019).

Previous ecosystem modeling studies in the GoM have used a suite of modeling platforms that cover a range of study areas and habitats (O'Farrell *et al.,* 2017). The entire Large Marine Ecosystem (LME) has been modeled using Atlantis (Ainsworth *et al.*, 2015) and Ecopath (Vidal and Pauly, 2004) while other models have focused on specific geographic areas or habitats in the GoM such as the north-central GoM (Robinson *et al.*, 2015; de Mutsert *et al.*, 2016; Geers *et al.*, 2016), northern GoM reef ecosystems (Chagaris *et al.*, 2020b), the West Florida Shelf (WFS) (Okey *et al.*, 2004; Chagaris *et al.*, 2015; Grüss *et al.*, 2016; DiLeone and Ainsworth, 2019; Perryman *et al.*, 2020), and coastal GoM waters (Walters *et al.*, 2008). A wide variety of models have been applied for multiple management and scientific issues, including gauging the effect of oil spills (Ainsworth *et al.*, 2018; Chagaris *et al.*, 2020b), hydrological changes (de Mutsert *et al.*, 2016), and harvest limitations and management scenarios (Ainsworth *et al.*, 2015; Chagaris *et al.*, 2015; Grüss *et al.*, 2016).

Ecosystem models, such as Ecopath with Ecosim (EwE; Christensen and Walters, 2004) are being increasingly applied to understand the dynamics of natural ecosystems and, in particular, how economically and ecologically important species may respond to changes in various environmental and anthropogenic drivers (e.g., nutrient loading, nutrient transport, oil spills, invasive species, climate change, and fishing pressure; Chagaris *et al.*, 2015, 2020; Serpetti *et al.*, 2017; Alava *et al.*, 2018; Corrales *et al.*, 2018). Over the last few decades, new software features have been developed for the EwE modeling framework including spatial dynamics (Ecospace; Christensen and Walters, 2004), tracking bioaccumulation of contaminants (Eco-tracer, Walters and Christensen, 2018), and evaluating management strategies (MSE, e.g., Surma *et al.*, 2018).

Ecosystem models can be particularly useful in the evaluation of fisheries management alternatives. However, ecosystem modeling efforts have traditionally been considered to provide strategic management advice, as opposed to tactical advice in the form of catch limits required for management (Grüss *et al.*, 2017). In particular, the potential complexity of these models coupled with a general lack of data to inform all aspects of model parameterization can create doubt in food web-based predictions that discourage direct use by fishery managers. However, synthesis of existing data collection programs (Grüss *et al.*, 2018) and systematic data collection in the US GoM has led to a more detailed representation of ecosystem dynamics. At the same time, improved modeling capacity has increased the utility of these models, which better inform fishery managers of effective harvest strategies in marine resource management (Chagaris *et al.*, 2019).

In this document, we present the methodology, data sources, and parameterization of the US Gulf-wide EwE model. This model represents those areas of the GoM under the jurisdiction of US fisheries managers and is primarily calibrated to biomass and catch trends of commercially and recreationally important marine stocks estimated from 1980 to 2016. The US Gulf-wide EwE model builds upon the 2005-2009 Ecopath model of Sagarese *et al.* (2017), and includes the following features:

(1) Increased number of federally (e.g., groupers and snappers) and internationally (highly migratory species) managed species modeled as functional groups,

(2) Increased resolution (i.e., age-structure) at which key fisheries species (e.g., red snapper *Lutjanus campechanus* and Gulf menhaden *Brevoortia patronus*) are modeled to capture ontogenetic shifts in feeding behavior,

(3) Improved diet matrix based on a comprehensive meta-analysis of diet composition of GoM predators from stomach content studies; and

(4) Updated biomass time series for SEDAR-assessed species, and other groups based on NOAA fishery dependent and independent surveys.

The primary purpose of the US Gulf-wide EwE model is to better inform decision makers of the trade-offs in alternative management actions while accounting for the system's trophic dynamics including predator-prey interactions, top-down and bottom-up processes (e.g., fishing and nutrient loading).

Methods

Study area

The Gulf of Mexico (GoM) Large Marine Ecosystem (LME) is a semi-enclosed, warm-water ecosystem that links to the Caribbean Sea and the Atlantic Ocean via the Yucatan, Loop, and Florida current systems. The US territory is largely in the northern GoM, supporting a number of marine, estuarine, and coastal communities with a diversity of marine wildlife and an abundance of natural resources such as petroleum and fisheries. The GoM is under constant natural and anthropogenic pressures that include over-fishing, oil spills, hurricanes, HABs, hypoxia and dead zones, all of which threaten the productivity of and services provided by this important region (Turner, 1997; Walsh *et al.*, 2006; Karnauskas *et al.*, 2013; de Mutsert *et al.*, 2016; Berenshtein *et al.*, 2020). Of particular concern in this region is the threat of habitat loss from oil spills, sea-level rise, and hurricanes in wetland areas and along barrier islands (Turner, 1997; Yáñez-Arancibia and Day, 2004; Karnauskas *et al.*, 2013; Spies *et al.*, 2016).

The dynamics of the GoM ecosystem are highly affected by nutrient inputs from the Mississippi River. The Mississippi River watershed covers more than 40% of the contiguous US and supplies more than 90% of GoM nutrients (Howe *et al.*, 2020), including natural river-terrestrial nutrients and massive quantities of agriculture-related nutrients from industrial fertilizers and pesticides, which are linked to the extensive dead zones in the northern GoM (Rabalais *et al.*, 2002). These same nutrients are transported throughout the Gulf depending on the strength and direction of prevailing winds and other circulation drivers. An additional contributor to the high primary productivity in the northern GoM is wind-driven coastal upwelling, which has been linked to regional HABs primarily along the WFS (Walsh *et al.*, 2006). These nutrient inputs result in extensive primary productivity in the estuarine, coastal, and shelf regions of the GoM, supporting the growth of phytoplankton, seagrass, and algae that, along with detrital sources, serve as the trophic foundation for the highly productive fisheries supported by this ecosystem (Sagarese *et al.*, 2017). Lower trophic level taxa such as forage fish (e.g., Gulf menhaden) and shrimp feed on primary producers and detritus (Karnauskas *et al.*, 2013; Sagarese *et al.*, 2017). These primary consumers, in turn, serve as prey for higher trophic level predators, including commercially and recreationally important stocks such as highly migratory species (e.g., sharks, tunas, billfish), mackerels, snappers, and groupers (Vaughan *et al.*, 2011; Robinson *et al.*, 2015).

Most fisheries in the US GoM are managed by the Gulf of Mexico Fishery Management Council or, depending on the stock and its geographic distribution, jointly with the South Atlantic Fishery Management Council. HMS are managed both domestically (e.g., coastal sharks) and internationally, under the International Commission for the Conservation of Atlantic Tunas (ICCAT). There are more than 70 GoM stocks that are managed under Fishery Management Plans (FMPs) (Karnauskas *et al.*, 2017, 2019). Management regulations implemented mainly in the 1990s led to a decrease in the proportion of stocks undergoing overfishing, and a general trend of rebuilding has occurred in most stocks, which is expressed both in landings and revenues (Karnauskas *et al.*, 2019). Notably, many species are not regulated by any FMP because they represent a small fraction of the total biomass/landings in the US GoM (Karnauskas *et al.*, 2017), and several inshore associated species that are managed by individual Gulf States.

Modeling framework

Ecopath with Ecosim (EwE; Christensen *et al.*, 2000; Christensen and Walters, 2004) is an ecosystem modeling framework that is widely used for exploring past, present and future trophic dynamics of ecosystems, often applied in the context of fishing, climate change, and marine pollution (Colléter *et al.,* 2015). It includes three main components: (1) Ecopath, a static mass-balanced snapshot of the ecosystem (Christensen and Walters, 2004); (2) Ecosim, a temporal-dynamic model expressed through a series of differential equations (Walters *et al.*, 1997); and (3) Ecospace, a spatially explicit time dynamic model (Christensen *et al.*, 2014, Steenbeek *et al.*, 2013, Walters *et al.,* 2010). The Ecopath component is based on an extensive collection of biological, ecological, and fishery data, whereas the Ecosim component requires time series of biomass, catches, fishing mortality, fishing effort, and nutrient forcing (Walters *et al.*, 1997; Christensen and Walters, 2004). The Ecospace component incorporates habitat maps, environmental preferences, and movement. Only the Ecopath and Ecosim components are described in this paper.

Ecopath

The static mass balance component of EwE represents a snapshot of the ecosystem for a given year or time period and serves as the initial starting values for time dynamic simulations. The Ecopath snapshot is governed by the production mass balance master equation, where the production term (P_i) for each functional group (*i)* must be equal to the sum of catches (Y_i), net migration (E_i), biomass accumulation (BA_i), predation mortality ($M2_i$), and other mortality $M0_i$.

$$Pi = Yi + Ei + BAi + M2i + M0i \quad (1)$$

The predation mortality ($M2_i$) on group *i* is calculated as the sum of the products of the total consumption rate of all *j* predator groups that prey upon group *i* (Q_j) and the fraction of prey (*i*) in the diets of predator (*j*) (DC_{ij}).

$$M2i = \sum_{j=1}^{n} Qj \cdot DCij \quad (2)$$

Other mortality ($M0_i$) represents all mortality that is not related to fishing or predation and includes disease and senescence.

$$M0i = Pi \cdot (1 - EEi) \quad (3)$$

Ecotrophic efficiency (EE_i) is the proportion of the production (P_i) that is utilized by the ecosystem and ranges from 0 (i.e., no biomass utilized in the ecosystem) to 1 (all biomass utilized in the ecosystem). The Ecopath mass balance equation is then written by combining Equations (1-3):

$$Bi \cdot (P/B)i \cdot EEi - Yi - Ei - BAi - \sum_{j=1}^{n} Bj \cdot \left(\frac{Q}{B}\right) j \cdot DCji = 0 \quad (4)$$

where for group *i* the parameters include the biomass (B_i), production/biomass ratio (P_i/B_i), Y_i, consumption/biomass ratio for predator *j* (Q/B_j), and EE_i. While inputs of Y_i and DC_{ij} are always required, only three of the four inputs for B_i, P_i/B_i, Q/B_j, and EE_i are required for each functional group. Ecopath would then compute the fourth.

Ecosim

Ecosim is the temporal biomass dynamic component of EwE and simulates changes in the ecosystem due to combinations of top-down (fishing and predation) and bottom-up (nutrients and primary production) drivers of group biomass dynamics. These dynamics are expressed as a set of differential equations (Walters *et al.*, 1997) where the change in biomass over time (dB_i/dt) for functional group *i* can be calculated as:

$$dBi/dt = \frac{P}{Q} i \sum_{j=1}^{n} Qij + Ii - (M0i + Fi + ei) - \sum_{j=1}^{n} Qji \quad (5)$$

where the total consumption and conversion efficiency (*P*/*Q*) of food from all *n* prey groups by group *i* ($\frac{P}{Q}i\ \sum_{j=1}^{n} Qij$) and immigration ($I_i$) represent biomass growth while predation ($\sum_{j=1}^{n} Qji$), fishing mortality (F_i), other mortality ($M0_i$), and emigration (e_i) represent sources of biomass loss. Consumption (Q_{ji}) is modeled from foraging arena theory (Ahrens *et al.*, 2012) and partitions the entire prey population into two pools, one vulnerable to predation and the other invulnerable. The transfer rate between these two pools is represented by the EwE vulnerability parameters (V_{ij}). These parameters control the degree to which the dynamics of individual functional groups are controlled by "top down" (e.g., predation mortality) and "bottom-up" (e.g., nutrient loads) processes (Christensen and Walters, 2004). When the vulnerability is very high (V_{ij} >100), the consumption of prey *i* by predator *j* increases nearly-linearly with increasing predator biomass (e.g. a Type-I functional response). In contrast, low vulnerabilities lead to a fairly constant predation rate regardless of fluctuations in predator biomass (i.e., asymptotic, type-2 functional response). The vulnerability parameters are the main tuning parameters in the Ecosim time series fitting optimization routine (Walters *et al.*, 1997). This routine can also estimate primary production anomalies to further improve fits to time series inputs. Lastly, additional parameters describing prey switching, foraging time adjustments, risk-sensitive foraging behavior, and handling time effects can be manually adjusted to represent different assumptions about foraging processes.

US Gulf-wide EwE model structure

Biomass Structure

The Ecopath model represents a mass-balance snapshot of the US GoM ecosystem for the year 1980, and its general structure is largely based on the model described in Sagarese *et al.,* (2017) with major differences described below. Modifications to functional groups were made following feedback from stakeholders during a 2017 Scoping Workshop (Chagaris *et al.,* 2019) and subsequent discussions. The dolphin functional group from Sagarese *et al.*, (2017) was separated into coastal and offshore components to capture differences in habitat and diet, and baleen whales were added as a single group. Further refinement of marine mammals and other protected species groups (e.g., turtles, sturgeon, manta rays) was limited by a lack of information, specifically estimates of biomass and trophic interactions.

The US Gulf-wide EwE model includes 78 functional groups, with a focus on federally managed species of commercial or recreational importance such as reef fishes, migratory pelagic species, coastal species, shrimp, menhaden, and crabs (Table 1). Functional groups include three marine mammal groups, an aggregate seabird group, an aggregate sea turtle group, eight elasmobranch groups, 52 fish groups (18 of which are sub-divided into multiple life stages as discussed below), nine invertebrate groups, three primary producers, and one detritus group (Table 1). The model has greater taxonomic resolution for most fish groups, with decreasing taxonomic resolution towards lower trophic groups following a lower availability of data. Trophic levels (*TL*) of functional groups range from phytoplankton and detritus at the bottom of the food web (*TL* = 1) to marine mammals and sharks as apex predators (*TL* > 3).

The treatment of age classes for reef fish was modified to capture key ontogenetic changes in habitat selection and diet for select species, as well as fishery selectivity patterns. Age stanzas were modeled for seven species to capture ontogenetic variability in diet and fishing pressure (Table 1). King mackerel (*Scomberomorus cavalla*) and Spanish mackerel (*Scomberomorus maculatus*) were both represented by juveniles (0-1 yr) and adults (1+ yr). Gag grouper (*Mycteroperca microlepis*), red grouper (*Epinephelus morio*), and yellowedge grouper (*Mycteroperca interstitialis*) were represented by juveniles (0-3 yr) and adults (3+ yr), whereas red snapper (*L. campechanus*) was represented by three age groups: age-0 (0-1 yr), juveniles (1-2 yr), and adults (3+ yr). Juvenile red snapper were explicitly modeled to enable consideration of bycatch in the shrimp trawl fishery (Diamond *et al.*, 2010; SEDAR 52, 2018). Lastly, Gulf menhaden (*B. patronus*), a focal species in our model, was represented by five age groups to match the age structure in the stock assessment model: age-0 (0-1 yr), age-1 (1-2 yr), age-2 (2-3 yr), age-3 (3-4 yr), and age-4+ (4+ yr).

The aggregate shrimp functional group was separated by species into brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus),* and pink shrimp (*Farfantepenaeus duorarum*) to match stock designations for assessments as well as spatial overlap with their predators. Additional groups that are not targeted for fishing but are essential for a realistic food web model included: benthic and planktonic primary producers, zooplankton (includes jellyfish), infauna, mobile and sessile invertebrates, and detritus (water column, sediments, and dead discards).

Fishing fleets

Twelve commercial fishing fleets were included in the model (Tables 2 and 3). The commercial purse seine fishery for Gulf menhaden was responsible for almost half (48.1%) of all commercial catch (in weight) between 1980 and 2016 (Table 2). While finer resolution of commercial fishing fleets was presented in Sagarese *et al.,* (2017), commercial fleets were re-evaluated and combined for commercial nets (active, gill, passive, seine) and commercial pots and traps (fish, lobster, crab) due to inconsistent landings and confidential information on fishing effort.

Following classifications in the Marine Recreational Information Program (MRIP), four recreational fishing fleets were included in the US Gulf-wide model: headboat, charter, private, and shore. Private anglers were responsible for more than half (68%) of all recreational catch (in weight) between 1986 and 2017 (Table 2).

Spatial domain

The modeled area covered the northern GoM, with approximately 310,000 km^2 of shelf habitat out to a bottom depth of 400 m extending from the southwestern border of Texas up to (but excluding) the Florida Keys. This domain also includes the region's inshore estuaries (Figure 1). The spatial domain of the US Gulf-wide EwE model initially included the US Exclusive Economic Zone, but this area was ultimately omitted given the lack of data from areas deeper than 400 meters (B Wrege, pers. Comm.[l]).

Temporal structure

The Ecopath model represented a static snapshot of the 1980 US GoM ecosystem, and the time-dynamic Ecosim model was calibrated to data from 1980 to 2016. A 1980 start year was chosen due to data availability, as many biological sampling programs were initiated at that time and most stock assessments include a start year of at least 1980. Availability of stock biomass estimates prior to the 1980s varies between stocks; however, there is a general lack of data or high uncertainty around information prior to 1980. In addition, estimates of recreational landings, discards, and fishing effort became widely available in 1981 after the implementation of the Marine Recreational Fisheries Statistics Survey, which has since transitioned into the Marine Recreational Information Program (Matter and Nuttall 2020a).

Ecopath model parameterization

Inputs into the US Gulf-wide Ecopath model included B_i, P_i/B_i, *and* Q_j/B_j, leaving EwE to estimate EE_i for all functional groups. The majority of information used for model parameterization was collected from stock assessments (e.g., natural mortality inputs, estimates of catch in weight, population biomass, and fishing mortality rates), and published literature (e.g., equations used to derive Ecopath parameters and predator diet). Stock assessments were available for many of the functional groups and were developed either by NOAA SEFSC, FWC, or ICCAT. For other groups, estimates of biomass, mortality, diet, or production were derived from the literature or adopted from other GoM ecosystem models (Walters *et al.*, 2008, Geers *et al.*, 2016, Chagaris *et al.*, 2015, Sagarese *et al.*, 2017; see Tables 4 and 5 for details). The following sections explain the data sources and methods used for the Ecopath parameterization.

[l] Southeast Fisheries Science Center, Fisheries Statistics Division.

Biomass (*B*)

When possible, initial biomass estimates (t km^{-2}) were obtained from recent stock assessments of federally assessed species or survey data (Table 4). For higher trophic level functional groups that lack absolute biomass estimates, biomass inputs were calculated from mean annual catch estimates divided by fishing mortality (*F*) estimates obtained from stock assessments (Table 4). Catch and *F* estimates from 1980 were preferred, but estimates from close years (e.g., 1981) or averages across the first few years (e.g., 1980-1984) were used when there was high interannual variability around the base year. For unassessed species, parameter estimates were obtained from previous GoM Ecopath models (e.g., coastal GoM; Walters *et al.*, 2008).

Biomass inputs for assessed species were derived directly from the Stock Synthesis (SS) or Beaufort Assessment Model (BAM) report files. This information was available for gag, greater amberjack *Seriola dumerili*, cobia *Rachycentron canadum*, gray triggerfish *Balistes capriscus*, king mackerel, red grouper, red snapper, Spanish mackerel, tilefish *Lopholatilus chamaeleonticeps*, vermilion snapper *Rhomboplites aurorubens*, yellowedge grouper *Epinephelus flavolimbatus*, gray snapper *Lutjanus griseus*, hogfish *Lachnolaimus maximus*, and Gulf menhaden. To convert SS or BAM estimates to Ecopath biomass inputs, mean biomass at age ($\bar{B}_{a,y}$) was calculated for each age *a* and year *y* in the assessment as the product of mean numbers (*N*) at age: ($\bar{N}_{a,y} = N_{a,y} \cdot (1 - \exp(-Z_{a,y}))/Z_{a,y}$) and the mid-year mean body weight. For multi-stanza groups, the $\bar{B}_{a,y}$ was summed over the ages included in each stanza and for non-multi-stanza groups, the $\bar{B}_{a,y}$ was summed over all ages.

Biomass accumulation (BA)

Biomass accumulation rates (BA_i/B) were calculated for all multi-stanza species as the biomass change between the first and the second years:

$$BA = (B_{1981} - B_{1980}) \, / \, B_{1980} \quad (6)$$

BA rates are relevant for functional groups that are not in equilibrium during the Ecopath base year (i.e., production does not equal mortality; see Equation 1), representing the instantaneous rate of change in the group’s biomass.

Production per biomass (*P/B*)

In Ecopath, production per unit biomass (*P*/*B*) and total mortality (*Z*) are used interchangeably because *P*/*B* is equal to *Z* under equilibrium conditions. Specifically, the change in biomass (*dB*) equals production minus mortality, *dB* = Production – Mortality.

If biomass is in equilibrium, then *dB* = 0 and Production = Mortality. If we express production and mortality as rates times biomass, then *P*/*B* x *B* = *ZB*, i.e., *P*/*B* = *Z*.

For each functional group, *P/B* values were assumed equal to total mortality (*Z* = *M*+*F* or *Z* = *M x 2* if no *F* estimate was available; Table 5). Mortality estimates from stock assessments were preferred for all fish functional groups. For assessed species, *F* was calculated from the assessment report files by first summing the total landings and dead discards (in weight) for each stanza or functional group (described below) and dividing the total fishery loss by the mean biomass $\bar{B}_{a,y}$ to give an instantaneous fishing mortality rate. Natural mortality (*M*) is typically assumed to vary with age in the stock assessments, following a Lorenzen curve (Lorenzen, 1996). Therefore, for each Ecopath functional group or age stanza, *M* was averaged across ages and weighted by the mean numbers at age ($\bar{N}_{a,y}$).

However, when such estimates were unavailable, natural mortality (*M*) was estimated using empirical equations (Pauly, 1980; Table 6):

$$\log(M) = -0.2107 - 0.0824 \cdot log_{10} W_{\infty} + 0.6757 \cdot log_{10} K + 0.4627\, log_{10} T \qquad (7)$$

$$\log(M) = -0.0066 - 0.279 \cdot log_{10} L_{\infty} + 0.6543 \cdot log_{10} K + 0.4634\, log_{10} T \qquad (8)$$

where W_{∞} is the asymptotic weight (g), *K* is the growth coefficient of the Von Bertalanffy length equation, *T* is a temperature expression for the mean annual temperature of the water body (25°C assumed representative of mean annual conditions within the GoM), and L_{∞} is the asymptotic length (mm).

If a proxy of *F* was unavailable, it was assumed that *F* was approximately equal to *M* or an *F* estimate from a similar species was applied. Additional details on *P/B* sources can be found in Table 5.

Consumption per biomass (*Q*/*B*):

Estimates of *Q/B* (yr^{-1}) were obtained using the empirical equation of Pauly *et al.*, (1990):

$$\log\left(\frac{Q}{B}\right) = -5.04 + 1.94 \cdot log_{10}T' - 0.151 \cdot log_{10}W + 0.178 \cdot PF + 0.291 \cdot h \qquad (9)$$

where *T’* is a temperature expression for the mean annual temperature of the water body (25°C assumed representative of mean annual conditions within the GoM), expressed as *T’* = 1000/°Kelvin, *W* is the asymptotic weight (g), and *PF* and *h* are dummy variables expressing food types; *PF* = 1 for apex/pelagic predators and *PF* = 0 for zooplankton feeders, and h = 1 for herbivores and h = 0 for detritivores and carnivores.

Estimates of Q/B (yr^{-1}) were also obtained using the equations of Palomares and Pauly (1989) and (1998) for species with available estimates of aspect ratio (tail height/area)^2:

$$\log\left(\frac{Q}{B}\right) = 7.964 - 0.204 \cdot logW_{\infty}\, d - 1.965 \cdot T' + 0.083 \cdot A + 0.532 \cdot h + 0.398 \cdot d \qquad (10)$$

where A is the fish form aspect ratio, and d is a dummy variable expressing food types, d = 1 for detritivores and d = 0 for herbivores and carnivores.

For each fish species falling within a functional group, estimates of Q/B were obtained using the equations above. The average Q/B value for each functional group (averaged across species and methods) was used as an initial Q/B value. For the marine mammal groups (e.g., bottlenose dolphin *Tursiops truncatus*), Q/B was estimated using the equation modified from Innes *et al.*, (1987) in Trites and Heise (1996). For the seabird group, Q/B was estimated using weight parameters presented in Okey and Mahmoudi (2002) and the equation given in Nilsson and Nilsson (1976). Additional details on Q/B ranges from these equations and final Q/B estimates are shown in Table 7.

Unassimilated consumption (*U*):

There is little information to inform the relative consumption of prey not assimilated into predator growth. The default assumption of U = 0.2 for high trophic level groups (secondary consumers and higher) and U = 0.4 for lower trophic level groups (primary consumers, e.g., zooplankton) was therefore used, as recommended in Christensen *et al.,* (2005).

Diet composition (*DC*)

Initial values of diet composition for most functional groups are based on a probabilistic approach using maximum likelihood estimation previously applied in meta-analyses of trophic interactions (Ainsworth *et al.*, 2010). The method, applied in Sagarese *et al.,* (2016), includes four main steps: (1) drawing 10 random diet composition estimates (with replacement) for each predator from all available regions and/or studies; (2) from these random draws, estimating the weighted mean diet contribution of each prey item to predator diet, with weights based on how well individual diet records are believed to represent feeding behavior in the US GoM ecosystem; (3) repeating steps (1) and (2) 10,000 times to generate probability distributions of mean predator diet; and (4) fitting a Dirichlet distribution to the bootstrapped, average diet composition data for all prey items of each predator (Figure S1.1). The end-product is a marginal distribution of prey-specific predictions of the relative contribution of each prey item (by weight or biomass) to predator diet. If at least 10 random observations were not available, as was typically the case for juvenile life stages, five observations were used in the maximum likelihood estimation approach. Quantification of diets for some functional groups required inclusion of studies outside the GoM given a paucity of diet data specific to the GoM, particularly for higher trophic level groups. A total of 568 references were used to quantify trophic interactions in the GoM, with 1,906 diet observations (i.e., 1 observation = 1 study for a single region or length-class) incorporated into the analysis (Table S1.1). Additional details on the approach, available data and assumptions are provided in Sagarese *et al.*, (2016) and (2017).

The diet matrix from the balanced US Gulf-wide Ecopath model is presented in Table 8. This table provides a summary of the trophic interactions defined in the EwE model after achieving mass balance (see results section for additional details on achieving mass balance). For highly migratory species, which likely spend a substantial portion of time outside the modeled area, we assumed that the majority of their diet was imported into the ecosystem. For bluefin tuna *Thunnus thynnus*, 90% of their diet was imported (i.e. obtained outside the modeled region), whereas 50% was imported for large oceanic sharks, other tunas, yellowfin tuna *Thunnus albacares*, billfish, and swordfish *Xiphias gladius*. In addition, we assumed about 30% dietary import for large coastal sharks, oceanic piscivores, and dusky shark *Carcharhinus obscurus*, and about 20% dietary import for pelagic coastal piscivores, blacktip shark *Carcharhinus limbatus*, and sandbar shark *Carcharhinus plumbeus*, due to the potential for these species to travel outside the modeled area.

Refining predator-prey linkages for Gulf menhaden

This model was designed, in part, to evaluate the effects of menhaden harvest on federally managed species. Due to the high uncertainty and lack of comprehensive data describing menhaden-predator interactions discussed in Sagarese *et al.* (2016), we used an indirect approach to confirm predator-prey interactions concerning menhaden (*Brevoortia sp*). The initial predator list of Gulf menhaden in Sagarese *et al.* (2016) was based on species identified to consume Gulf menhaden, *Brevoortia spp*., or unidentified clupeids. We reviewed a variety of references including biological field reports and peer-reviewed studies (Table S2.1) to identify species that co-occur with menhaden in the GoM. Information on the species composition of bycatch, which focused on species that could potentially prey upon menhaden (*Brevoortia* spp.), are summarized in Table S2.2. We refined the initial predator list of Gulf menhaden by individually confirming that menhaden (*Brevoortia sp.*) were a plausible prey item based on spatial overlap. Additional data sources were also examined for evidence of predation on menhaden, including the FWRI Fisheries-Independent Monitoring (FIM) diet database and Dr. Will Patterson’s diet database collected from the northern GoM (Tarnecki and Patterson III, 2015). The final list of plausible predators was determined based on our current understanding of trophic interactions and the presence of menhaden predators in bycatch, as summarized in Table S2.3. The associated references of predator diet, by species, are provided in Table S2.4.

Multi-stanza group inputs

In Ecopath, *B* and *Q/B* for multi-stanza groups are entered for a “leading” stanza only, usually the oldest stanza or a life-stage fully selected to a fishery (e.g., age-2 Gulf menhaden), and *Z* is entered for all stanzas. Additionally, multi-stanza groups require inputs for the von-Bertalanffy growth parameter *K* and relative weight-at-maturity (W_{mat}/W_{inf}) maturity. Based on these parameters, *B* and *Q/B* for non-leading stanzas are calculated assuming a stable age distribution. Because all multi-stanza groups have stock assessments, these parameters were taken directly from the assessment report files. The multi-stanza recruitment power parameter was set to 1 (default), which assumes that juveniles spend all of their time within the modeled system (Christensen *et al.*, 2005).

Landings and discards

Landings and discards (t km^{-2} yr^{-1}) were quantified for 1980. For assessed species, data from 1980 (or the closest year possible) were used. For un-assessed species, available data between 1980 and 1984 were averaged given considerable data variability and associated concerns with uncertainty. Since MRIP data began in 1981, landings and discards in 1981 were used as a proxy for 1980 catch (i.e., assumed equal). Discards were input into Ecopath as dead discards based on the available estimates in weights derived from stock assessments. Dead discards were calculated when possible using discard mortality rates obtained from stock assessments or for similar species. If no discard mortality information was available, a mortality rate of 100% was assumed.

To convert commercial and recreational landings and discards from stock assessments to EwE inputs required the conversion of catch in numbers to catch in weight and partitioning that catch between retained and dead discards. First, the total catch-at-age matrix was partitioned to retained and discarded fish using the model selectivity and retention functions. Fleet-specific mean body weight was then used to convert landings and discards numbers to metric tons. Lastly, landings and discards in metric tons were summed over ages within each model stanza (or over all ages for pooled groups). Additional details on landings and discards are provided in the next section.

Commercial landings

Landings of functional groups were obtained from stock assessment reports or model output files, when available. These data are considered the best available estimates of removals as they often include additional data processing steps such as assignment of landings for unidentified groups, examination of outliers, and a synthesis of landings estimates from multiple data sources. If no stock assessment estimates were available for a given species, commercial landings were obtained from the NOAA NMFS Fisheries Statistics Division (NMFS Fisheries Statistics Division; https://www.fisheries.noaa.gov/national/commercial-fishing/commercial-landings/annual). Landings from unspecified gears were allocated across functional groups based on the relative proportion of landings in identified gear types. When available, landings from the International Commission for the Conservation of Atlantic Tunas online database (ICCAT; https://www.iccat.int/en/accesingdb.HTM) were also considered for pelagic species.

Retained bycatch within the commercial purse seine fishery was treated as landings. The species composition and magnitude of retained bycatch in the menhaden purse seine reduction fishery were obtained from two studies: Guillory and Hutton (1982) and de Silva and Condrey (1997). The total catch of Gulf menhaden by the purse seine fishery in 1980 (701,229 t; SEDAR 63, 2018) was scaled by the proportion of retained bycatch observed in these studies to infer the total magnitude of bycatch by the purse seine fleet. Approximately 2.5% (by weight) of all reported purse seine landings between 1980 and 1981 were bycatch within the Louisiana menhaden fishery, although it is important to note that sampling occurred at the fish plants in this study (i.e., large bycatch species were likely discarded at sea; Guillory and Hutton 1982). Retained bycatch was also reported during 1994 and 1995 in de Silva and Condrey (1997) and was estimated at about 2.1% of total purse seine landings. The species composition of bycatch and landings of bycatch species (i.e., retained bycatch) were then calculated from the composition reported in each study. Since Guillory and Hutton (1982) did not distinguish between shark species within the bycatch, species-specific bycatch estimates for sharks were informed by de Silva *et al.*, (2001), which sampled dead bycatch aboard commercial menhaden fishing vessels. The estimated retained bycatch in 1980 were similar in magnitude between these two studies, with total bycatch estimated as 0.0526 and 0.0564 t km^{-2} yr^{-1} respectively (Table 9).

In 1980, the majority of commercial landings in weight came from purse seines targeting menhaden (82%) and the shrimp bottom trawl (9%). The highest commercial landings in 1980 were of age-2 menhaden (45%), age-1 menhaden (27%), age-3 menhaden (8%), brown shrimp (5%), and white shrimp (2%; Table 10A-B).

Commercial discards

Commercial discards were primarily obtained from stock assessments, but additional sources were used when available for unassessed species. Bycatch estimates were obtained from the National Bycatch Report, First Edition Update 2 (National Marine Fisheries Service, 2013). Since bycatch estimates were reported for 2013, we scaled the estimates back to 1980 using the proportion of landings between years.

$$Bycatch_{1980} = Landings_{1980} * \frac{Bycatch_{2013}}{Landings_{2013}} \quad (11)$$

This approach assumes that the species composition and relative proportion of bycatch (to total catch) is similar across years, which may not be true if fisher behavior or the distribution or abundance of fished stocks changes over time. Commercial discards for the GoM HMS Pelagic Longline, which were aggregated with Atlantic discards, were scaled to the GoM using the proportion of landings between these regions. For discards from both the GoM Coastal Migratory Pelagic Gillnet (included in commercial nets fleet) and Troll (included in commercial handline) fisheries, individual counts were converted to weights using median sizes of individuals. Although bycatch estimates in numbers are available for reef fish in the longline and vertical line fisheries, these were not converted to weights (i.e., discards assumed = 0 for these fleets) due to a lack of corresponding size information to infer weights.

Released bycatch within the commercial purse seine fishery was treated as discards. The species composition and magnitude of released discards were obtained from de Silva and Condrey (1997), which conducted onboard sampling in 1994 and 1995 to estimate released bycatch. First, a weighted average of the released species-specific bycatch in 1994 and 1995 was calculated with weights based on respective sample sizes (N_{1994} = 235 sets; N_{1995} = 257 sets). Second, the numbers of released bycatch were converted to weights using the average weight of species that were retained according to the study. Since these estimates were for 1994 and 1995, we scaled these estimates back to 1980 using the ratio of Gulf menhaden landings, assuming the proportions and species compositions remain static (Table 11).

In the 1980 snapshot, 96% of commercial discards came from the bottom trawl targeting shrimp (Table 12). Shrimp bycatch during this year was quite high because turtle exclusion devices (TEDs) were not required on shrimp vessels until 1987 in the Gulf of Mexico. Overall, in 1980, the highest commercial discards included demersal coastal invertebrate feeders (32%), Atlantic sharpnose shark *Rhizoprionodon terraenovae* (15%), and gray triggerfish (14%; Table 12).

Recreational landings

For the headboat recreational fishery, landings were obtained from the Southeast Region Headboat Survey (SRHS), which is a census of all headboat fishing activity from trip-level logbook records that report landings, fishing effort and biological sampling data, from which average weights were estimated (Fitzpatrick *et al.*, 2017). While the survey started in 1986 in the GoM, observations of fish weight were not collected until 1988. We therefore scaled the 1988 headboat landings estimates in weights back to 1980 using an adjustment factor (0.4) based on the relative number of active vessels between 1980 (SEDAR 42, 2015) and 1988 (from raw logbook files). This approach assumed that catchability of individual species would be similar over these years. Counts of registered headboat vessels in specific ports were used as a proxy for headboat effort in years where landings in weight were unavailable (1986-1988; 2013-2016).

For the private, charter, and shore recreational fisheries, landings were obtained from the MRIP, formerly the Marine Recreational Fisheries Statistics Survey (MRFSS) (Matter and Nuttall, 2020a). MRIP collects information on participation, effort, and species-specific catch. Data are collected to provide catch and effort estimates in two-month periods for each recreational fishing mode (shore, private, and charter), area of fishing (inshore, state Territorial Seas, US Exclusive Economic Zone), and state (except Texas). Total removals by fishery are estimated by MRIP and included fish landed, dead discards, and live releases (of which a proportion is assumed to die based on a release mortality estimate).

MRIP catch estimates for all species were obtained for the period 1981 to 2017 (personal communication[II]). At the time, MRIP was transitioning from the Coastal Household Telephone Survey (CHTS) to the Fishing Effort Survey (FES), but all stock assessments were still using estimates in CHTS currency. Since the US Gulf-wide EwE model is meant to explore potential management actions and their influence on the ecosystem, MRIP-FES data were explored (personal communication[III]) but ultimately not used because calibration factors to the CHTS were not yet available. Catch estimates in weight for the private mode were available in the CHTS time series back to 1981. However, the CHTS time series was missing charter and shore estimates between 1981 and 1985, which were not missing in the FES time series. Estimates for these modes in these years were scaled back to 1981 using the ratio of group-specific landings in 1986 between the CHTS and FES time series. For this analysis, we

[II] National Marine Fisheries Service, Fisheries Statistics Division. March 11, 2018
[III] National Marine Fisheries Service, Fisheries Statistics Division. July 18, 2018

assumed that the species composition and magnitude of catches in 1980 are similar to those in 1981.

In the 1980 snapshot, the majority of recreational landings came from private anglers (59%) and shore fishermen (21%), followed by charters (16%) and headboats (4%). Overall, recreational landings in 1980 were highest for seatrout (22%), demersal coastal invertebrate feeders (12%), and reef invertebrate feeders (9%; Table 13).

Recreational discards

Discards from each recreational fishery were obtained from stock assessments whenever possible. The MRIP dataset provided the number of fish released alive but did not include discards by weight. These self-reported discards in number of fish were converted to weight using the mean weight of each fish in the landings. This approach assumes that the sizes of fish discarded are similar to the sizes of fish landed, which may not hold if fish are discarded largely due to being undersized. When available, discard mortality estimates were used to estimate dead discards. A similar scaling approach was applied for recreational discards as discussed above for the landings.

In the 1980 Ecopath model, the majority of recreational discards came from private anglers (63%) followed by shore anglers (29%; Table 14). Overall in 1980, recreational discards were highest for demersal coastal invertebrate feeders (36%), pelagic coastal piscivores (10%), and sea trout (7%; Table 14).

Landings and discards summary

The Purse Seine (Menhaden) fishery yielded the highest catch of 2.32 t km^{-2} yr^{-1} followed by the bottom trawl shrimp fleet with a catch of 0.25 t km^{-2} yr^{-1}. The bottom trawl shrimp was responsible for 0.044 t km^{-2} yr^{-1} of discards, which was the highest among the fleets (Table 15). For all fishing fleets, landings were considerably larger, with discards accounting for up to XX percent of total catch (Table 15).

Ecopath diagnostics and balancing procedure

The Pre-balance diagnostics procedure (PREBAL) of Link (2010) was followed to ensure biological realism of the Ecopath estimates. Biomass (*B*), production (*P*), consumption (*Q*), respiration (*R*), and vital rates (*P/B*, *Q/B*, and *R/B*) were examined across all taxa and *TLs*. Each was $\log_e$ transformed and expected to decrease with increasing *TL*. Biomass estimates were expected to range 5-7 orders of magnitude between the highest and lowest *TLs*, while ratios of biomass and vital rates between predators and prey (via guilds, defined and assigned in Table 1) are expected to remain below one (Link, 2010). Biomass of each functional group relative to primary producers, production of each functional group relative to primary producers, and *P/B* of each functional group relative to primary producers are expected to remain below 1. Estimates of *P/Q* were calculated across taxa and were expected to fall between 0.1 and 0.3 (Darwall *et al.*, 2010; Link, 2010). For each functional group, the ratio of the consumption of that functional group to its production (ratio equivalent to *M2*/*Z*) was expected to remain below one (i.e., for mass-balance, prey production is higher than predator consumption), whereas the ratio of the consumption by that functional group to its production (ratio equivalent to the inverse of *P*/*Q*) was expected to exceed one (i.e., metabolic inefficiencies require the production of functional groups to be smaller than its consumption by predators) (Link, 2010). Lastly, the ratio of total fishing removals to consumption of each group was expected to remain below one, with values above 1 suggestive of system imbalance (Link, 2010). In addition to the PREBAL diagnostics, the ecological and thermodynamic rules listed in Darwall *et al.,* (2010) were examined: Ecotrophic Efficiency < 1, Net Efficiency < Gross food-conversion Efficiency (*GE*), and Respiration / Assimilation Biomass < 1.

Ecopath mass balance procedure

During model balancing, model inputs including biomass, *P/B*, *Q/B* and diet composition were re-evaluated and modified to attain mass-balance (while maintaining PREBAL criteria within acceptable limits). Initial balancing efforts focused on bringing higher trophic level groups into balance first, and then working down to lower trophic level groups. The parameters most frequently changed were the input diet compositions, which were thought the most uncertain of the input parameters. Additional changes were made to some biomass estimates, such as non-assessed aggregate groups (e.g., invertebrate feeder groups) where biomass estimates were considered uncertain. Other modifications that were entertained in the process included shifting the *Q*/*B* estimate from the average for the group to another plausible estimate (e.g., within the range of estimates) or modifying the *P*/*B* estimate for non-assessed groups.

Network analyses

Ecopath's network analysis builds on concepts from ecological network analysis (Ulanowicz, 1986) and enables a holistic view of trophic interactions, providing information regarding the ecosystem's health, maturity, efficiency, and resilience. We used the following network indicators: trophic level decomposition, transfer efficiency, relative ascendancy, connectance, and system omnivory to describe the modeled system as a whole. Trophic level decomposition describes the distribution of biomass flow between aggregated discrete trophic levels at the functional group level (Christensen *et al.*, 2005). Discrete trophic level represents the fraction of energy sourced from a given step in a trophic sequence/path, such that for example, partial consumption of primary producer A by primary consumer B represents discrete level I; partial consumption of primary consumer B by secondary consumer C represents discrete level II; partial consumption of secondary consumer C by tertiary consumer D represents discrete level III, etc. Per functional group, the value in each discrete trophic level represents the fraction of energy that can be traced to that specific level, for example, discrete level I for the primary producer functional groups equals one because 100% of its energy comes from the first discrete trophic level. Fractional trophic levels, on the other hand, are group-centric and are computed in Ecopath as 1+ the weighted mean of each preys' trophic level, with the following general partitioning to trophic levels: 1- primary producer, 2-herbivores, 3- predators that eat herbivores, 4- predators that eat other predators, 5- Apex predators that have no predators. Fractional trophic levels usually do not exceed five, but discrete trophic levels often do. Transfer efficiencies between successive discrete trophic levels are calculated as the ratio between the sum of the exports from a given trophic level, plus the flow that is transferred from one trophic level to the next, and the throughput on the trophic level (Christensen *et al.*, 2005). Mean transfer efficiency is computed as the geometric mean of transfer efficiencies for discrete trophic levels II–IV.

Relative ascendancy is a measure of ecosystem network efficiency, or organization, and is computed as the ratio between ascendancy and developmental capacity. Ascendency, in turn, represents the average mutual information in a system (measured in flowbits) scaled by system throughput (i.e., the sum of all flows in the system). For example, a system with high ascendancy would imply that the flow of energy through that system is well known and highly deterministic (and also more fragile) whereas low ascendancy implies disorganization in trophic structure. It is hypothesized that systems with moderate ascendancy are more resilient because alternative energy pathways exist when another pathway is disrupted. Developmental capacity represents the upper limit of ascendency for a given system (Ulanowicz and Norden, 1990; Christensen *et al.*, 2005). Connectance refers to the ratio between the number of actual trophic links and the total number of possible links and is expected to increase along with a system's maturity (Odum, 1971). However, it is also dependent on the taxonomic resolution of the system, which limits the capacity for a meaningful comparison between different systems. System's omnivory index, on the other hand, is more suitable for systems' comparison, and is computed as the average consumer omnivory index (the variance of the consumer's prey groups trophic levels) of all consumers weighted by the logarithm of each consumer's food intake, representing the degree to which a system structure is web-like (Christensen and Walters, 2004).

Summary statistics of the US GoM Ecopath model were compared to statistics from other available Ecopath models of the GoM and Ecopath models from other LMEs, most of which were downloaded from Ecobase (Colléter *et al.*, 2015; Geers *et al.,* 2016 values obtained from Sagarese *et al.,* 2017). Summary statistics related to trophic ecology included: (1) Basic model parameters including snapshot year/s and the number of biomass pools, which provide information about the taxonomic richness as well as temporal range, and are important due to region-specific interannual variability in fishing and environmental drivers; (2) Trophic indicators, including the sums (t km^{-2} yr^{-1}) of consumption, exports production, total system throughput (sum of all flows in the system), and net system production; (3) Fishery indicators including total catch and mean trophic level of the catch, which provides information with respect to the total harvested biomass, and whether the fisheries are primarily supported by low-trophic level groups versus predatory-based catch; (4) Energetic indicators include total primary productivity/total respiration and total productivity/total biomass, which serve as indicators to the system's maturity such that in immature systems, production takes a larger portion compared to mature systems (Odum, 1971); and (5) Network indicators, including respiratory flows, flows into detritus, connectance, system omnivory, and relative ascendency.

Ecosim model parameterization and calibration

Time Series Data

The time-dynamic component of EwE, Ecosim, is the primary means for which to simulate harvest policies and environmental change. Prior to doing so, Ecosim models must first be calibrated and able to re-construct historical patterns of biomass, catches, and nutrient input. The main tuning parameter for this adjustment is the predator-prey vulnerability parameter, which defines the degree to which prey consumed is dependent on the predators' density. There are two basic types of time series data used in Ecosim: (1) reference and (2) forcing time series. Reference time series are treated as observed values during the model fitting process whereas forcing time series are primarily used to drive fishing and environmental patterns. Reference time series typically include group biomass (relative or absolute) and group specific catch (absolute or relative, with landings and discards combined or separated), but may also include population mean weight information and estimates of total mortality rate. Reference time series may be weighted (1 weight per time series) to account for differences in relative uncertainty in individual data sources and model groups. Forcing time series typically include group-specific fishing mortalities, fleet-specific fishing effort, and environmental forcing functions (nutrients, river discharge).

In total, there were 109 reference time series and 51 forcing time series used in the calibration procedure of the US Gulf-wide Ecosim model. The majority of the time series covered the entire modeled time period (1980-2016) and were derived from stock assessments and fisheries independent monitoring data. While time series of relative biomass and catch were used for reference time series (to which Ecosim model predictions were calibrated), estimated values of fishing mortality and effort were applied as forcing functions to drive the model for assessed and unassessed groups, respectively. Following Heymans *et al.,* (2016), time series weights were assigned based on the inverse of the mean coefficient of variation (CV) across all years included in each time series. Weights were applied to reference time series for biomass and catch, such that the weight of each reference time series was calculated as the inverse of the mean CV across all years with data. This enables higher weights for more precise time series, which provide more influence on model fit to these time series. Otherwise, a default weight of 1 was used (Table 16). Details on time series construction are provided below.

Biomass time series

For assessed species, and their multi-stanza groups, time series of stock biomass were obtained from SEDAR stock assessment models and treated as relative biomass indices within Ecosim (Table 16). Biomass time series were calculated from stock assessment reports in the same mean numbers-at-age approach as that used to derive Ecopath inputs.

When available, indices of relative abundance from individual (species-specific) assessments were used for multi-species functional groups. For example, an index of relative abundance was available from SEDAR 49 (SEDAR 49, 2016) for shallow water grouper (video index of yellowmouth grouper *Mycteroperca interstitialis*; Table 16). This index of relative abundance was considered the best available estimate of relative abundance for these groups, assuming the trends for individual species followed those of the species group.

For HMS bluefin tuna, yellowfin tuna, other tuna, swordfish, and billfish, annual indices of relative abundance were developed using data from the Pelagic Longline Observer Program (Table 16). Index standardization assumed a negative binomial distribution and utilized a generalized linear regression of species count with an effort (number of hooks) offset. Fixed effect covariates included year, target species, season, sea surface temperature (weekly average), time of day (bivariate [day, night]), hook type, and hooks per float (proxy for set depth). The annual abundance index was calculated as the least squares mean by year.

For some of the remaining (unassessed) species and demersal functional groups, relative biomass indices were developed using a delta Generalized Linear Model (GLM) approach applied to data from the SEAMAP groundfish bottom trawl survey (Table 16). Influential environmental variables explaining the variation in relative abundance were selected using a forward stepwise approach (Lo *et al.*, 1992; Maunder and Punt, 2004). The confidence interval for the index was obtained by using Monte-Carlo simulations.

Catch

For assessed functional groups, time series of commercial and recreational catches were obtained directly from the stock assessment output files (Table 16) and calculated following the same method used to estimate initial Ecopath inputs. For the remaining species, time series of catches were obtained by adding the commercial NOAA landings with the recreational landings from MRIP, SRHS, and the Texas Parks and Wildlife Department (TPWD). Landings estimates from the Texas sport-harvest monitoring program were used for 1983+ (Matter and Nuttall 2020b). Landings from Texas were available in numbers from both charter and private modes and were converted to weights using the average size of each species in the MRIP dataset, assuming that sizes landed would be similar across the GoM.

The catch time series was a single, total catch, summed over all fleets and gears. Retained bycatch in the menhaden purse seine fishery (Table 9) was also included within the catch time series where available to capture removals of non-target species from the ecosystem.

Fishing mortality

For assessed species, time series of fishing mortality (*F*) were computed as $F = C/\bar{B}$, where $\bar{B}$ is the mean, or mid-year biomass, and *C* is the stanza or functional group total harvest (landings) calculated from catch-at-age matrices, selectivity and retention patterns, and mean body weight (Table 16). Dead discards were not included in the time series of landings or F at this time. If no *F* time series was available for a given species or functional group, then fishing mortality was driven by the fleet specific trend in effort.

Fishing effort

Time series of commercial fishing effort by fleet and recreational fishing effort by mode were obtained from stock assessment documents when possible (Table 17, Figure 2A). For the remaining commercial fishing fleets, time series of commercial effort were obtained from the NMFS Vessel Operating Units (VOU) database (https://www.fisheries.noaa.gov/inport/item/5380), which provides a general sense of trends in fishing effort over time (in terms of number of vessels or gear fished). The NMFS VOU Survey is an annual survey of the active participants in the fisheries. The database includes physical characteristics of the vessels (e.g., gross tonnage) and the operating or fishing characteristics of the vessel (e.g., type of gear, number, and quantity of gear). Time series of effort based on the NMFS VOU database were first smoothed using a moving average to help reduce the relatively high variability in effort estimates for obscure gears (e.g., of other, other purse seine, and other bottom trawls) and to obtain a more realistic trend in fishing effort (e.g., effort for other gear dropped six-fold between 1993 and 1996, likely due to sparse observations or incomplete reporting). If time series were incomplete, a moving average was used to fill in missing values since a forcing function in Ecosim cannot have any missing values. Further, all effort time series were scaled so the starting value was 1. Time series of recreational fishing effort by mode (in number of trips) were obtained from MRIP, SRHS, and TPWD (Table 17).

Nutrient loading

Monthly nutrient loads (t mo^{-1}) delivered to the GoM from the Mississippi-Atchafalaya River Basin (https://toxics.usgs.gov/hypoxia/mississippi/nutrient_flux_yield_est.html) were used as a direct proxy for the primary productivity of phytoplankton (Figure 2B). The nutrient loads include the sum of total Nitrogen (N) and total Phosphorus (P) scaled to the first value total N+P value (i.e., 1980). This scaled time series was used as the EwE nutrient loading forcing function. Proportion of free nutrients was set to 0.5 according to Ecosim default, representing an effect of nutrient limitation (Christensen *et al.*, 2005). Ecosim assumes a simple Michealis-Menton nutrient uptake relationship, and these free nutrients were available for uptake by all primary producers in the model. Primary producers with higher production rates (i.e. phytoplankton) assimilate free nutrients at a higher rate than producers with lower production rates (i.e. seagrasses).

Ecosim calibration

Ecosim “best practices” (Heymans *et al.,* 2016, Christensen *et al.,* 2005) were largely followed in calibrating our model to time series of biomass and catch, while forcing the model with time series of nutrient loads, fishing effort, and fishing mortality (Figure 2). Using the EwE *fit to time series* module, we applied five recursive vulnerability searches and three consecutive primary production (PP) anomaly searches (Chagaris *et al.*, 2020a). As the main tuning parameters for the Ecosim time series fitting routine, the vulnerability parameters (V_{ij}) represent the exchange rate of prey biomass between invulnerable states (resting, hiding) to vulnerable foraging arenas where they are subjected to predation. Low vulnerability settings (~1-2) restrict the flow of prey biomass into vulnerable pools, which limits the amount consumed by predators regardless of predator biomass, resulting in bottom-up dynamics. High vulnerability settings (>10) allow for fast exchange into the vulnerable pool, which allows consumption by predators, and therefore predation mortality, to increase as predator populations increase, resulting in top-down dynamics. Effectively, low V_{ij} restricts consumption and therefore biomass gains by predators and keeps predation mortality rates of prey near their Ecopath baseline levels, while high V_{ij} allows for increases in consumption, which leads to increases in predator biomass and predation mortality.

Through the Ecosim *fit to time series* tool, the model's fit to each reference time series is sequentially improved. There is a single vulnerability parameter for each predator-prey interaction and the most sensitive V_{ij} are first identified through a sensitivity search. The routine applies small changes to each V_{ij} to determine which parameters have the largest effect on model fit, defined by the sum of squared differences (SSE) between Ecosim predictions and reference time series. The *K-1* most sensitive vulnerabilities are then 'turned on' for estimation, where *K* is the number of reference time series used in calibration. In our application of the Ecosim *fit to time series* routine, the maximum number of vulnerability parameters estimated during any single estimation run was 107. Because Ecosim models are prone to local minima, it is important to repeat the minimization routine several times. At each iteration, a different set of parameters will be estimated, and this process is repeated until no further reduction in SSE is obtained. A convergence on a solution is normally obtained after 5-7 repeated search iterations (Chagaris *et al.*, 2020a).

For several unassessed groups (shallow water groupers, deep water groupers, and red drum) for which Gulf-wide F time series were not available, catch time series were defined as forced catches (type = -6). Similarly, for groups with high uncertainty associated with their biomass estimate (e.g., swordfish and dusky shark), catch time series were defined as a relative catch (type = 61) to avoid issues of scaling between catch and biomass (Table 16). Catch time series of the younger stanzas were not included in the Ecosim calibration due the high uncertainty associated with removals of early life stages (i.e., high uncertainty in bycatch of juveniles).

For several highly migratory species, adjustments were made due to discrepancies between the magnitude of catch in Ecopath and Ecosim. These discrepancies are mainly due to the consideration of dead discards in Ecopath but not in Ecosim time series (which are mostly based on NOAA landings data for unassessed species). The adjustments that were applied are listed below:

- Sandbar shark - Ecopath total catch (0.0004 t km^{-2} yr^{-1}) vs Ecosim total catch (0.000012 t km^{-2} yr^{-1}). Longline shark landings were omitted from the Ecopath input, which reduced the absolute difference between Ecopath and Ecosim catches from 0.00039 to 0.000234 t km^{-2} yr^{-1}
- Large oceanic sharks - Ecopath total catch (0.00036 t km^{-2} yr^{-1}) vs Ecosim total catch (0.0000113 t km^{-2} yr^{-1}). Longline pelagic landings were omitted from the Ecopath input, which reduced the absolute difference between Ecopath and Ecosim catches from 0.00039 to 0.0000096 t km^{-2} yr^{-1}.

- Atlantic sharpnose shark - Ecopath total catches (0.00735 t km^{-2} yr^{-1}) vs Ecosim total catches (0.000021 t km^{-2} yr^{-1}). Ecosim catch time series data included landings only, and dead discards for this group were extremely high in Ecopath (0.0067 t km^{-2} yr^{-1}). We scaled the time series catches based on the discards/landings ratio.
- Yellowfin tuna - the first two years of Ecosim catches were low (<0.000015 t km^{-2} yr^{-1}), with subsequent years increasing in nearly an order of magnitude. We excluded these two first years from the time series in Ecosim since they may not properly represent the true catches. The Ecopath catch input value was based on the year 1982 for the same reason. This reduced the absolute difference between Ecopath and Ecosim catches from 0.00216 to 0.00192 t km^{-2} yr^{-1}.
- Billfish - the first year of Ecosim catches time series were close to zero (<0.0000062 t km^{-2} yr^{-1}), with subsequent years increasing in nearly two orders of magnitude. We excluded this first year, as it may not properly represent the true catches. This reduced the difference between Ecopath and Ecosim catches from 0.00151 to 0.00086 t km^{-2} yr^{-1}.

As an additional diagnostic step, we projected the model 20 years into the future to evaluate the groups' response to no-fishing and extremely high fishing mortalities to make sure that the modeled ecosystem responds as expected. For example, we expected biomass to increase with a decrease of *F* and vice-versa. We also expected the values to stabilize and remain within a biologically reasonable range without diminishing to zero, or continuously increasing (Chagaris *et al.*, 2015). Modifications to the *vulnerability* and *feeding time adjustment rate* parameters solved these problems in Ecosim. The biomass of the yellowfin tuna increased at an unrealistic rate in these projections. To solve this, we set this group's *feeding time adjustment rate* to 0.5 instead of the default of 0. In contrast, the groups of oceanic piscivores, reef piscivores and benthic coastal invertebrate feeders were completely diminishing in the 20 year projections due to increased predation mortality. This was solved by adjusting the minimal vulnerabilities of these groups to 1.05 instead of 1 (see more details about vulnerability caps below).

Vulnerability caps

The Ecosim SSE minimization is unconstrained, meaning that there are no penalized bounds in the optimization function and parameters are not informed by priors or specification of the variance. When there is poor contrast in the data, this often leads to V_{ij} estimated at upper and lower bounds (1.0 and 1e10), which can cause unstable dynamics in simulations, and especially in future long-term projections. Since the vulnerability parameters represent the theoretical maximum predation mortality rate (*M2*) relative to the Ecopath baseline *M2*, we set V_{ij} to represent assumptions about the relationship between predation mortality and natural mortality of the prey. For example, we assumed that the theoretical maximum $M2$ of a single predator on a single prey item cannot account for more than half the natural mortality of the prey. To adjust the vulnerabilities accordingly, we set a vulnerability cap equal to the ratio of theoretical maximum $M2$ and baseline Ecopath $M2$ rates, where $V_{cap} = (M2_{cap} * M)/M2_{base}$, such that $M2_{cap}$ is a multiplier on the Ecopath prey M. These vulnerability caps were applied to the estimated V_{ij} after the repeated search was complete (Chagaris *et al.*, 2020a).

F_{MSY}- equilibrium yield and biomass

An important test of model performance is evaluating the equilibrium relationship between total yield and biomass (Heymans *et al.,* 2016). From this relationship, one can assess: (1) group productivity relative to the removals from fisheries, and (2) the ecosystem's carrying capacity for the group in question. In addition, important fishery benchmarks such as F_{MSY}, $F_{0.1}$, and B_0 can be determined from F_{MSY} plots, and compared against stock assessment-derived benchmarks.

We used the MSY search routine to compute equilibrium estimates of F_{MSY}, which runs Ecosim long-term (40 yrs) simulations over a range of F values and record the resultant response in group catch and biomass (Christensen *et al.*, 2005, Christensen and Walters 2004). Two options exist for applying the MSY search: stationary and compensatory (Walters *et al.,* 2005). The stationary analysis is analogous to a single-species MSY estimate, which fixes the parameters of all other groups at their Ecopath inputs so that they cannot respond to changes in the target group. In the non-stationary (compensatory) option, other groups (both predators and prey) can respond to changes in biomass of the target group. We compared the values derived from Ecosim with those estimated from stock assessments where possible. For Gulf menhaden, since F_{MSY} was not estimable in the stock assessment model, we used the value of 4.5, which was the upper bound of the search algorithm (SEDAR 63 2018). For diagnostic purposes only, in some cases we assume $F_{MSY} = M$ for this analysis.

Ecosim network analysis

We used the Ecosim network analysis to compute the changes in biomass and catches between the start (1980) and the end (2016) of our modeling period. In addition, we used this module to compute the Shannon index of diversity and mean trophic level of the catch.

Results

Ecopath

Pre-balance diagnostics and tuning

Model balance diagnostics ensured biologically realistic trends across functional groups in terms of energy production and transfer. The biomass of functional groups spanned four orders of magnitude in scale, and generally, biomass declined across trophic levels (estimate = 3.47, slope = -1.56; Link, 2010; Heymans *et al.,* 2016; Figure 3; Table 18). Production (*P*), consumption (*Q*), respiration (*R*), and vital rates all tended to increase (linearly) with decreasing *TL* as expected, with R^2 estimates ranging from 0.31 (*R*/*B*) to 0.64 (*P*) or 0.45 (*R*/*B*) to 0.68 (P) when excluding juvenile groups (Figure 4). Biomass estimates for multi-stanza groups (e.g., juveniles) diverged from the regression line for most model estimates, for example the juvenile (0-1 yr) age classes of king mackerel (group #21) and Spanish mackerel (group #23), and juvenile (0-3 yr) yellowedge grouper (group #30) all fall below the regression line, indicating that the biomass of these groups are low compared to the biomass expected given their trophic levels. This could occur because of over-estimation of *TL*s or underestimation of their biomasses. The overestimation of the *TL*s for juvenile mackerels may be due to the sparse diet data, which prevented the use of the probabilistic approach. Their initial diet composition was based on a weighted average and was modified as needed during model balancing. For yellowedge grouper, no diet data were available and therefore the juvenile diet composition was borrowed from adults. Overestimation of their biomasses might be due to the high uncertainty in recruitment variations and post-larval mortality rates of these groups. All predator-prey ratios fell below one as expected with the exception of *Q*/*B* and *R*/*B* for marine mammals and birds relative to small pelagics (Table 19). This might be due to mis-parameterization of catch, production, respiration, or over-estimation of predation pressure on prey (Link, 2010). The majority of functional groups displayed *P/Q* ratios between 0.10 and 0.30, with the exception of a few multi-stanza groups, marine mammal groups, seabirds, and sea turtles, which had *P*/*Q* ratios at or below 0.10 (Table 18).

The following estimates remained below 1 for all groups, appropriately: biomass relative to primary producers (range: 0 – 0.09), production relative to primary producers (range: 0 – 0.053), *P/B* or *Z* relative to primary producers (range: 0.001 – 0.141), and the ratio of the predation losses of each functional group to its production (i.e., production is higher than consumption by predators; range: 0.006 – 0.98; Table 20). In addition, estimates remained below 1 for the ratio of total fishing removals to production or *F*/*Z* (range: 0 – 0.9) and the ratio of total fishing removals to consumption (range: 0 – 0.112; Table 21). The following estimates remained above 1 for all groups, appropriately: the ratio of the consumption by each functional group to its production (i.e., inverse of *P*/*C,* or where production is smaller than consumption by functional group; range: 3.68 – 132; Table 20). Combined, these diagnostics demonstrated that the data inputs are compatible with model predictions and that the US Gulf-wide EwE model does not violate critical assumptions about mass balance, bioenergetics, and vital rates for the modeled groups (Link, 2010).

The most frequent error encountered during model balancing was predation mortality exceeding the biomass production rate of a prey group. This result primarily occurred for prey taxa with highly abundant predator(s) or those with high consumption rates. The most common modification during model balancing was the reduction of these predation events via modifications to the diet matrix, under the assumption that starting values of diet inputs have high uncertainty and may not be representative of system-wide or group-wide predation rates. On average, the diet composition was modified by about 7 to 10 percent, with the largest changes made to juvenile king and Spanish mackerel (anchovy prey composition reduced by 20%) and skates/rays (detritus prey composition increased by 23%). Notably, very little data (*N* = 3 studies) were available to parameterize the diets of juvenile mackerels. For skates/rays, predation on select prey items (i.e., fishes) was reduced and assigned to detritus under the assumption that these predation events were likely due to scavenging. Observed landings were fixed during model balancing, such that in situations where fishing mortality exceeded stock production, either the functional group's biomass or *P/B* value was increased. This was necessary for many high *TL* predators, which exhibited low biomass but high landings (e.g., tunas), possibly a result of limited biomass estimates for the GoM (i.e., not representative of GoM trends) or violations of the assumptions required for estimating biomass from catch and *F* (e.g., migration effects).

The balanced US Gulf-wide Ecopath model captures the trophic dynamics in biomass, consumption, mortality, and diet for 78 functional groups ranging from phytoplankton to a variety of apex predators in the GoM (Table 18). A food web diagram (Figure 5) of the mass-balanced Ecopath component demonstrates the complexity and interconnectedness of populations in this ecosystem, highlighting ecosystem interactions with the Gulf menhaden (2+ yr) group.

Ecotrophic efficiency

Ecotrophic efficiency (*EE*) is a measure of the proportion of a group's production that is accounted for in the model by predation and harvest. Through mass balance adjustments, *EE* estimates were below 1 for all functional groups except a few groups that exhibited very low *EE*s, indicative of low predation and fishing mortality relative to biomass production and therefore a high proportion of unexplained mortality (e.g., minimal accounting of production fate; Table 18). These groups included primary producers, baleen whales, and age-0 menhaden that have high biomass and/or few predators. The Gulf menhaden group is characterized by relatively low *EE* in our model (*EE*: 0.03-0.456 for the different age-stanzas), which suggests that a majority of production is unaccounted for and feeds into detritus. This result was also obtained in previous models in the GoM (Sagarese *et al.*, 2016). Possible reasons for the low *EE* are: (1) limited abundance of predators compared to a large menhaden biomass; (2) neglect of other sources of mortality, including environmental conditions such as dead-zones or diseases; (3) under-representation of menhaden consumption in the diet matrix, which may stem from inadequate sampling of species that eat menhaden (or robustness of the diet data in general), rapid degradation of menhaden in predator stomachs, or the coarse taxonomic resolution of prey items in diet studies (Sagarese *et al.*, 2016); and (4) potentially an overestimate of biomass and total mortality rate inherited from the stock assessment.

Other groups, such as juvenile Red snapper (1-2 yr) and white shrimp are also characterized by low *EEs* in our model (*EE*: 0.17 and 0.18, respectively; Table 18). Data on predation of juvenile fishes can be limiting because the feeding events are usually isolated in time/space and not captured in diet studies and rapid digestion of juvenile fishes prohibits species level identification in stomach contents. For some high trophic groups such as Baleen whales (*TL* = 3.467) and Large oceanic sharks (*TL* = 3.61), low *EEs* (0.067 and 0.275, respectively) are expected due to the fact that their removal is more related to senescence, diseases, and migration rather than fishing and predation.

Mortality rates

The largest fishing mortalities were noted for brown shrimp (F = 2.15 yr^{-1}), juvenile (0-1 yr) Spanish mackerel (F = 1.37 yr^{-1}), and yellowfin tuna (F = 0.8 yr^{-1}; Table 21). Functional groups that were primarily driven by fishing mortality (i.e., higher *F/Z* ratio) included swordfish (*F/Z* = 0.90), billfish (*F/Z* = 0.84), and adult red snapper (*F/Z* = 0.77; Table 21). Other functional groups with relatively high F/Z ratios (i.e., > 0.5) included adult red grouper, yellowfin tuna, juvenile Spanish mackerel, adult gag grouper, Atlantic sharpnose shark, goliath grouper, sea trout, other tunas, and shallow-water groupers (Table 21). The majority of functional groups had M/Z ratios above 0.5; Table 21). Functional groups for which mortality was solely based on natural mortality through either predation or other mortality sources included marine mammals, seabirds, sea turtles, planktivores, anchovies-silversides-killifish, cephalopods, zooplankton, infauna and primary producers (Table 21).

Predation mortality was highest for lower trophic level groups including phytoplankton ($M2$ = 48 yr^{-1}), zooplankton ($M2$ = 7.2 yr^{-1}), and infauna ($M2$ = 2.5 yr^{-1}; Table 21).

Predation mortality was lowest for baleen whales (*M2* = 0.011 yr^{-1}), which were consumed solely by large oceanic sharks (Table 8); adult red snapper (*M2* = 0.024 yr^{-1}) (Table 21), which were consumed by a wide variety of sharks and teleosts; and adult yellowedge grouper (*M2* = 0.0265 yr^{-1}), which were consumed by sharks and larger teleosts (Table 8). The fish groups with the highest predation mortality included anchovy-silverside-killifish (*M2* = 1.34), reef omnivores (*M2* = 1.32), surface pelagics (*M2* = 1.32), butterfish (*M2* = 1.31), and benthic coastal invertebrate feeders (*M2* = 1.20). Other sources of mortality were highest for primary producers including phytoplankton (*M0* = 111.9 yr^{-1}), algae (*M0* = 25.5 yr^{-1}), and seagrass (*M0* = 24.8 yr^{-1}), and lowest for swordfish (*M0* = 0.007 yr^{-1}), oceanic piscivores (*M0* = 0.009 yr^{-1}), and adult (3+ yr) red grouper (*M0* = 0.0097 yr^{-1}; Table 21).

Gulf menhaden represent key forage and supported 32 predator groups in the US Gulf-wide EwE model (Figure 5). The main predators of age-0 Gulf menhaden included: red drum (*M2* = 0.016 yr^{-1}), sea trout (*M2* = 0.015 yr^{-1}), and seabirds (*M2* = 0.011 yr^{-1}). Sea trout and red drum remained key predators for older Gulf menhaden (ages 1+), in addition to juvenile king and Spanish mackerels (Figure 6). Predation mortality by juvenile king mackerel increased with age for Gulf menhaden (age-2, *M2* = 0.019 yr^{-1}; age-3, *M2* = 0.052 yr^{-1}; and age-4+; *M2* = 0.229 yr^{-1}). Additional top predators of Gulf menhaden included blacktip shark (e.g., Gulf menhaden age-4+; *M2*= 0.019 yr^{-1}), adult gag grouper (e.g., Gulf menhaden age-3; *M2* = 0.002 yr^{-1}), coastal piscivores (e.g., Gulf menhaden age-3; *M2* = 0.013 yr^{-1}), and coastal dolphins (e.g., Gulf menhaden age-2; *M2* = 0.009). Other predators which exhibited lower rates of predation on Gulf menhaden are shown on the x-axis in Figure 6.

System summary statistics

The US Gulf-wide Ecopath model displayed one of the highest indices of connectance and system omnivory among GoM models examined (Table 22), although estimates were lower than the nGoM model developed for the time period 2005-2009 (Sagarese *et al.,* 2017). This result is likely attributable to the greater number of multi-stanza groups in the 1980 model, which split out key fisheries species into age classes (e.g., menhaden) or species (e.g., shrimp). In addition, some predator-prey interactions were re-evaluated and modified following input from stakeholders.

Among regional models, the US Gulf-wide Ecopath model produced higher estimates of respiration, exports, total system throughput, and production, but lower estimates of consumption and catch (Table 22). Total system throughput and production were also higher than other LMEs, yet lower than the upwelling system in Peru (Tam *et al.*, 2008, Table 22). The US Gulf-wide EwE model showed high throughput (18,917 t km^{-2} yr^{-1}) out of which 8,936 and 9,980 t km^{-2} yr^{-1} are sourced from detritus and primary productivity, respectively. The relatively high ratio between detritus and primary productivity throughput is characteristic of a shallow-water detritus-driven GoM system, which is similar to the Gulf of California ecosystem (Arreguın-Sánchez *et al.*, 2002), and is in contrast to upwelling systems, such as Peru, that are dominated by primary productivity (Tam *et al.*, 2008; Table 22). Similarly, as expected for a highly fished, shallow, warm-water, productive, and detritus-driven system, the mean trophic level of the catch was low (*TL* = 2.34) due to the large portion of forage fish (Gulf menhaden), shrimp, and crab in the catch, but was reduced from the 2005 to 2009 nGoM Ecopath model estimate (*TL* = 2.8). This result may be attributed to the increased landings of Gulf menhaden in the 1980s as well as better characterization or increased representation of dead discards within the model, which often include lower trophic level groups. A noteworthy difference between the 2005-2009 nGoM Ecopath model and the US Gulf-wide Ecopath model is in the transfer efficiency, with 20.41% and 7.9%, respectively (Table 22). This difference is likely attributed to alternative model structure compared to the 2005 model (e.g., greater resolution of lower trophic level groups including menhaden and shrimp), and input values that lead to lower *EE*, which in turn result in lower transfer efficiency.

Trophic Levels

Group-level *TL* analysis (Table 18) indicated that yellowfin tuna exhibited the highest estimated *TL* (3.85) followed by offshore dolphins (3.79) and dusky shark (3.75; Table 18), which fed upon a range of teleost and invertebrate prey items (Table 8). Estimated *TL*s for other sharks ranged from 3.64 for sandbar shark and large coastal sharks to 3.39 for the smaller coastal Atlantic sharpnose shark. Other predatory groups include swordfish (*TL* = 3.75), goliath grouper (*TL* = 3.59), greater amberjack (*TL* = 3.57), and Spanish mackerel (*TL* = 3.54). Mid trophic level finfish groups, which feed largely on invertebrates, included red snapper (*TL* = 3.32-3.42), mutton snapper (*TL* = 3.24) and tilefish (*TL* = 3.27). The main forage fish in the GoM ecosystem is the Gulf menhaden (*TL* = 2.25), which accounts for ~85% of forage fish biomass, although it is important to note the high uncertainty in estimating total biomass for the other forage fish groups due to the lack of stock assessments. The different age classes of the Gulf menhaden support a total of 32 predator groups (Figure 5) and are particularly important in the diets of coastal predators such as red drum and sea trout and more pelagic species such as king and Spanish mackerels (Figure 6). Other forage groups consisting of teleosts in the model include the sardine-herring-scad complex (*TL* = 2.77), the anchovy-silverside-killifish (*TL* = 2.62) complex, and mullet (*TL* = 2.41). These forage groups collectively support a large spectrum of predators, some of which are not supported by Gulf menhaden, likely due to different habitat preferences and lack of spatial overlap (e.g., yellowedge grouper, goliath grouper, red snapper, vermilion snapper, and mutton snapper).

The commercial pelagic longline, commercial shark longline and recreational charter fleets yielded the catches with the highest *TL*s (*TL* of catch = 3.79, 3.42, and 3.37, respectively; Table 15). In contrast, the lowest *TL*s of the catch occurred for the commercial dredge/dig fleet (*TL* of catch = 2.01), the commercial bottom trawl fleet targetting species other than shrimp (*TL* of catch = 2.07), and the commercial purse seine menhaden fleet (*TL* of catch = 2.26; Table 15). The remaining fishing fleets generally caught fish with *TL*s ranging from 3.3 to 2.3 on average (Table 15).

Network analysis

The overall trophic flows among functional groups and *TL*s show that most of the flows from detritus and primary producers occur within discrete trophic levels 1-3 (>99.2%), i.e., largely through primary producers, primary consumers, and secondary consumers. Transfer efficiency was 7.835% from primary producers, 8.105% from detritus, and 7.9% in total, with 47% of total flow originating from detritus, which is expected in a detritus-driven system such as the GoM. Gulf menhaden accounted for 8.3% of the total flows from discrete trophic levels 2 to 3 and for 93% out of all fish-related groups (Table 23), demonstrating the important role of menhaden in the GoM ecosystem. The model exhibited a relative ascendancy value of 37.4%, indicating an organized system compared to other systems (Table 22), but less organized compared to the upwelling system of Peru (relative ascendancy = 46.2%; Tam *et al.*, 2008, Table 22; Ulanowicz and Norden, 1990).

The main functional groups with the highest flows included the primary producers: algae, seagrass, phytoplankton, and detritus (819.5, 3750, 4000, and 8152 t km^{-2} yr^{-1} respectively), followed by sessile epifauna, mobile epifauna, zooplankton, and infauna (108.01, 288, 1110.3, and 407 t km^{-2} yr^{-1}, respectively). Out of the harvested groups, age-0, age-1, and age-2 Gulf menhaden had the highest flows of 81.2, 96.7, and 30.9 t km^{-2} yr^{-1}, respectively. Main flows from primary producers and detritus to secondary producers include zooplankton, infauna, and mobile epifauna at 1061, 390, and 253.7 t km^{-2} yr^{-1}, respectively. Transfer efficiencies were 7.9% for total flow, and 7.8% and 8.1% from primary producers and detritus, respectively. These values are relatively low compared to other systems, potentially due to a high proportion of unexplained mortality in the current model. The limited availability of absolute biomass estimates for lower trophic levels may have led to an under-representation of their biomasses in the modeled system. Alternative Ecopath configurations, which estimate biomass based on input *EEs*, could be explored to identify alternative biomass estimates for these uncertain groups.

Ecosim

Ecosim base run configuration

The base configuration was achieved after finalization of the reference time series and refinement of the Ecopath parameters, the vulnerabilities matrix, and the estimated primary production (PP) anomaly time series. The Ecosim tuning and calibration process represents a tradeoff between reducing the SSE and achieving realistic model performance and parameterization. The overall SSE was reduced from 12,572 at the start and before applying the automatic fitting routine to 4,582 after applying the automated fitting routine. Given the differences in time series and weightings applied to each, the SSE values are not comparable among the different models. The final vulnerability matrix and estimated PP anomaly are given in Table S3.1 and Figure S3.1, respectively.

Ecosim fits

Ecosim predictions largely correspond to observed trends in historical biomass (Figure 7) and catch (Figure 8), especially for those economically important groups for which data were obtained from SEDAR stock assessments (e.g., greater amberjack, Spanish mackerel, and yellowedge grouper). In contrast, modeled trends did not always fit the biomass and catch data for groups such as sharks (Figures 7-8) and HMS species (e.g., yellowfin tuna; Figures 7-8). Time series estimates for these groups were considered uncertain given concerns with the representativeness of the data for the GoM region and their movement (i.e., migration). Therefore, the weights applied to time series for these groups during model fitting were relatively low to capture the large uncertainty (Table 16). Moreover, in cases where fishing mortality time series were not available, fishing pressure was forced based on fishing effort, which is not group-specific and was characterized by rough trends in the number of vessels or gears fished over time, and therefore does not always correspond to the actual fishing mortality exerted on a given species.

The Ecosim optimization routine, which attempts to reduce the overall SSE, focuses on groups with higher weights (i.e., lower CV) which, in turn, artificially increase the group's SSE. For example, the model predicts the catch of adult (3+ yr) yellowedge grouper almost perfectly (Figure 8), but the associated SSE is relatively high (24.13) due to the high weight assigned to this group's catch (27.14). Similarly, adult (3+ yr) red snapper, tilefish, Gulf menhaden (all age classes), and brown shrimp, also exhibit good fits with high SSEs. In some cases, the trend was generally correct, but the model missed the high frequency fluctuations (e.g., biomass of billfish, bluefin tuna, and swordfish). This is reasonable for HMS, since large-scale oceanic migrations are not well captured by the closed EwE model. For other groups, such as the white, pink, and brown shrimps, the model did not adequately capture the relatively high biomass of GoM shrimp from 2007 to 2013, which was evident in the reference time series. Similarly, the model missed a sharp decline in red grouper and gag grouper biomass during 2005, which was attributed to red tide mortality (SEDAR 61, 2019; SEDAR 33 Update, 2016), a process that is not currently included as a forcing function in this model. Additional discrepancies between observed data and predicted data are possibly associated with environmental drivers that represent areas of future research, including water temperature effects, ocean circulation, or other nutrient sources, such as upwelling.

Conversely, model predictions were relatively poor for the group biomasses of some young age-stanzas, including juvenile (0-3 yr) yellowedge grouper, red grouper, and gag grouper, possibly due to the lack of interannual recruitment deviation estimates in Ecosim. Groups such as shallow-water grouper exhibited poor fits to biomass inputs, which could indicate that the relative index of abundance used for a single species was not representative of the aggregate group. Note that for groups for which fishing mortality time series were not available (i.e., deep water groupers and shallow water groupers), catch time series were defined as forcing, and therefore there are no SSE.

Ecosim F_{MSY} estimation

The evaluation of F_{MSY} estimates from Ecosim showed relative agreement with those derived from single-species stock assessments (Figures 9-10, Table 24). A slight bias towards higher F_{MSY} estimates in EwE compared to the assessment estimates (Figure 10) was observed, likely due to differences in age structure and selectivity, in addition to the foraging parameters. For several groups, prey vulnerabilities were adjusted to increase the correspondence between the EwE-derived and the assessment F_{MSY}.

Ecosim results summary

A comparison between ecosystem snapshots at the start (1980) and the end of the modeled time period (2016), resulted in an approximate 60% increase in biomass (excluding detritus) and 30% increase in fishery catches. Groups with higher biomass estimates in the recent period include yellowfin tuna, swordfish, adult (3+ yr) red snapper, and adult Gulf menhaden (2+ yr). In contrast, groups with lower catches and biomass in the recent period include large oceanic sharks, other tunas, adult (1+ yr) Spanish mackerel, adult (1+ yr) king mackerel, and reef piscivores (Table 25). Overall, the US Gulf-wide EwE model results indicated a general trend of rebuilding stocks over the past 25 years (1992-2016). These findings are in agreement with those reported in the GoM ecosystem status report (Karnauskas *et al.* 2017). The GoM ecosystem status report as well as the US Gulf-wide EwE model highlight a recovery of multiple groups, such as Spanish mackerel, king mackerel, and red snapper, in contrast to other groups for which stocks were declining in the recent period, e.g., Atlantic sharpnose shark.

Interestingly, the primary production anomaly time series increased ~30% in the simulation time period (Figure S3.1), with higher trophic levels characterized by higher proportional increases (Table 25). This result may be explained by complex interactions and various feedback processes that can result in non-linear amplifications or reductions (Levin, 1998). A classic example for such an effect is the non-linear change that the presence of keystone species such as sea otters caused on the littoral and sublittoral species abundance and composition in the western Aleutian Islands (Estes and Palmisano, 1974). Similarly, fluctuations in primary productivity can propagate up the food web resulting in complex dynamics in higher trophic levels in the ecosystem (Kearney *et al.*, 2013).

Lastly, species diversity and mean trophic level of the catch did not show a large change over the modeled time period, as predicted by the US Gulf-wide EwE model (Figure 11). The model predicted a slightly increasing *TL* of the catch since 1990, potentially a result of lower menhaden harvest. The Shannon's diversity index revealed a slow decline through the mid-1990s, and has shown a slight increase thereafter (Figure 11). These finding are generally in line with the trends published in the GoM ecosystem status report, which were largely based on the same input data (Karnauskas *et al.* 2017).

Conclusions

The development and calibration of the US Gulf-wide EwE model presented in this report represents a substantial first step in supporting EBFM in the GoM and provides a useful tool to complement single-species stock assessment and fishery management decisions. The model represents a state-of-the-art EwE model in taxonomic resolution that spans key ecologically and economically important species and incorporates diverse datasets of reference time series used for model calibration, as well as integration of fleet bycatch across fisheries. Both the Ecopath and Ecosim components of this model are based on current best practices and available data at the time of model development. Overall, the predicted trends in biomass and catch match associated time series inputs and EwE predictions of fishing mortality reference points match those estimated as part of the SEDAR process (e.g., F_{MSY} from stock assessments). As presented, this model could be applied for a number of different species and research questions pending small modifications and peer review (Table 26). Extensive modifications such as disaggregating marine mammal and sea turtle groups and data additions such as time series of biomass for marine mammals or sea turtles could increase utility of this model for addressing protected resource issues

(Table 26). This work identifies clear data gaps and uncertainties associated with the various data inputs, which is expanded upon below. Nevertheless, this work represents a key advancement in developing a tool that can be used to provide analytical support for Ecosystem-based Fisheries Management (EBFM) in the GoM.

Future work

The US Gulf-wide EwE model presented in this study will need to be updated with newly acquired input data representing the best scientific information available. In addition to keeping the model up-to-date, such data may reflect previously unobserved dynamics in the ecosystem and so such updates are important in ensuring the model is an accurate representation of the functioning of the true ecosystem. Occasional model updates will therefore be necessary in the future such as:

- Incorporating diet data as they become available, particularly for juvenile fishes and higher trophic level predators (see Table S1.1 in Appendix 1), for which comprehensive GoM-specific data are lacking.
- Gain a better understanding of predation on age-0, juvenile, and adult Gulf menhaden through traditional diet studies or DNA barcoding approaches.
- Updating recreational landings to reflect the newest and best available estimates based on the MRIP Fishing Effort Survey. Incorporation of this dataset would also improve characterization of recreational data in 1981 due to improved QAQC and species identification issues.
- Updating reference time series for recently conducted stock assessments and extending Ecosim simulations through 2020.
- Incorporating the effect of additional environmental drivers including water temperature effects, ocean circulation, or other nutrient sources, such as upwelling.

Ongoing work with the US Gulf-wide EwE model includes addressing the following research questions:

- Examination of the possible effect of optional Gulf menhaden harvest strategies on the GoM ecosystem.
- Development of ecological indicators related to the Gulf menhaden fishery.
- Development of the spatial component of EwE (Ecospace) for our model domain, with the objective of capturing spatially explicit dynamics in the GoM ecosystem as separated into different management zones (e.g., east vs. west).

Other potential uses of the US Gulf-wide EwE model pending data additions, model improvements and technical review include:

- Evaluation of Gulf-wide bycatch reduction programs on fisheries and protected resources
- Marine spatial planning
- Climate vulnerability analysis
- Evaluating the importance of habitat on fisheries productivity
- Operating model of ecosystem dynamics for simulation-based studies or management strategy evaluation

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Figures

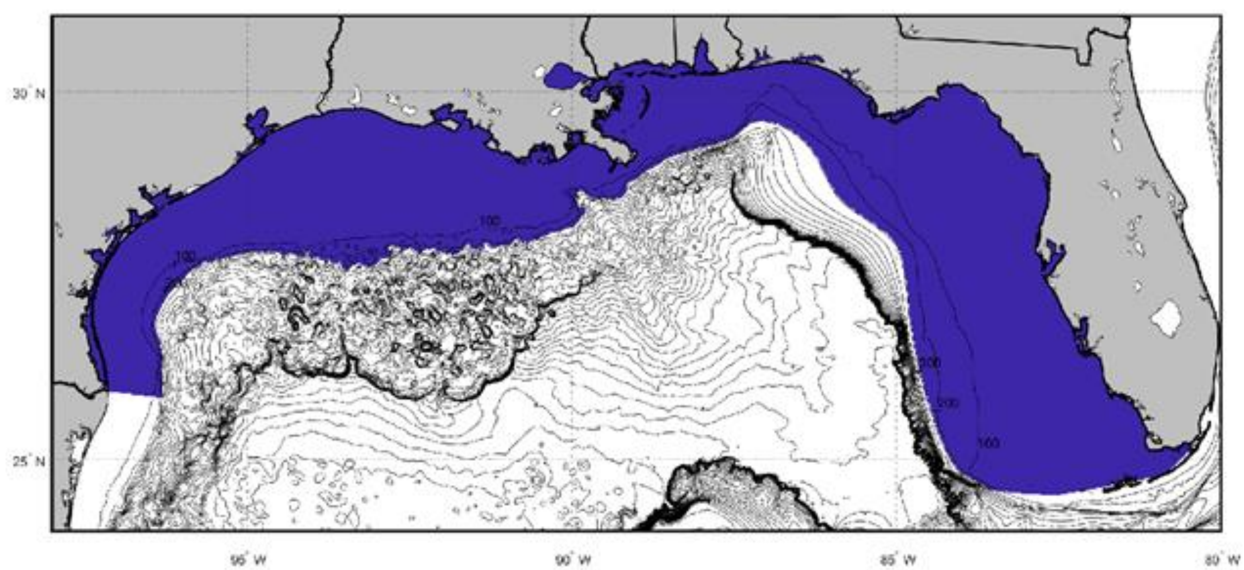

Figure 1. US Gulf-wide EwE model's spatial domain (purple color) includes aquatic habitat in the coastal and shelf areas of the US GoM down to a depth of 400 m.

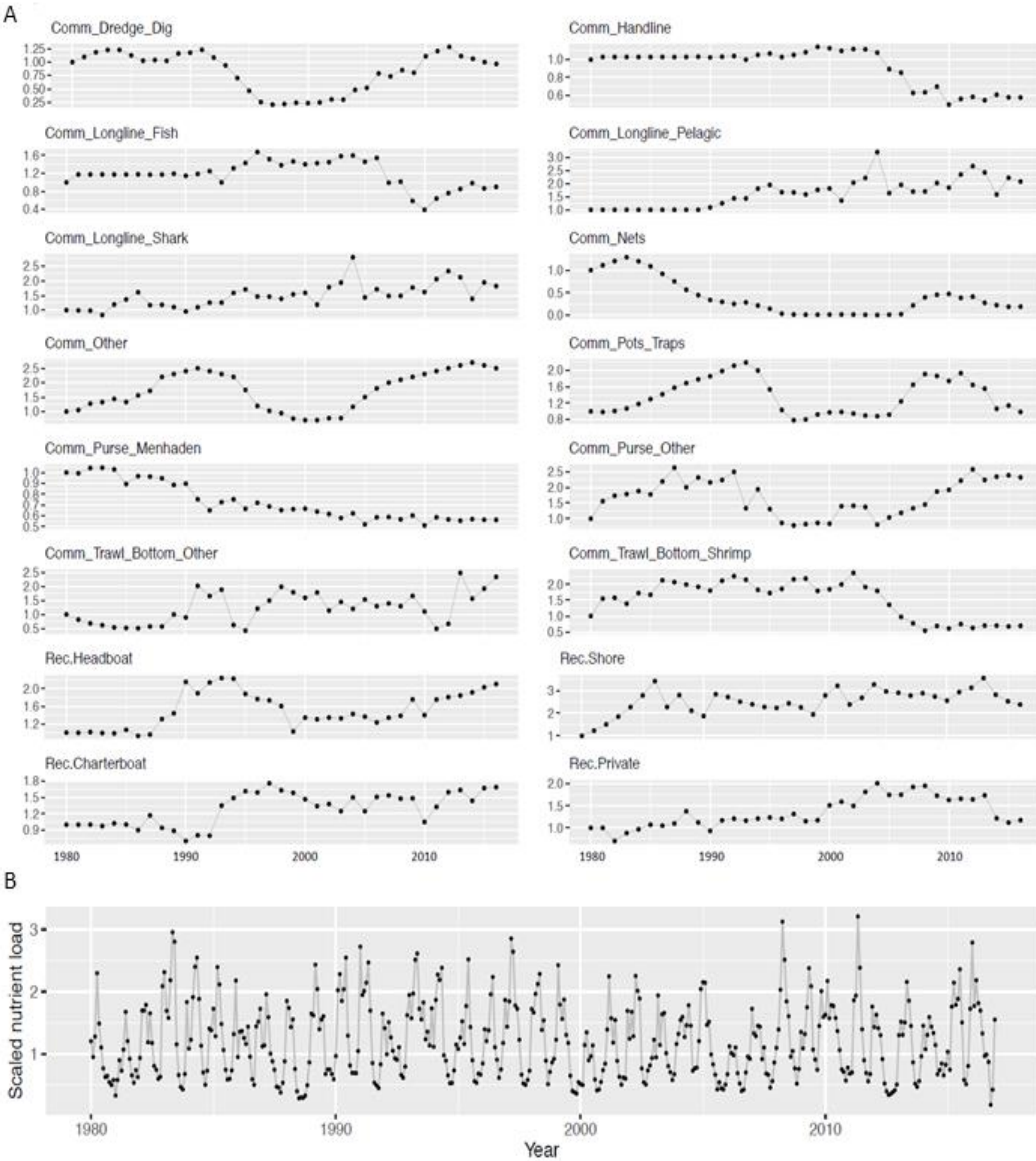

Figure 2. US Gulf-wide EwE model's forcing functions for (A) Relative annual fishing effort by fleet, and (B) Relative monthly nutrient influx from the Mississippi-Atchafalaya river basin.

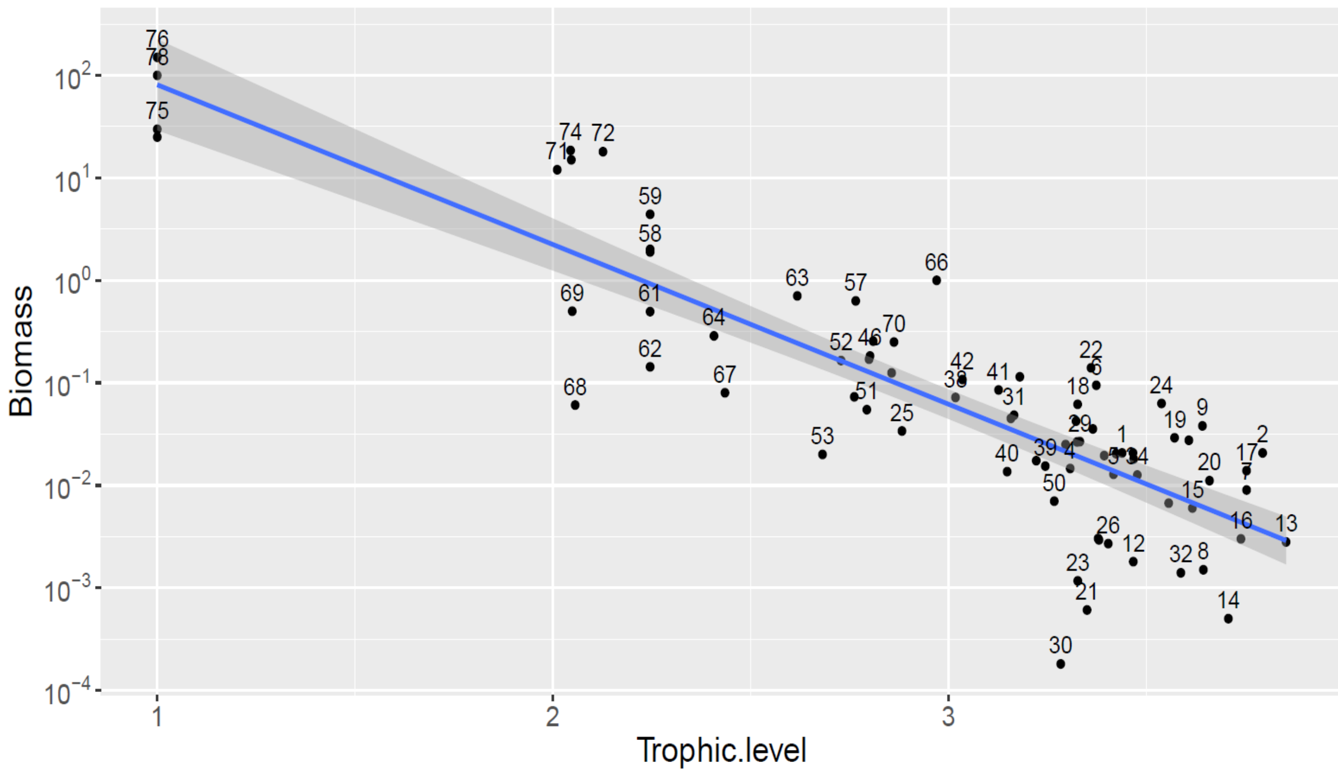

Figure 3. Biomass of functional groups (labeled by group number) versus trophic level (*TL*). Biomass is log10 transformed. Line represents fitted linear regression (estimate = 3.47, slope = -1.56, Adjusted $R^2 = 0.74$, $F_{1,76} = 215.5$, p-value: < 0.0001). Shaded area represents linear regression ± 95% Confidence Interval (CI).

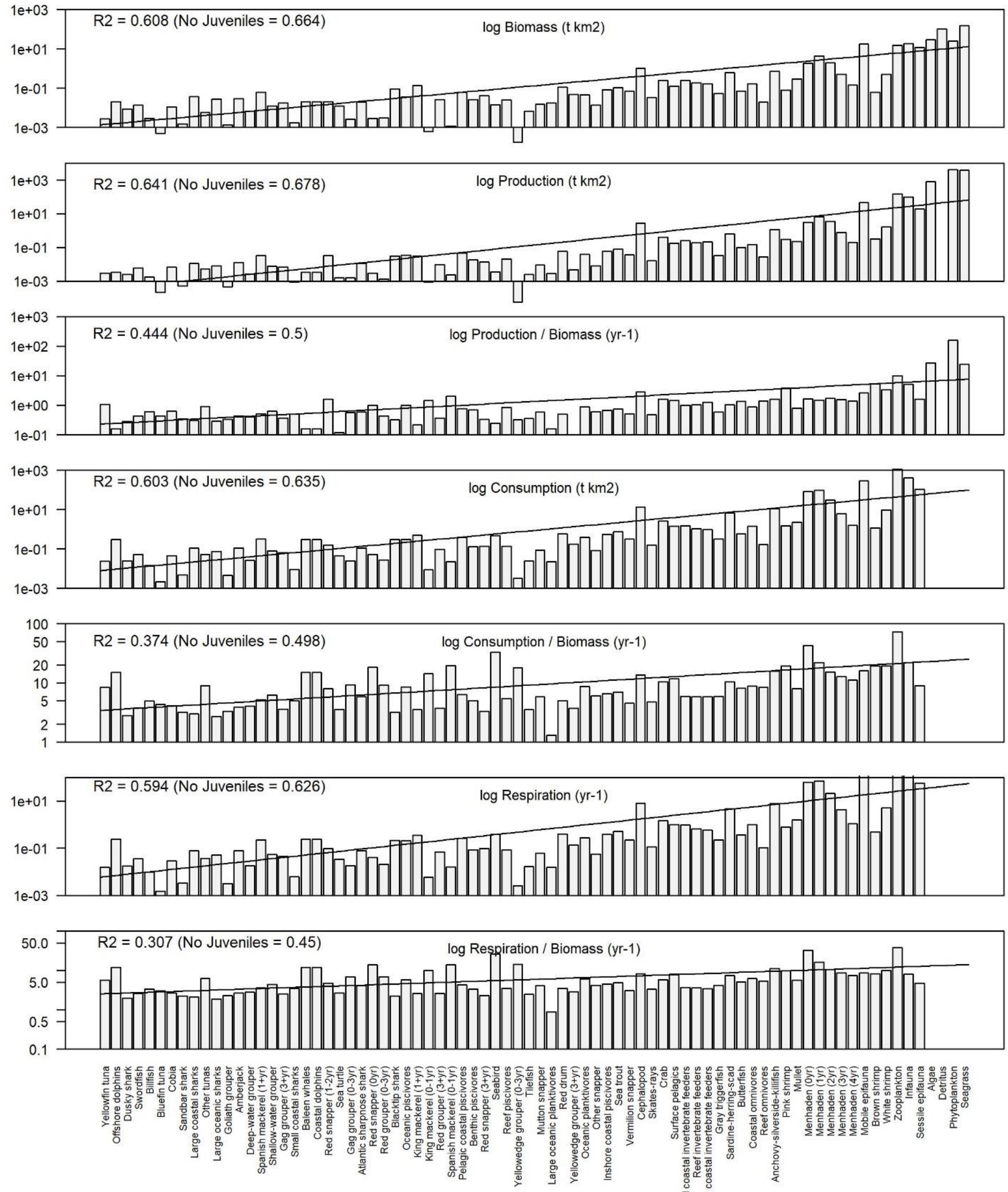

Figure 4. Trends in log-scaled biomass (*B*), production (*P*), consumption (*Q*), respiration (*R*) and vital rates (*P*/*B*, *Q*/*B*, *R*/*B*) across trophic levels. Note that biomass is log-transformed because biomass spans several orders of magnitude. Functional groups, as described in Table 1, are organized by decreasing trophic level (from left to right). As per Link (2010), homeothermic groups (e.g., marine mammals, seabirds) are excluded from regression analyses for *Q*/*B* and *P*/*B*.

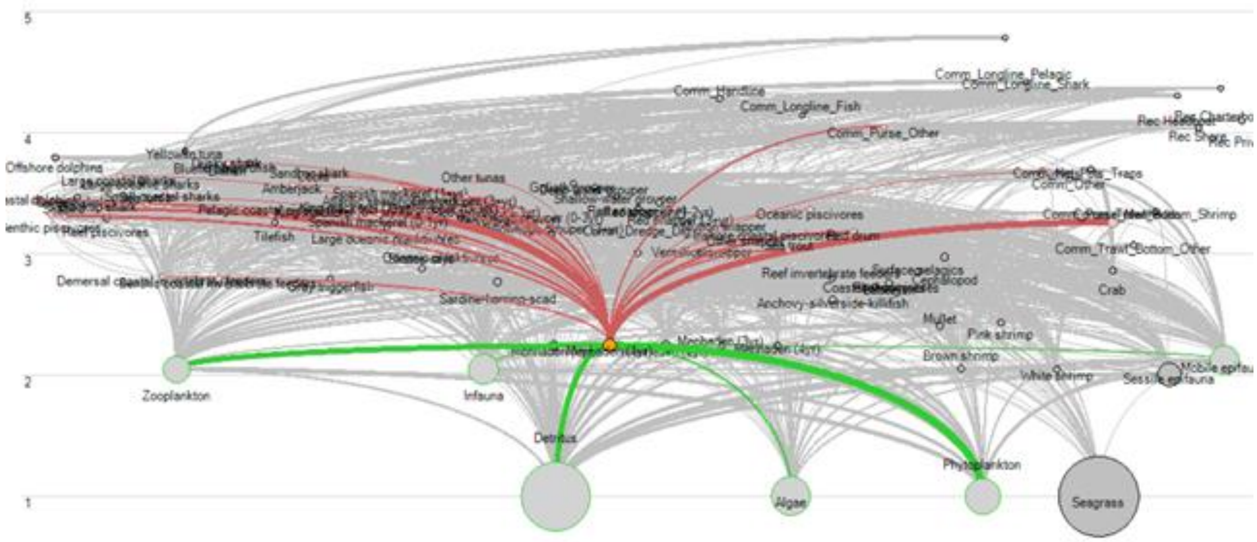

Figure 5. Flow diagram of the US Gulf-wide Ecopath model. Nodes represent modeled trophic groups with the size of the node proportional to biomass and lines represent trophic interactions between groups. Numbers on the left represent trophic level. As an example, the age-2 Gulf menhaden functional group is colored orange, the main food sources of which are phytoplankton, detritus, and zooplankton (green lines) and which supports the removals (predation and fishing, red lines) from 32 trophic groups and 3 commercial fleets.

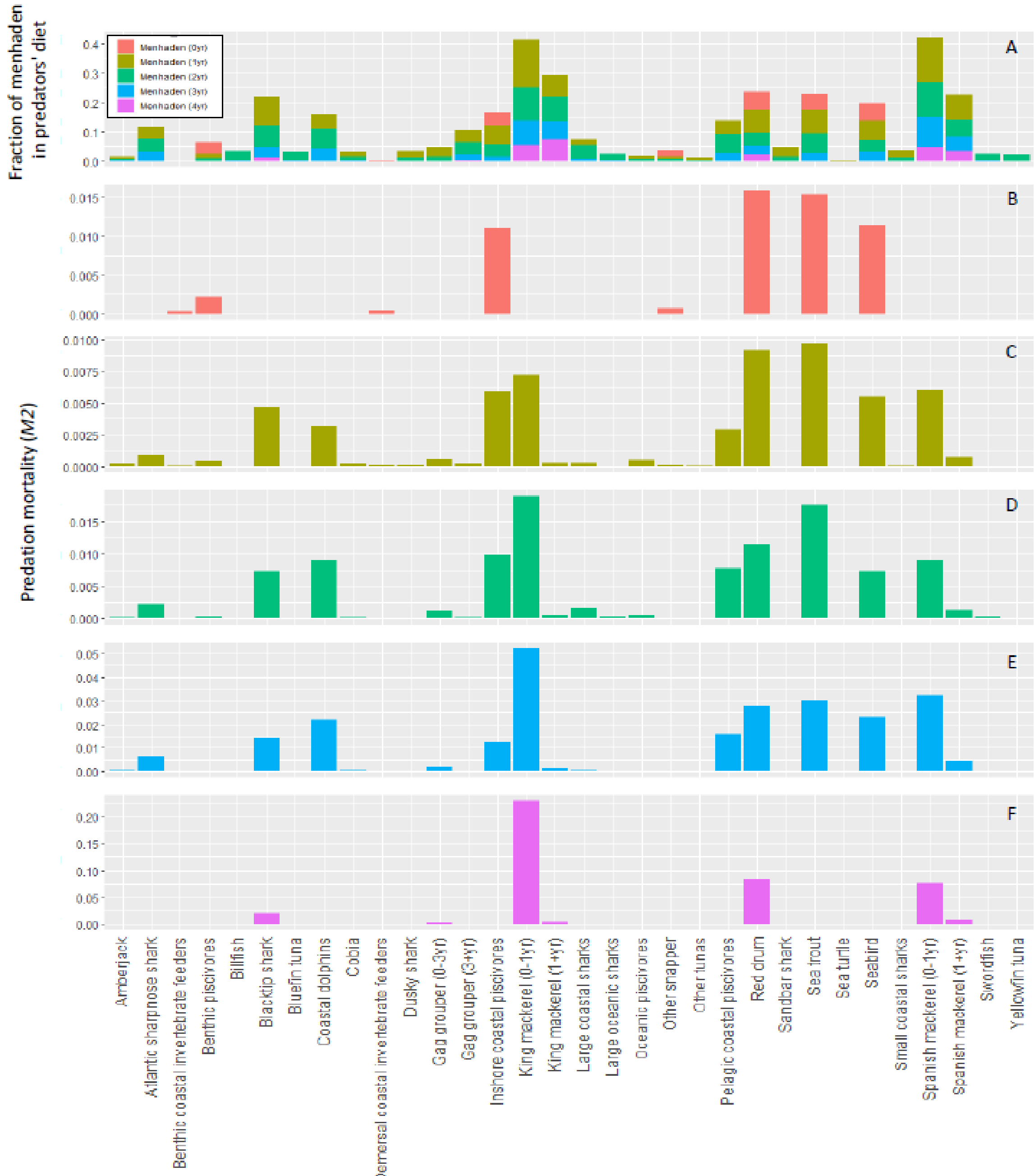

Figure 6. The contribution of Gulf menhaden to the diets of the different predators in the US Gulf-wide EwE model (A). Predation mortality for age-0 (B), age-1 (C), age-2 (D), age-3 (E) and age-4+ (F) Gulf menhaden by predator.

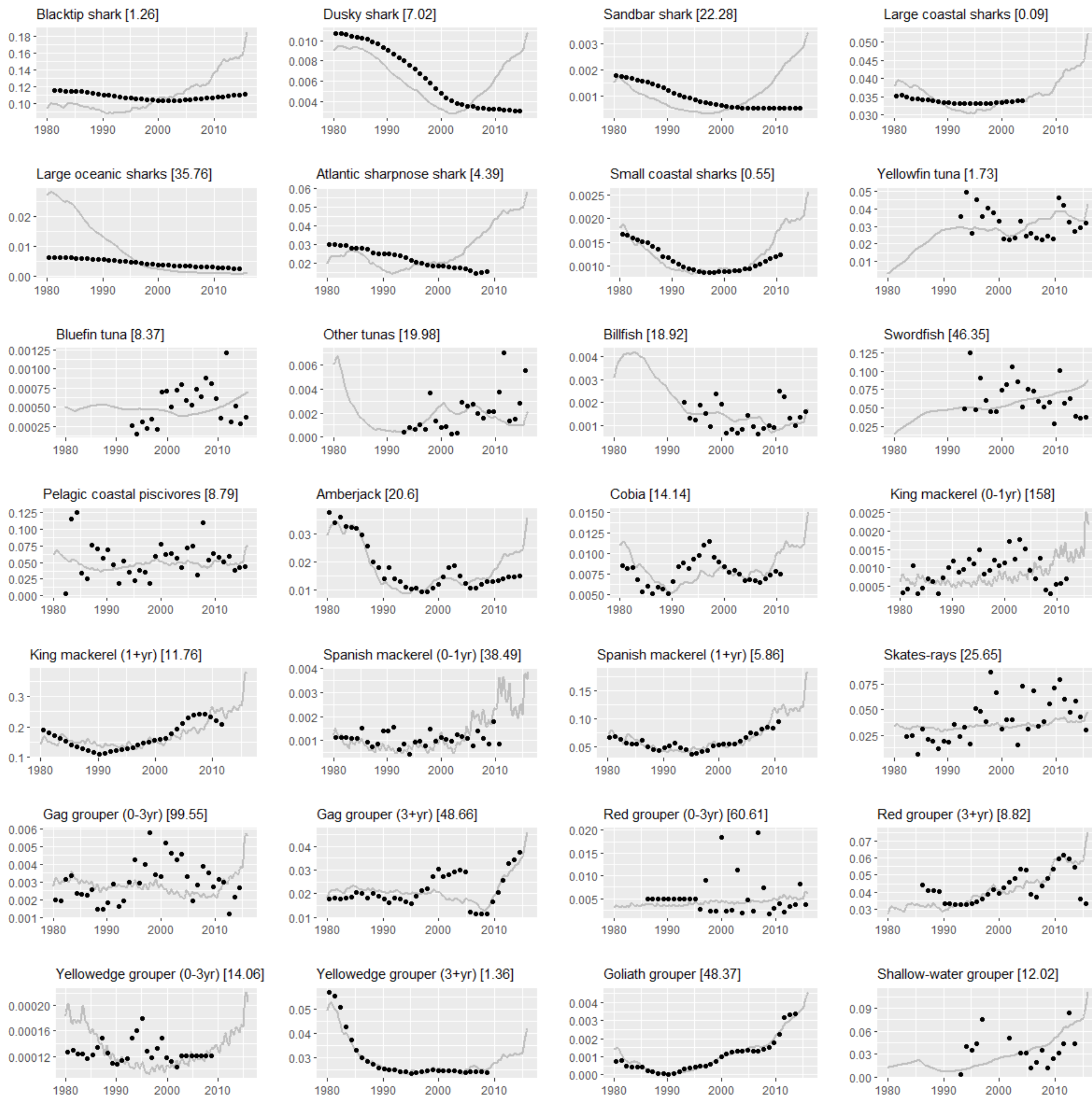

Figure 7. Time series fits for group biomass. Observed (black points) and predicted (grey lines) biomass estimates by year from the US Gulf-wide EwE model. The sum-of-squared errors (SSE) of model fits are given in squared brackets.

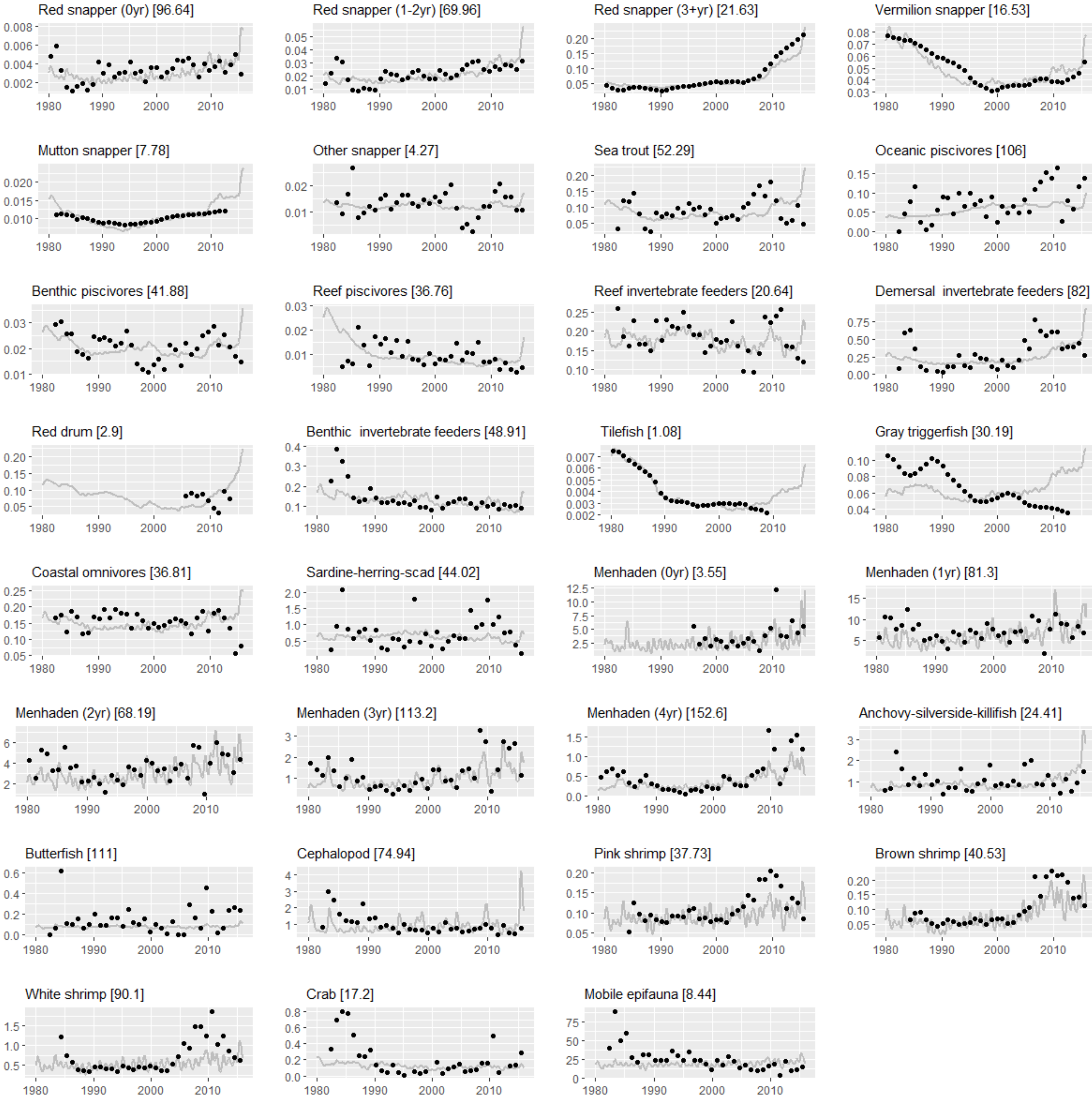

Figure 7-Continued. Time series fits for group biomass. Observed (black points) and predicted (grey lines) biomass estimates by year from the US Gulf-wide EwE model. The sum-of-squared errors (SSE) of model fits are given in squared brackets.

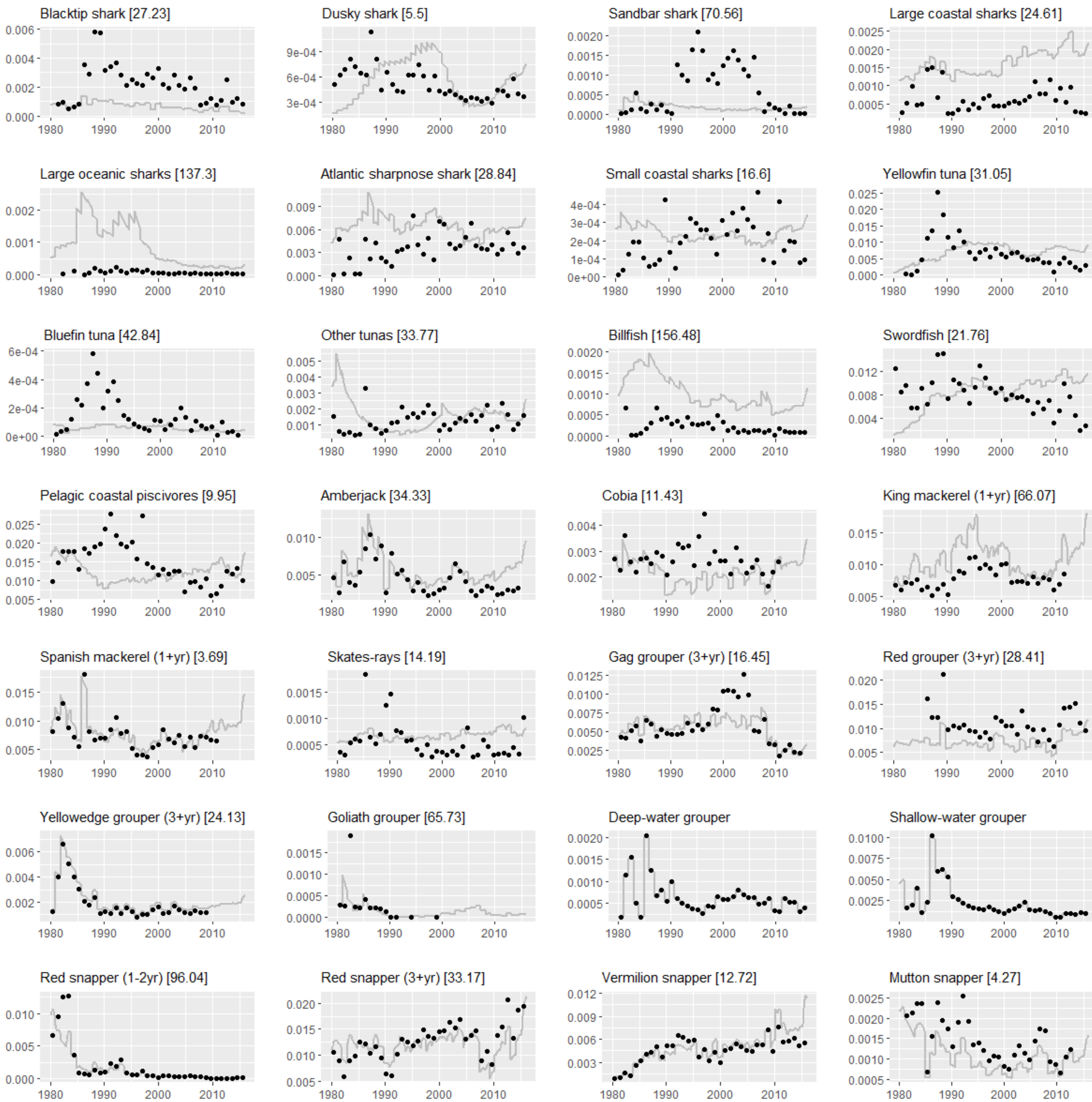

Figure 8. Time series fits for group catches. Observed (black points) and predicted (grey lines) biomass estimates by year from the US Gulf-wide EwE model. The sum-of-squared errors (SSE) of model fits are given in squared brackets. Note that for shallow-water and deep-water groupers, catch time series are used as forcing time series (Table 16).

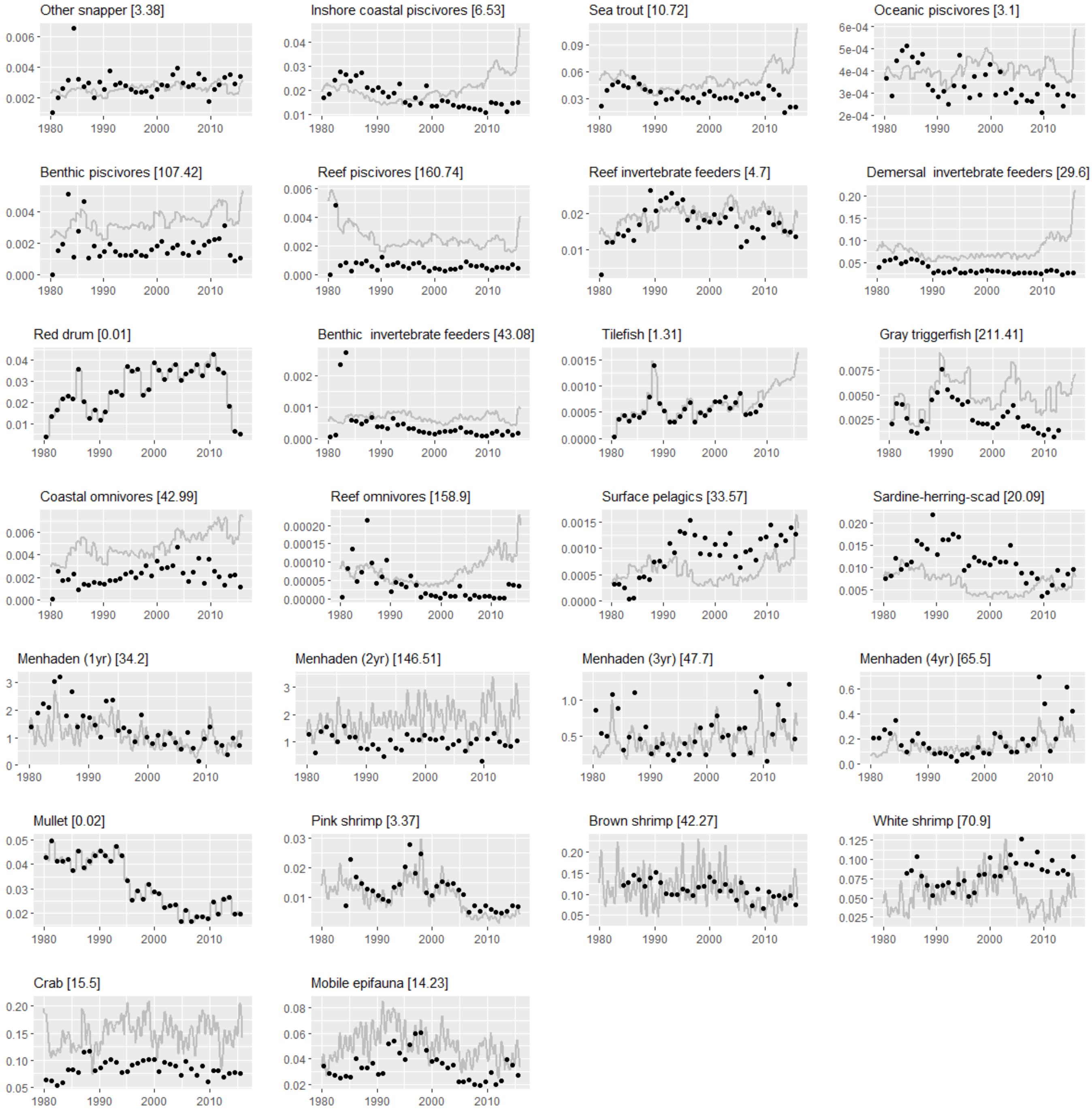

Figure 8-Continued. Time series fits for group catches. Observed (black points) and predicted (grey lines) biomass estimates by year from the US Gulf-wide EwE model. The sum-of-squared errors (SSE) of model fits are given in squared brackets. Note that for red drum, catch time series are used as forcing time series (Table 16).

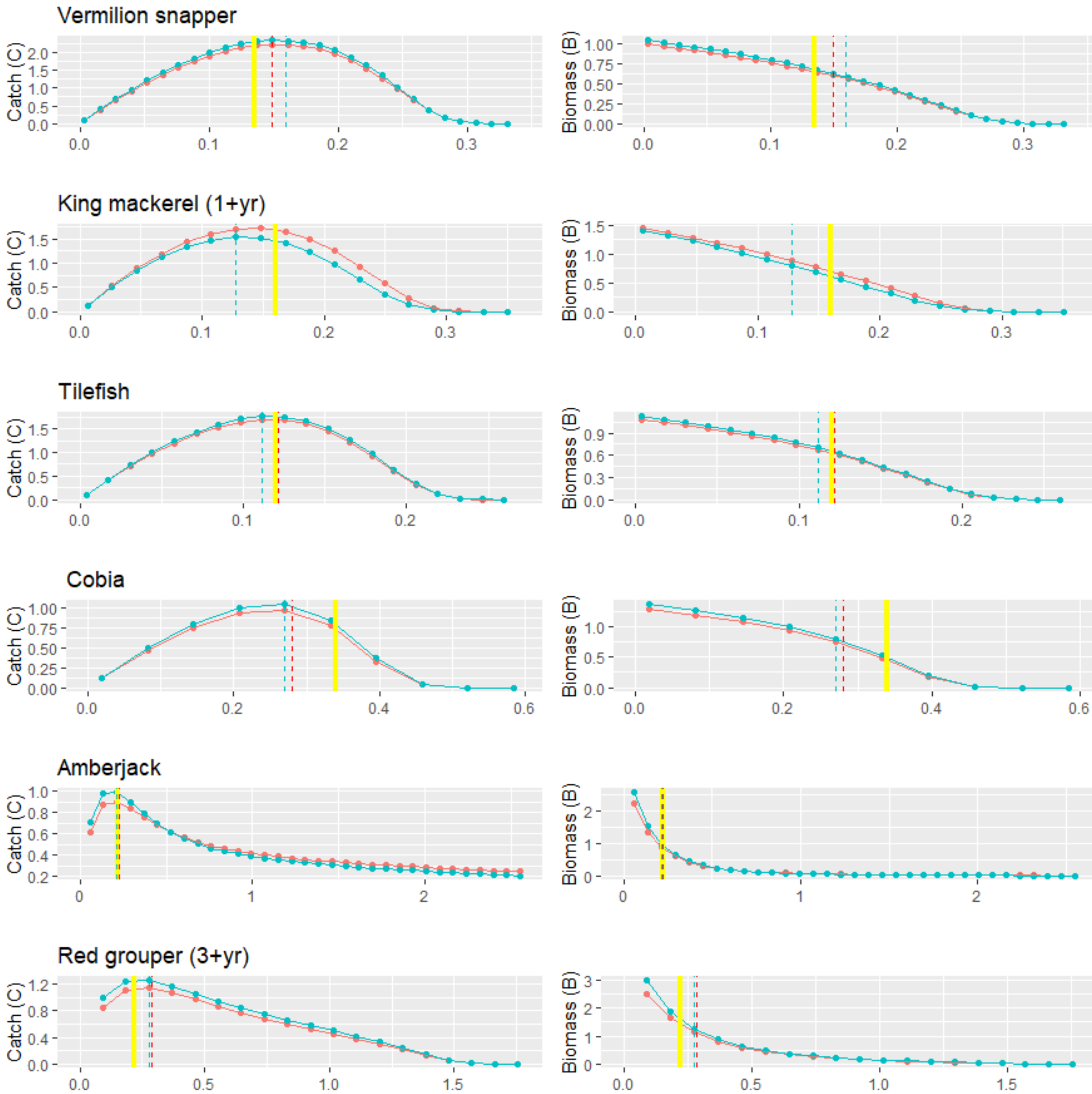

Figure 9. F_{MSY} for selected species. Red lines represent a stationary system in which all other groups have fixed biomass, whereas blue lines represent compensatory systems, in which the other groups' biomasses change in response to the change in the target group. Red and blue dashed lines represent the EwE stationary and compensatory systems F_{MSY} estimates. Yellow lines represent the F_{MSY} estimated by single species stock assessment. For more information on F_{MSY} estimates from stock assessment, see Table 24.

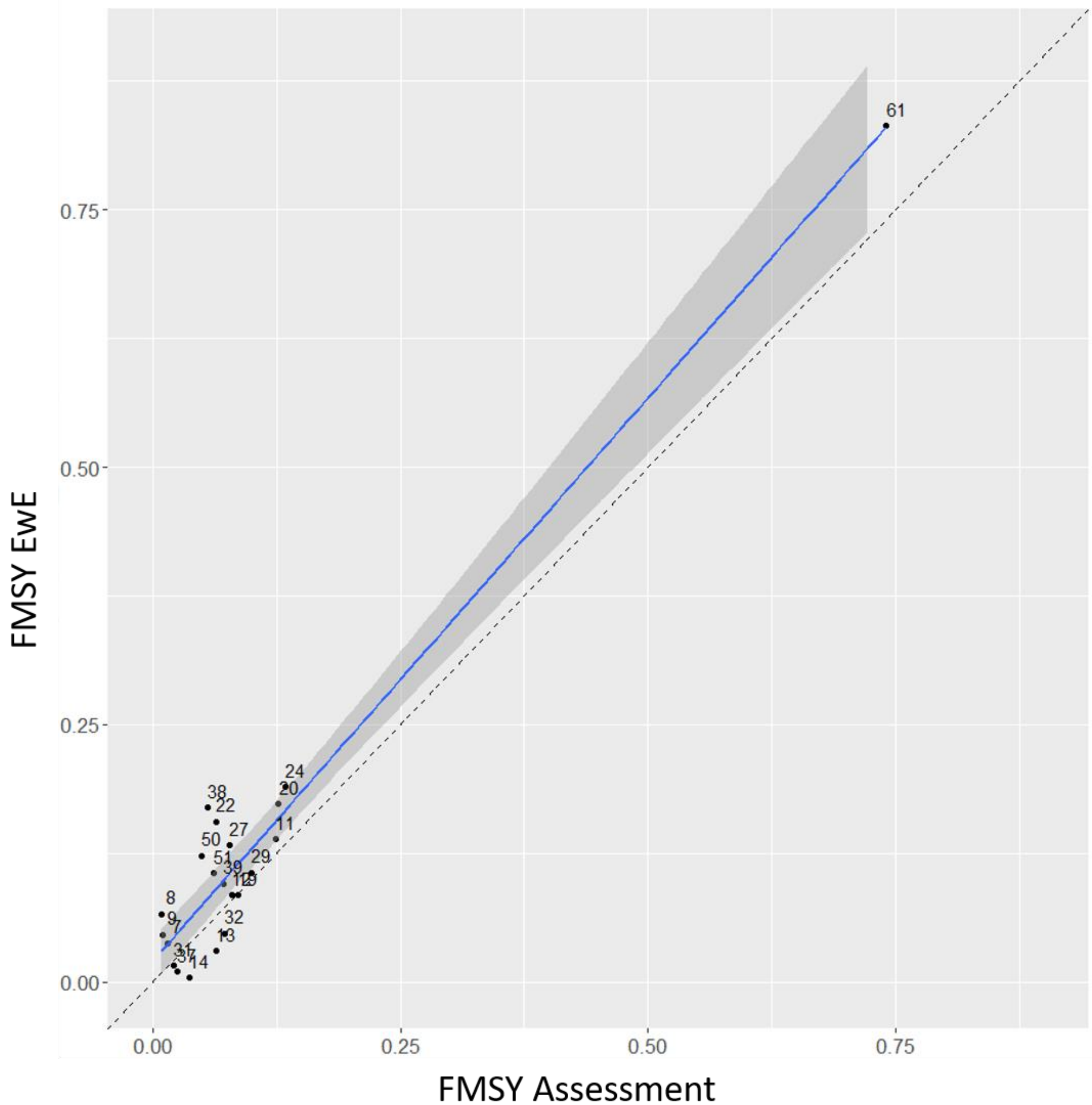

Figure 10. Relationship between estimates of F_{MSY} derived from EwE and the estimates produced by stock assessments. F_{MSY} was $\log_{10}$(X+1) transformed. Numbers in the plot represent functional group numbers (for list of names see Table 1). For more information about the F_{MSY} estimates see Table 24.

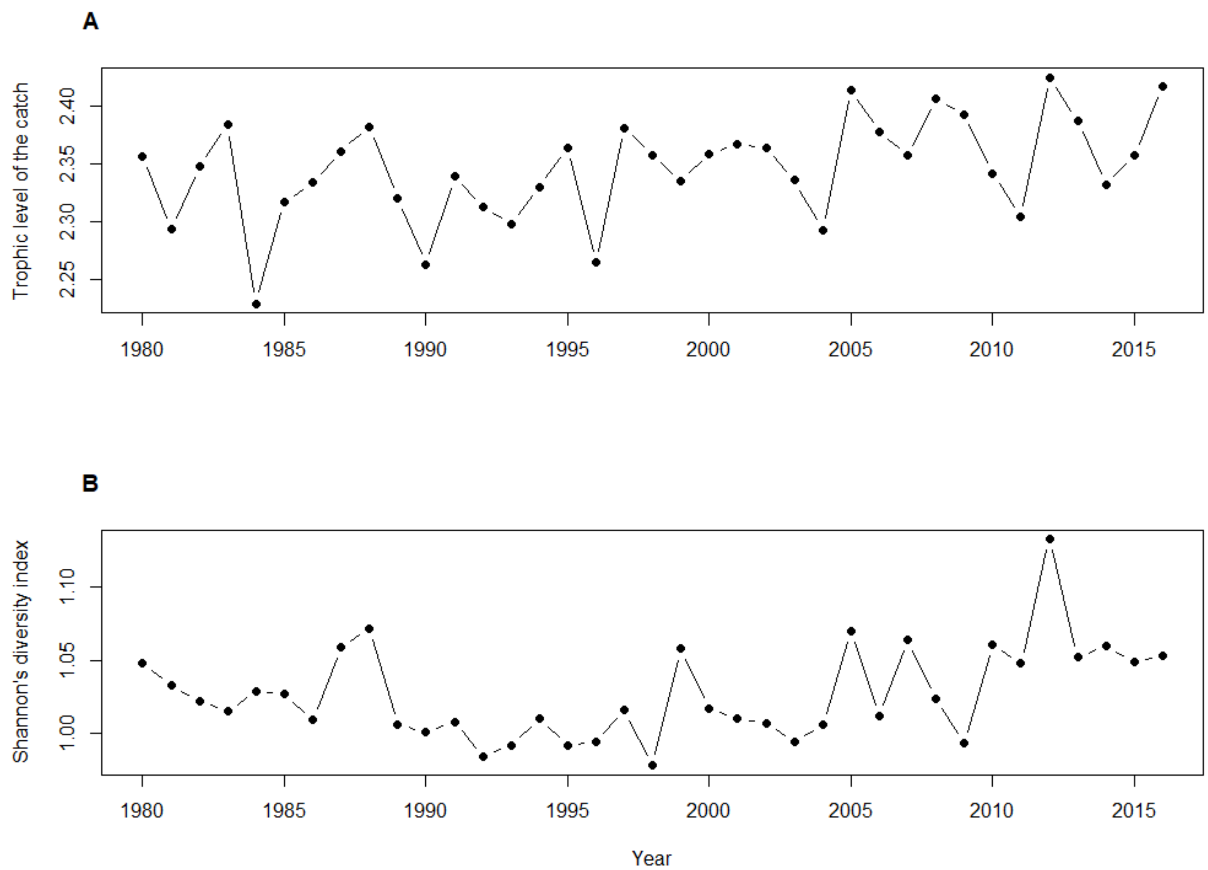

Figure 11. Ecosim ecosystem indices of (A) trophic level of the catch and (B) Shannon's diversity index.

Tables

Table 1. Marine taxa included in functional groups of the US Gulf-wide EwE model. For the full list of species see supplementary file. Guilds include: Benthic Invertebrates (BI), Demersal and Medium Pelagic Piscivores (DMPP), Demersals (D), Detritus (DET), Marine Mammals and Birds (MMB), Phytoplankton (PHY), Planktivores (PLK), Primary Producers (PP), Sharks and HMS (S and H), Small Pelagics (SP), and Zooplankton (ZOO).

No	Functional group	Guild	Included taxonomic groups
1	Coastal dolphins	MMB	Bottlenose dolphins, spinner dolphins
2	Offshore dolphins	MMB	Delphinidae
3	Baleen whales	MMB	Balaenoptera sp.
4	Seabird	MMB	Families of Phalacrocoracidae, Pelecanidae, Laridae, Gaviidae, Sternidae, Hydrobatidae, Procellariidae, Pandionidae, and Accipitridae.
5	Sea turtle	D	*Cheloniidae and Dermochelyidae.*
6	Blacktip shark	S and H	*Carcharhinus limbatus*
7	Dusky shark	S and H	*Carcharhinus obscurus*
8	Sandbar shark	S and H	*Carcharhinus plumbeus*
9	Large coastal sharks	S and H	Sphyrnidae, Odontaspididae, large Carcharhinidae.
10	Large oceanic sharks	S and H	Lamnidae, Alopiidae, *Prionace glauca*
11	Atlantic sharpnose shark	D	*Rhizoprionodon terraenovae*
12	Small coastal sharks	D	Carcharhinidae and Triakidae families, and *Sphyrna tiburo*.
13	Yellowfin tuna	S&H	*Thunnus albacares*
14	Bluefin tuna	S&H	*Thunnus thynnus*
15	Other tunas	S&H	*Katsuwonus pelamis, Thunnus obesus*, and *Thunnus Atlanticus*
16	Billfish	S&H	Istiophoridae
17	Swordfish	S&H	*Xiphias gladius*
18	Pelagic coastal piscivores	DMPP	Coryphaenidae, Pomatomidae, Carangidae, Echeneidae, Belonidae, Lobotidae, *Sarda spp.*, *Euthynnus spp., Auxis spp., Acanthocybium solandri*
19	Amberjack	DMPP	*Seriola dumerili, S. fasciata*
20	Cobia	DMPP	*Rachycentron canadum*
21	King mackerel (0-1yr)	DMPP	Age-0 to 1 year *Scomberomorus cavalla*
22	King mackerel (1+yr)	DMPP	Age-1 and older *S. cavalla*
23	Spanish mackerel (0-1yr)	DMPP	Age-0 to 1 year *S. maculatus*
24	Spanish mackerel (1+yr)	DMPP	Age-1 and older *S. maculatus*
25	Skates-rays	D	Rajidae, Gymnuridae, Myliobatidae, Dasyatidae, Rhinobatidae, *Ginglymostoma cirratum*
26	Gag grouper (0-3yr)	D	Age-0 to 3 years *Mycteroperca microlepis*
27	Gag grouper (3+yr)	D	Age-3 and older years *M. microlepis*
28	Red grouper (0-3yr)	D	Age-0 to 3 years *Epinephelus morio*
29	Red grouper (3+yr)	D	Age-3 and older years *E. morio*

Table 1-Continued. Marine taxa included in functional groups of the US Gulf-wide EwE model. For the full list of species see supplementary file. Guilds include: Benthic Invertebrates (BI), Demersal and Medium Pelagic Piscivores (DMPP), Demersals (D), Detritus (DET), Marine Mammals and Birds (MMB), Phytoplankton (PHY), Planktivores (PLK), Primary Producers (PP), Sharks and HMS (S and H), Small Pelagics (SP), and Zooplankton (ZOO).

No	Functional group	Guild	Included taxonomic groups
30	Yellowedge grouper (0-3yr)	D	Age-0 to 3 years *Hyporthodus flavolimbatus*
31	Yellowedge grouper (3+yr)	D	Age-3 and older years *H. flavolimbatus*
32	Goliath grouper	D	*E. itajara*
33	Deep-water grouper	D	*Hyporthodus niveatus, H. nigritus, E. drummondhayi, H. mystacinus*
34	Shallow-water grouper	D	*Epinephelus striatus, Mycteroperca venenosa, M. interstitialis, E. adscensionis, E. guttatus, M. phenax*
35	Red snapper (0yr)	D	Age-0 to 1 year *Lutjanus campechanus*
36	Red snapper (1-2yr)	D	Age-1 to 2 years *Lutjanus campechanus*
37	Red snapper (3+yr)	D	Age-3 and older years *Lutjanus campechanus*
38	Vermilion snapper	D	*Rhomboplites aurorubens*
39	Mutton snapper	D	*Lutjanus analis*
40	Other snapper	D	Lutjanidae
41	Coastal piscivores	DMPP	Megalopidae, Elopidae, Centropomidae, Albulidae
42	Sea trout	DMPP	Cynoscion spp.
43	Oceanic piscivores	DMPP	Trichiuridae, Gempylidae, Bramidae, *Merluccius albidus*
44	Benthic piscivores	DMPP	Paralichthyidae, Uranoscopidae, Synodontidae, Ophichthidae, Squatinidae
45	Reef piscivores	DMPP	Holocentridae, Sphyraenidae, Muraenidae, Congridae, *Rypticus* spp.
46	Reef invertebrate feeders	D	Serranidae, Labridae, Scorpaenidae, Chaetodontidae, Priacanthidae, Haemulidae, Sparidae, *Ocyurus chrysurus*
47	Demersal coastal invertebrate feeders	D	Sciaenidae, Ariidae, Gerreidae, *Trachinotus spp., Chloroscombrus chrysurus, Oligoplites saurus, Pagrus pagrus, Haemulon aurolineatum, Orthopristis chrysoptera*
48	Red drum	D	*Sciaenops ocellatus*
49	Benthic coastal invertebrate feeders	D	Pleuronectiformes, Triglidae, Polynemidae, Gobiidae, Ophidiidae
50	Tilefish	D	Malacanthidae
51	Gray triggerfish	D	*Balistes capriscus*
52	Coastal omnivores	D	Tetraodontiformes, Ephippidae, *Lagodon rhomboides*
53	Reef omnivores	D	Pomacanthidae, Acanthuridae, Pomacentridae, Scaridae
54	Surface pelagics	SP	Exocoetidae, Hemiramphidae

Table 1-Continued. Marine taxa included in functional groups of the US Gulf-wide EwE model. For the full list of species see supplementary file. Guilds include: Benthic Invertebrates (BI), Demersal and Medium Pelagic Piscivores (DMPP), Demersals (D), Detritus (DET), Marine Mammals and Birds (MMB), Phytoplankton (PHY), Planktivores (PLK), Primary Producers (PP), Sharks and HMS (S and H), Small Pelagics (SP), and Zooplankton (ZOO).

No	Functional group	Guild	Included taxonomic groups
55	Large oceanic planktivores	PLK	*Manta birostris*, *Cetorhinus maximus*, *Rhincodon typus*, *Mola*
56	Oceanic planktivores	PLK	Argentinidae, Nomeidae
57	Sardine-herring-scad	SP	Clupeidae, *Decapterus* spp.
58	Menhaden (0yr)	SP	*Brevoortia* spp. Ages 0 to 1 year
59	Menhaden (1yr)	SP	*Brevoortia* spp. Ages 1 to 2 years
60	Menhaden (2yr)	SP	*Brevoortia* spp. Ages 2 to 3 years
61	Menhaden (3yr)	SP	*Brevoortia* spp. Ages 3 to 4 years
62	Menhaden (4+yr)	SP	*Brevoortia* spp. Ages 4 and older years
63	Anchovy-silverside-killifish	SP	Engraulidae, Atherinidae, Fundulidae
64	Mullet	SP	Mugilidae
65	Butterfish	SP	Stromateidae
66	Cephalopod	SP	Cephalopoda
67	Pink shrimp	BI	*Farfantepenaeus duorarum*
68	Brown shrimp	BI	*Farfantepenaeus aztecus*
69	White shrimp	BI	*Litopenaeus setiferus*
70	Crab	BI	Portunidae
71	Sessile epifauna	BI	Porifera, Anthozoa, Tunicata, Bryozoa, Hydrozoa, Crinoidea, Mytilidae
72	Mobile epifauna	BI	Malacostraca, Ostracoda, Echinoderma, Gastropoda, Pectinidae
73	Zooplankton	ZOO	Copepoda, Euphausiacea, Scyphozoa, planktonic eggs/larvae
74	Infauna	BI	Annelida, Nematoda, Bivalvia, Thalassinidea, Hippidae
75	Algae	PP	Rhodophyta, Chlorophyta, Phaeophyta, Cyanophyta, Xanthophyta, Cyanobacteria
76	Seagrass	PP	Marine angiosperms
77	Phytoplankton	PHY	Bacillariophyceae, Dinoflagellata, Protozoa
78	Detritus	DET	Calcareous debris, mud, organic matter, fishery discards, detritus

Table 2. Fishing fleets included within the US Gulf-wide ecosystem model and ranked in order of total landings from 1980 through 2016 for commercial gears and from 1986 through 2017 for recreational modes. Table 3 provides details on targeted species by each fleet and its respective gear.

Fishing fleet	Landings (pounds)	Landings (%)
Commercial		
Purse Seine (Menhaden)	30,494,203,471	48.08
Purse Seine (Other)	13,286,997,996	20.95
Other	8,156,193,396	12.86
Bottom Trawl (Shrimp)	6,770,606,621	10.68
Pots and Traps	1,641,872,320	2.59
Nets	1,506,410,456	2.38
Dredge/Dig	507,228,383	0.8
Handline	356,135,429	0.56
Bottom Trawl (Other)	338,174,455	0.53
Longline (Fish)	289,596,500	0.46
Longline (Pelagic)	44,376,564	0.07
Longline (Shark)	33,852,150	0.05
Recreational		
Private	1,720,319,405	68.09
Charter	414,438,918	16.40
Headboat	335,948,229	13.30
Shore	55,726,934	2.21

Table 3. Commercial fishing gears and classifications for the US Gulf-wide ecosystem model. The major species landed by each gear is also provided, where the number in parentheses represents the percent of total catch (1980-2016) composed of this species.

Gear	Fishing fleet	Main species caught (%)
Dredge Other	Dredge/Dig	OYSTER, EASTERN (99.8)
Dredge Oyster, Common	Dredge/Dig	OYSTER, EASTERN (96.8)
Tongs and Grabs, Oyster	Dredge/Dig	OYSTER, EASTERN (97.9)
By Hand, Other	Dredge/Dig	OYSTER, EASTERN (30.3)
Tongs and Grabs, Other	Dredge/Dig	OYSTER, EASTERN (98.8)
Tongs Patent, Oyster	Dredge/Dig	OYSTER, EASTERN (99.8)
By Hand, Oyster	Dredge/Dig	SHELLFISH (70.9)
Rakes, Other	Dredge/Dig	SHELLFISH (83.2)
Frog Grabs	Dredge/Dig	SHELLFISH (100)
Rakes, Oyster	Dredge/Dig	SHELLFISH (100)
Shovels	Dredge/Dig	OYSTER, EASTERN (100)
Lines Hand, Other	Handline	SNAPPER, RED (17.7)
Reel, Electric or Hydraulic	Handline	SNAPPER, RED (31)
Rod and Reel	Handline	SNAPPER, YELLOWTAIL (20.9)
Troll & Hand Lines Cmb	Handline	SNAPPER, YELLOWTAIL (40.1)
Lines Troll, Other	Handline	MACKEREL, KING AND CERO (53.5)
Reel, Manual	Handline	FINFISHES, UNC GENERAL (47.1)
Lines Troll, Green-Stick	Handline	FINFISHES, UNC GENERAL (100)
Lines Power Troll Other	Handline	FINFISHES, UNC GENERAL (100)
Lines Jigging Machine	Handline	FINFISHES, UNC GENERAL (100)
Lines Long, Reef Fish	Longline (Fish)	GROUPER, RED (47.5)
Lines Long Set With Hooks	Longline (Fish)	TUNA, YELLOWFIN (55)
Lines Trot With Baits	Longline (Fish)	DRUM, BLACK (88.4)
Lines Long, Vertical	Longline (Fish)	GROUPER, RED (60.1)
Lines Electrical Devices	Longline (Fish)	FINFISHES, UNC GENERAL (100)
Lines Long Drift With Hooks	Longline (Pelagic)	TUNA, YELLOWFIN (67.1)
Lines Long, Shark	Longline (Shark)	FINFISHES, UNC GENERAL (34.8)
Skimmer Net	Nets	SHRIMP, WHITE (63)
Butterfly Nets	Nets	SHRIMP, BROWN (54.2)
Cast Nets	Nets	MULLET, STRIPED (LIZA) (81.9)
Dip Nets, Common	Nets	SHAD, GIZZARD (61)
Brush Trap	Nets	CRAB, BLUE, SOFT AND PEELER (88.7)
Dip Nets, Drop	Nets	LOBSTER, CARIBBEAN SPINY (99.9)
Brail Or Scoop	Nets	FINFISHES, UNC GENERAL (98.5)

Table 3-Continued. Commercial fishing gears and classifications for the US Gulf-wide ecosystem model. The major species landed by each gear is also provided, where the number in parentheses represents the percent of total catch (1980-2016) composed of this species.

Gear	Fishing fleet	Main species caught (%)
Bag Nets	Nets	FINFISHES, UNC GENERAL (100)
Push Net	Nets	FINFISHES, UNC GENERAL (100)
Gill Nets, Drift, Runaround	Nets	MULLET, STRIPED (LIZA) (46.1)
Entangling Nets (Gill) Unspc	Nets	MULLET, STRIPED (LIZA) (34.1)
Gill Nets, Other	Nets	DRUM, BLACK (31.5)
Trammel Nets	Nets	DRUM, BLACK (24)
Gill Nets, Stake	Nets	GARS (26.7)
Gill Nets, Sink/Anchor, Other	Nets	FINFISHES, UNC GENERAL (98.2)
Gill Nets, Drift, Other	Nets	FINFISHES, UNC GENERAL (63.4)
Gill Nets, Crab	Nets	FINFISHES, UNC GENERAL (100)
Fyke And Hoop Nets, Fish	Nets	CATFISHES & BULLHEADS (79.6)
Fyke And Hoop Nets, Turtle	Nets	SHELLFISH (100)
Haul Seines, Beach	Nets	MULLET, STRIPED (LIZA) (69.8)
Haul Seines, Long	Nets	MULLET, STRIPED (LIZA) (36)
Combined Gears	Other	MENHADEN (64.2)
Not Coded	Other	SHRIMP, BROWN (41.4)
Unspecified Gear	Other	SHRIMP, PINK (29.1)
Diving Outfits, Other	Other	LOBSTER, CARIBBEAN SPINY (48.5)
Hooks, Sponge	Other	SPONGE, YELLOW (31.7)
Spears	Other	FLATFISH (58.2)
Forks	Other	FLATFISH (73.3)
Various Gear, Fishponds Hawaii	Other	OYSTER, EASTERN (98.6)
Harpoons, Turtle	Other	SHELLFISH (100)
Pots And Traps, Other	Pots and Traps	CRAB, DEEPSEA GOLDEN (60.2)
Pots And Traps, Crayfsh(frhwa)	Pots and Traps	CRAB, BLUE (45.9)
Slat Traps (Virginia)	Pots and Traps	FINFISHES, UNC GENERAL (99.3)
Pots And Traps, Turtle	Pots and Traps	SHELLFISH (70)
Pots And Traps, Shrimp	Pots and Traps	SHRIMP, WHITE (65.6)
Pots And Traps, Box Trap	Pots and Traps	SHELLFISH (99.6)
Pots And Traps, Conch	Pots and Traps	SHELLFISH (97.3)
Pots And Traps, Crab, Blue	Pots and Traps	CRAB, BLUE (99.4)
Pots And Traps, Crab, Other	Pots and Traps	CRAB, FLORIDA STONE CLAWS (98.6)
Pots And Traps, Cmb	Pots and Traps	CRAB, BLUE (48.8)

Table 3-Continued. Commercial fishing gears and classifications for the US Gulf-wide ecosystem model. The major species landed by each gear is also provided, where the number in parentheses represents the percent of total catch (1980-2016) composed of this species.

Gear	Fishing fleet	Main species caught (%)
Pots, Unclassified	Pots and Traps	FINFISHES, UNC GENERAL (100)
Pots And Traps, Fish	Pots and Traps	GROUPER, RED (34.9)
Pots And Traps, Eel	Pots and Traps	EEL, AMERICAN (79.5)
Pots And Traps, Spiny Lobster	Pots and Traps	LOBSTER, CARIBBEAN SPINY (98)
Purse Seines, Menhaden	Purse Seine (Menhaden)	MENHADEN (100)
Encircling Nets (Purse)	Purse Seine (Other)	MENHADEN (99.9)
Purse Seines, Other	Purse Seine (Other)	MENHADEN (54.1)
Lampara & Ring Nets, Other	Purse Seine (Other)	BALLYHOO (95.4)
Trawls, Unspecified	Bottom Trawl (Other)	SHRIMP, WHITE (46.6)
Otter Trawl Bottom, Fish	Bottom Trawl (Other)	FINFISHES, UNC GENERAL (93.4)
Trawl Bottom, Paired	Bottom Trawl (Other)	FINFISHES, UNC GENERAL (97.5)
Otter Trawl Bottom, Scallop	Bottom Trawl (Other)	SCALLOP, CALICO (94.7)
Beam Trawls, Other	Bottom Trawl (Other)	SHRIMP, MARINE, OTHER (98.8)
Beam Trawls, Chopsticks	Bottom Trawl (Other)	SHRIMP, BROWN (52)
Otter Trawl Bottom, Other	Bottom Trawl (Other)	SHRIMP, MARINE, OTHER (100)
Roller Frame Trawl	Bottom Trawl (Other)	SHRIMP, MARINE, OTHER (74.1)
Otter Trawl Bottom, Crab	Bottom Trawl (Other)	SHELLFISH (100)
Beam Trawls, Crab	Bottom Trawl (Other)	SHELLFISH (100)
Otter Trawl Bottom, Shrimp	Bottom Trawl (Shrimp)	SHRIMP, BROWN (52.8)
Beam Trawls, Shrimp	Bottom Trawl (Shrimp)	SHRIMP, MARINE, OTHER (54.8)

Table 4. Parameters for initial biomass estimates (B, t km^{-2}) and corresponding sources for the 1980 Ecopath model. – indicates no data required (e.g., multi-stanza, where biomass was estimated based on the input for the leading stanza) or available.

No	Functional group	Initial B	Source (Reference)
1	Coastal dolphins	0.0156	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
2	Offshore dolphins	0.0156	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
3	Baleen whales	0.0156	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
4	Seabirds	0.0119	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
5	Sea turtles	0.0128	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
6	Blacktip shark	0.0946	C_{1981} / F_{1981} (SEDAR 29 Update)
7	Dusky shark	0.0090	C_{1980} / F_{1980} (SEDAR 21 Update)
8	Sandbar shark	0.0014	$C_{1980:1984AVG}$ / ($F_{1980:1984AVG)}$ / 2) (divided by two because of two area configuration, (SEDAR 54)
9	Large coastal sharks	0.0380	C_{1980} / $F_{1980:1982AVG}$ (SEDAR 11)
10	Large oceanic sharks	0.0275	C_{1982} / F_{1980} (ICCAT 2017a for shortfin mako)
11	Atlantic sharpnose shark	0.0013	$C_{1980:1984AVG}$ / ($F_{1980:1984AVG}$ / 2) (divided by two because of two area configuration, (SEDAR 34)
12	Small coastal sharks	0.0009	$C_{1980:1984AVG}$ / (Atlantic sharpnose $F_{1980:1984AVG}$ / 2) (divided by two because of two area configuration, SEDAR 34, SEDAR 13)
13	Yellowfin tuna	0.0008	$C_{1980:1984\ average}$ / F (F assumed similar to M)
14	Bluefin tuna	0.0001	C_{1980}/F (F assumed similar to M)
15	Other tuna	0.0009	$C_{1980:1984AVG}$ / F (F assumed similar to M)
16	Billfish	0.0010	$C_{1980:1984AVG}$ / F (F assumed similar to M)
17	Swordfish	0.0139	C_{1980} / F (F assumed similar to M)
18	Pelagic coastal piscivores	0.0617	C_{1980} / F_{1980} (F borrowed from Amberjacks)
19	Amberjacks	0.0291	C_{1980} / F_{1980} (SEDAR 33 Update)
20	Cobia	0.0111	C_{1980} / F_{1980} (SEDAR 28)
21	King mackerel (0-1yr)	-	Multi-stanza
22	King mackerel (1+yr)	0.1401	C_{1980} / F_{1980} (SEDAR 38)
23	Spanish mackerel (0-1yr)	-	Multi-stanza
24	Spanish mackerel (1+yr)	0.0629	C_{1980} / F_{1980} (SEDAR 28)
25	Skates-rays	0.0339	C_{1980} / F (F assumed ~0.01, limited data)
26	Gag grouper (0-3yr)	-	Multi-stanza
27	Gag grouper (3+yr)	0.0181	C1980 / *F*1980 (SEDAR 33 Update)
28	Red grouper (0-3yr)	-	Multi-stanza
29	Red grouper (3+yr)	0.0247	$C_{1981\ from\ NOAA\ landings}$ / F_{1986} (assumed similar)
30	Yellowedge grouper (0-3yr)	-	Multi-stanza
31	Yellowedge grouper (3+yr)	0.0483	C_{1980} / F_{1980} (SEDAR 22)

Table 4-Continued. Parameters for initial biomass estimates (*B*, t km^{-2}) and corresponding sources for the 1980 Ecopath model. – indicates no data required (e.g., multi-stanza, where biomass was estimated based on the input for the leading stanza) or available.

No	Functional group	Initial *B*	Source (Reference)
32	Goliath grouper	0.0014	C_{1980} / F_{1980} (SEDAR 47)
33	Deep-water grouper	0.0067	C_{1980} / F_{1980} (*F* assumed similar to Yellowedge Grouper)
34	Shallow-water grouper	0.0126	$C_{1981;1983AVG}$ / *F* (*F* assumed similar to other shallow-water groupers like gag, red)
35	Red snapper (0 yr)	-	Multi-stanza
36	Red snapper (1-2 yr)	-	Multi-stanza
37	Red snapper (3+ yr)	0.0423	C_{1980} / F_{1980} (SEDAR 52)
38	Vermilion snapper	0.0738	C_{1980} / F_{1980} (SEDAR 67)
39	Mutton snapper	0.0154	S C_{1981} / F_{1981} (SEDAR 15A)
40	Other snapper	0.0134	C_{1980} / F_{1980} (Average *F* between mutton and vermilion)
41	Coastal piscivores	0.0852	C_{1980} / *F* (*F* assumed ~ 0.2)
42	Seatrout	0.1076	C_{1980} / *F* (*F* assumed ~ 0.2)
43	Oceanic piscivores	0.0074	C_{1980} / *F* (*F* assumed ~0.05)
44	Benthic piscivores	0.0115	$C_{1980:1982AVG}$ / *F* (*F* assumed ~0.1)
45	Reef piscivores	0.0364	$C_{1980:1982AVG}$ / *F* (*F* assumed ~ 0.05)
46	Reef invertebrate feeders	0.1828	$C_{1980:1982AVG}$ / *F* (*F* assumed 0.05)
47	Demersal coastal invertebrate feeders	0.2551	C_{1980} / *F* (F assumed ~0.15)
48	Red drum	0.1145	$C_{1980:1982AVG}$ / *F* (*F* assumed ~0.1)
49	Benthic coastal invertebrate feeders	0.0170	$C_{1980:1982AVG}$ / *F* (*F* assumed 0.05)
50	Tilefish	0.0070	C_{1980} / F_{1980} (SEDAR 22)
51	Gray triggerfish	0.0547	C_{1980} / F_{1980} (SEDAR 43)
52	Coastal omnivores	0.0291	$C_{1980:1982AVG}$ / *F* (*F* assumed ~ 0.05)
53	Reef omnivores	0.0015	$C_{1980:1982AVG}$ / *F* (*F* assumed ~0.05)
54	Surface pelagics	0.0064	C_{1980} / *F* (*F* assumed ~0.05)
55	Large oceanic planktivores	0.1540	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
56	Oceanic planktivores	0.0004	C_{1987} / *F* (*F* assumed ~0.05)
57	Sardine-herring-scad	0.1517	C_{1980} / F (*F* assumed 0.05)
58	Menhaden (0yr)	-	Multi-stanza
59	Menhaden (1yr)	-	Multi-stanza
60	Menhaden (2yr)	2.0025	C_{1980} / F_{1980} (SEDAR 63)
61	Menhaden (3yr)	-	Multi-stanza
62	Menhaden (4+yr)	-	Multi-stanza

Table 4-Continued. Parameters for initial biomass estimates (*B*, t km^{-2}) and corresponding sources for the 1980 Ecopath model. – indicates no data required (e.g., multi-stanza, where biomass was estimated based on the input for the leading stanza) or available.

No	Functional group	Initial *B*	Source (Reference)
63	Anchovies-silversides-killifish	0.0002	C_{1981} / *F* (*F* assumed ~0.05)
64	Mullet	0.2865	C_{1980} / *F* (*F* assumed ~0.15)
65	Butterfish	0.0236	C_{1980} / *F* (*F* assumed ~0.05)
66	Cephalopods	1.3800	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
67	Pink shrimp	0.1386	$C_{1985\ \text{[first year of catch data]}}$ / $F_{1980\ \text{[first year of F]}}$ (2018 Update)
68	Brown shrimp	0.0607	$C_{1984\ \text{[first year of catch data]}}$/ $F_{1980\ \text{[first year of F]}}$ (2018 Update)
69	White shrimp	0.9962	$C_{1984\ \text{[first year of catch data]}}$ / $F_{1980\ \text{[first year of F]}}$ (2018 Update)
70	Crab	0.1257	C_{1980} / *F* (*F* assumed 0.5)
71	Sessile epifauna	20	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
72	Mobile epifauna	15	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
73	Zooplankton	13	GoM menhaden EwE (Geers *et al.* 2016)
74	Infauna	18.5	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
75	Algae	29.8	Coastal GoM EwE (Walters *et al.* 2008)
76	Seagrass	150	Assumed 1980 Ecopath value = that estimated for 2005 (Sagarese *et al.* 2017) due to lack of data
77	Phytoplankton	25	Coastal GoM EwE (Walters *et al.* 2008)
78	Detritus	100	Coastal GoM EwE (Walters *et al.* 2008)

Table 5. Parameter estimates for initial production rate (*P*/*B*, yr^{-1}), assumed equivalent to the sum of natural mortality (*M*, yr^{-1}) and fishing mortality (*F*, yr^{-1}) where available, and the corresponding sources for the 1980 Ecopath model. When region specific estimates were not available, we assumed *F* was equal to *M*. – indicates no data available.

No	Functional group	Initial *P*/*B*	Source	*M*	*M* Source	F_{1980}	*F* Source
1	Coastal dolphins	0.16	Gray *et al.* (2014)	-	-	-	-
2	Offshore dolphins	0.16	Gray *et al.* (2014)	-	-	-	-
3	Baleen whales	0.16	Gray *et al.* (2014)	-	-	-	-
4	Seabird	0.25	Sagarese *et al.* (2017)	-	-	-	-
5	Sea turtle	0.31	Sagarese *et al.* (2017)	-	-	-	-
6	Blacktip shark	0.161	*M* + *F*	0.153	SEDAR 29 Update – age-independent *M*	0.008	SEDAR 29 Update
7	Dusky shark	0.084	*M* + *F*	0.066	SEDAR 21 Update – age-independent *M*	0.018	SEDAR 21 Update
8	Sandbar shark	0.234	*M* x 2	0.117	SEDAR 54 – ages 7-31	0.054	SEDAR 54
9	Large coastal sharks	0.13	*M* + *F*	0.125	Guesstimate based on sandbar/blacktip	0.005	SEDAR 11
10	Large oceanic sharks	0.144	*M* + *F*	0.125	Guesstimate based on sandbar/blacktip	0.019	ICCAT 2017a (shortfin mako)
11	Atlantic sharpnose shark	0.439	*M* + *F*	0.23	SEDAR 34 (average between low [0.209] and high [0.256])	0.209	SEDAR 34
12	Small coastal sharks	0.43	*M* + *F* (from 11)	0.222	SEDAR 34 bonnethead (average between low [0.199] and high [0.244])	0.209	SEDAR 34
13	Yellowfin tuna	1.08	*M* x 2	0.54	ICCAT 2016	NA	Not Available (GOM+)
14	Bluefin tuna	0.2	*M* x 2	0.1	ICCAT 2017c	NA	Not Available (GOM+)
15	Other tunas	0.4	*M* x 2	0.2	ICCAT 2015 (Bigeye Tuna)	NA	Not Available (GOM+)
16	Billfish	0.3	*M* x 2	0.15	ICCAT 2018 (Blue Marlin)	NA	Not Available (GOM+)
17	Swordfish	0.4	*M* x 2	0.2	ICCAT 2017b	NA	Not Available (GOM+)

Table 5-Continued. Parameter estimates for initial production rate (P/B, yr^{-1}), assumed equivalent to the sum of natural mortality (M, yr^{-1}) and fishing mortality (F, yr^{-1}) where available, and the corresponding sources for the 1980 Ecopath model. When region specific estimates were not available, we assumed F was equal to M. – indicates no data available.

No	Functional group	Initial *P/B*	Source	*M*	*M* Source	F_{1980}	F Source
18	Pelagic coastal piscivores	0.76	*M* + *F* (from 19)	0.6	Average *M* (see Table 6)	0.16	Assumed similar to amberjack in 1980
19	Amberjack	0.438	*M* + *F*	0.28	SEDAR 33 Update – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.158	SEDAR 33 Update
20	Cobia	0.624	*M* + *F*	0.38	SEDAR 28 – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.244	SEDAR 28
21	King mackerel (0-1yr)	1.459	Multi-stanza	0.657	SEDAR 38 – age-0	0.802	SEDAR 38
22	King mackerel (1+yr)	0.218	*M* + *F*	0.17	SEDAR 38 – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.048	SEDAR 38
23	Spanish mackerel (0-1yr)	1.806	*M* + *F*	0.4	SEDAR 28 – age-0	1.406	SEDAR 28
24	Spanish mackerel (1+yr)	0.511	*M* + *F*	0.38	SEDAR 28 – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.131	SEDAR 28
25	Skates-rays	0.39	*M* + *F*	0.38	Average *M* (see Table 6)	0.01	Assumed
26	Gag grouper (0-3yr)	0.573	*M* + *F*	0.403	SEDAR 33 Update – average age-0 (0.55), age-1 (0.37), age-2 (0.29)	0.169	SEDAR 33 Update
27	Gag grouper (3+yr)	0.369	*M* + *F*	0.134	SEDAR 33 Update – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.235	SEDAR 33 Update
28	Red grouper (0-3yr)	0.414	*M* + *F*	0.413	SEDAR 61 – average age-0 (0.56), age-1 (0.38), age-2 (0.30)	0	SEDAR 61
29	Red grouper (3+yr)	0.391	*M* + *F*	0.14	SEDAR 61 – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.251	SEDAR 61
30	Yellowedge grouper (0-3yr)	0.317	*M* + *F*	0.317	SEDAR 22 – average age-0 (0.44), age-1 (0.29), age-2 (0.22)	0	SEDAR 22
31	Yellowedge grouper (3+yr)	0.099	*M* + *F*	0.073	SEDAR 22 – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.026	SEDAR 22
32	Goliath grouper	0.332	*M* + *F*	0.12	SEDAR 47 – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.212	SEDAR 47
33	Deep-water grouper	0.118	*M* + *F*	0.092	$\text{Hoenig}_{\text{teleost}}$ (1983) (max age = 45 yr [speckled hind], 35 yr [snowy]; SEDAR 49)	0.026	Assumed similar to Yellowedge

Table 5-Continued. Parameter estimates for initial production rate (*P*/*B*, yr^{-1}), assumed equivalent to the sum of natural mortality (*M*, yr^{-1}) and fishing mortality (*F*, yr^{-1}) where available, and the corresponding sources for the 1980 Ecopath model. When region specific estimates were not available, we assumed *F* was equal to *M*. – indicates no data available.

No	Functional group	Initial *P*/*B*	Source	*M*	*M* Source	F_{1980}	*F* Source
34	Shallow-water grouper	0.349	*M* + *F*	0.149	$Hoenig_{teleost}$ (1983) (max age = 28 yr; yellowmouth SEDAR 49)	0.2	Assumed similar to other shallow groupers
35	Red snapper (0yr)	1	*M* + *F*	1	SEDAR 52 – age-0	-	-
36	Red snapper (1-2yr)	1.63	*M* + *F*	1.148	SEDAR 52 – average age-1 (1.6), age-2 (0.695)	0.482	SEDAR 52
37	Red snapper (3+yr)	0.327	*M* + *F*	0.075	SEDAR 52 (SS) – $Hoenig_{teleost}$ (1983)	0.252	SEDAR 52
38	Vermilion snapper	0.262	*M* + *F*	0.25	SEDAR 67 (SS) – life history working group recommendation ($Hoenig_{teleost}$ (1983) too low)	0.012	SEDAR 67
39	Mutton snapper	0.251	*M* + *F*	0.11	SEDAR 15A Update – $Hoenig_{teleost}$ (1983)	0.141	SEDAR 15A Update
40	Other snapper	0.291	*M* + *F*	0.15	SEDAR 51 – $Hoenig_{teleost}$ (1983)	0.141	Assumed similar to Mutton Snapper
41	Coastal piscivores	0.6	*M* + *F*	0.4	Average *M* (see Table 6)	0.2	Guestimate
42	Sea trout	0.55	*M* + *F*	0.35	$Hoenig_{teleost}$ (1983) (max age = 12 yr (spotted seatrout); FWC 2016	0.2	Guestimate
43	Oceanic piscivores	0.71	*M* + *F*	0.66	Average *M* (see Table 6)	0.05	Guestimate
44	Benthic piscivores	0.6	*M* + *F*	0.5	Average *M* (see Table 6)	0.1	Guestimate
45	Reef piscivores	0.84	*M* + *F*	0.79	Average *M* (see Table 6)	0.05	Guestimate
46	Reef invertebrate feeders	1.05	*M* + *F*	1	Average *M* (see Table 6)	0.05	Guestimate
47	Demersal coastal invertebrate feeders	0.9	*M* + *F*	0.8	Average *M* (see Table 6)	0.15	Guestimate
48	Red drum	0.198	*M* x 2	0.099	$Hoenig_{teleost}$ (1983) (max age = 42 yr, SEDAR 49)	0.1	Guestimate

Table 5-Continued. Parameter estimates for initial production rate (*P*/*B*, yr^{-1}), assumed equivalent to the sum of natural mortality (*M*, yr^{-1}) and fishing mortality (*F*, yr^{-1}) where available, and the corresponding sources for the 1980 Ecopath model. When region specific estimates were not available, we assumed *F* was equal to *M*. – indicates no data available.

No	Functional group	Initial *P*/*B*	Source	*M*	*M* Source	F_{1980}	*F* Source
49	Benthic coastal invertebrate feeders	1.25	*M* + *F*	1.2	Average *M* (see Table 6)	0.05	Guestimate
50	Tilefish	0.136	*M* + *F*	0.13	SEDAR 22 – Life history workgroup recommendation	0.006	SEDAR 22
51	Gray triggerfish	0.317	*M* + *F*	0.28	SEDAR 43 – $\text{Hoenig}_{\text{teleost}}$ (1983)	0.037	SEDAR 43
52	Coastal omnivores	0.85	*M* + *F*	0.8	Average *M* (see Table 6)	0.05	Guestimate
53	Reef omnivores	1.03	*M* + *F*	0.98	Average *M* (see Table 6)	0.05	Guestimate
54	Surface pelagics	1.45	*M* + *F*	1.4	Average *M* (see Table 6)	0.05	Guestimate
55	Large oceanic planktivores	0.6	Sagarese *et al.* (2017)				
56	Oceanic planktivores	0.55	*M* + *F*	0.5	Min *M* (see Table 6)	0.05	Guestimate
57	Sardine-herring-scad	0.94	*M* x 2	0.47	Min *M* (see Table 6)		
58	Menhaden (0yr)	1.671	*M* + *F*	1.67	SEDAR 63	0.001	SEDAR 63
59	Menhaden (1yr)	1.509	*M* + *F*	1.26	SEDAR 63	0.249	SEDAR 63
60	Menhaden (2yr)	1.726	*M* + *F*	1.1	SEDAR 63	0.626	SEDAR 63
61	Menhaden (3yr)	1.52	*M* + *F*	1.02	SEDAR 63	0.5	SEDAR 63
62	Menhaden (4+yr)	1.417	*M* + *F*	0.98	SEDAR 63	0.437	SEDAR 63
63	Anchovy-silverside-killifish	1.08	*M* x 2	0.54	Min *M* (see Table 6)	-	-
64	Mullet	0.49	*M* + *F*	0.34	Min *M* (see Table 6)	0.15	Guestimate
65	Butterfish	1.36	*M* x 2	0.68	Min *M* (see Table 6)	-	-
66	Cephalopod	3.5					
67	Pink shrimp	3.766	*M* + *F*	3.6	Hart 2018a (0.3 per season)	0.166	2018 Update
68	Brown shrimp	5.216	*M* + *F*	3.24	Hart 2018b (3.24 per year)	1.976	2018 Update

Table 5-Continued. Parameter estimates for initial production rate (*P*/*B*, yr^{-1}), assumed equivalent to the sum of natural mortality (*M*, yr^{-1}) and fishing mortality (*F*, yr^{-1}) where available, and the corresponding sources for the 1980 Ecopath model. When region specific estimates were not available, we assumed *F* was equal to *M*. – indicates no data available.

No	Functional group	Initial *P*/*B*	Source	*M*	*M* Source	F_{1980}	*F* Source
69	White shrimp	3.322	*M* + *F*	3.24	Hart 2018c (0.27 per month)	0.082	2018 Update
70	Crab	1.1	*M* + *F*	1	GDAR 01	0.1	Guestimate
71	Sessile epifauna	5	Sagarese *et al.* (2017)	-	-	-	-
72	Mobile epifauna	6	Sagarese *et al.* (2017)	-	-	-	-
73	Zooplankton	10	Sagarese *et al.* (2017)	-	-	-	-
74	Infauna	6	Sagarese *et al.* (2017)	-	-	-	-
75	Algae	28	Sagarese *et al.* (2017)	-	-	-	-
76	Seagrass	150	Sagarese *et al.* (2017)	-	-	-	-
77	Phytoplankton	25	Sagarese *et al.* (2017)	-	-	-	-
78	Detritus	-	-	-	-	-	-

Table 6. Range of natural mortality (*M*) estimates for each fish functional group based on estimates from Fishbase.org and as calculated using the empirical equations of Pauly (1980) using weight or length.

No	Functional group	M_{MIN}	$M_{AVERAGE}$	M_{MAX}
6	Blacktip shark	0.38	0.398	0.42
7	Dusky shark	0.08	0.087	0.1
8	Sandbar shark	0.13	0.128	0.13
9	Large coastal sharks	0.08	0.197	0.64
10	Large oceanic sharks	0.1	0.137	0.18
11	Atlantic sharpnose shark	0.39	0.388	0.39
12	Small coastal sharks	0.08	0.306	0.47
13	Yellowfin tuna	0.48	0.588	0.69
14	Bluefin tuna	0.1	0.283	0.49
15	Other tunas	0.31	0.635	0.98
16	Billfish	0.36	0.464	0.59
17	Swordfish	0.16	0.184	0.21
18	Pelagic coastal piscivores	0.21	0.637	1.9
19	Amberjack	0.43	0.431	0.43
20	Cobia	0.46	0.548	0.64
22	King mackerel (1+yr)	0.3	0.299	0.3
24	Spanish mackerel (1+yr)	0.53	0.531	0.53
25	Skates-rays	0.17	0.388	0.76
27	Gag grouper (3+yr)	0.29	0.312	0.34
29	Red grouper (3+yr)	0.27	0.325	0.38
31	Yellowedge grouper (3+yr)	0.2	0.222	0.25
32	Goliath grouper	0.23	0.246	0.26
33	Deep-water grouper	0.13	0.21	0.3
34	Shallow-water grouper	0.17	0.329	0.59
37	Red snapper (3+yr)	0.27	0.329	0.41
38	Vermilion snapper	0.36	0.386	0.41
39	Mutton snapper	0.37	0.383	0.4
40	Other snapper	0.21	0.488	0.94
41	Coastal piscivores	0.16	0.457	0.75
42	Sea trout	0.29	0.485	0.75
43	Oceanic piscivores	0.13	0.664	1.11
44	Benthic piscivores	0.22	0.498	0.77
45	Reef piscivores	0.16	0.794	2.31
46	Reef invertebrate feeders	0.28	1.007	2.28
47	Demersal coastal invertebrate feeders	0.22	0.805	2.01
48	Red drum	0.66	0.717	0.78
49	Benthic coastal invertebrate feeders	0.37	1.256	3.39
50	Tilefish	0.23	0.242	0.26
51	Gray triggerfish	0.54	0.592	0.64

Table 6-Continued. Range of natural mortality (*M*) estimates for each fish functional group based on estimates from Fishbase.org and as calculated using the empirical equations of Pauly (1980) using weight or length.

No	Functional group	M_{MIN}	$M_{AVERAGE}$	M_{MAX}
52	Coastal omnivores	0.41	0.805	1.46
53	Reef omnivores	0.32	0.978	2.12
54	Surface pelagics	1.06	1.406	1.87
55	Large oceanic planktivores	0.04	0.079	0.13
56	Oceanic planktivores	0.52	2.104	3.69
57	Sardine-herring-scad	0.47	1.521	6.41
60	Menhaden (2yr)	0.59	0.858	1.09
63	Anchovy-silverside-killifish	0.54	1.761	2.53
64	Mullet	0.34	0.622	0.78
65	Butterfish	0.68	1.921	2.98

Table 7. Range of consumption to biomass (*Q*/*B*) estimates for each functional group as calculated using the empirical equations of Pauly *et al.* (1990), Palomares and Pauly (1989), and Palomares and Pauly (1998). Average *Q*/*B* values were input as starting points whereas minimum and maximum *Q*/*B* values were used as bounds of reasonable parameters during model balancing. Final *Q*/*B* estimates are also shown along with their source. – indicates no data available.

No	Functional group	Q/B_{MIN}	$Q/B_{AVERAGE}$	Q/B_{MAX}	*Q*/*B*	Source
1	Coastal dolphins	-	-	-	15.0	Chagaris *et al.* (2015)
2	Offshore dolphins	-	-	-	15.0	Chagaris *et al.* (2015)
3	Baleen whales	-	-	-	15.0	Chagaris *et al.* (2015)
4	Seabird	-	-	-	33.0	Chagaris *et al.* (2015)
5	Sea turtle	-	-	-	3.5	Gray *et al.* (2014)
6	Blacktip shark	3.1	3.6	4.5	3.2	Within *Q*/*B* range
7	Dusky shark	1.8	2.2	2.8	2.8	Max *Q*/*B*
8	Sandbar shark	1.1	2.3	3.4	3.2	Within range
9	Large coastal sharks	1.1	2.6	4.5	3.0	Within range
10	Large oceanic sharks	0.9	2.7	9.6	2.7	Average *Q*/*B*
11	Atlantic sharpnose shark	5.8	6.7	7.4	5.8	Min *Q*/*B*
12	Small coastal sharks	2.2	3.7	6.3	5.0	Within range
13	Yellowfin tuna	4.3	8.4	11.6	8.4	Average *Q*/*B*
14	Bluefin tuna	3	3.8	4.3	4.3	Max *Q*/*B*
15	Other tunas	3.9	9.3	32.6	8.9	Within range
16	Billfish	1.7	4.9	14.5	4.9	Average *Q*/*B*
17	Swordfish	3.4	4	5.3	3.8	Within range
18	Pelagic coastal piscivores	2.3	6.3	13	6.3	Average *Q*/*B*
19	Amberjack	3.3	3.9	5.2	3.9	Average *Q*/*B*

Table 7-Continued. Range of consumption to biomass (*Q*/*B*) estimates for each functional group as calculated using the empirical equations of Pauly *et al.* (1990), Palomares and Pauly (1989), and Palomares and Pauly (1998). Average *Q*/*B* values were input as starting points whereas minimum and maximum *Q*/*B* values were used as bounds of reasonable parameters during model balancing. Final *Q*/*B* estimates are also shown along with their source. – indicates no data available.

No	Functional group	Q/B_{MIN}	$Q/B_{AVERAGE}$	Q/B_{MAX}	*Q*/*B*	Source
20	Cobia	3.4	4.1	4.8	4.1	Average *Q*/*B*
21	King mackerel (0-1yr)	-	-	-	14.3	Multi-stanza
22	King mackerel (1+yr)	2.7	3.5	4	3.5	Average *Q*/*B*
23	Spanish mackerel (0-1yr)	-	-	-	19.8	Multi-stanza
24	Spanish mackerel (1+yr)	6	7	8.3	5.2	Geers *et al.* (2016)
25	Skates-rays	1	7.6	64.6	4.8	Within range
26	Gag grouper (0-3yr)	-	-	-	9.3	Multi-stanza
27	Gag grouper (3+yr)	3.5	4.3	5	3.6	Within range
28	Red grouper (0-3yr)	-	-	-	9.2	Multi-stanza
29	Red grouper (3+yr)	4.8	5.5	6.3	3.7	Chagaris *et al.* (2015)
30	Yellowedge grouper (0-3yr)	-	-	-	18.1	Multi-stanza
31	Yellowedge grouper (3+yr)	3.2	3.9	4.6	3.7	Within range
32	Goliath grouper	2.7	3.3	4	3.3	Average *Q*/*B*
33	Deep-water grouper	1.4	3.7	7.8	4.0	Within range
34	Shallow-water grouper	2.8	5.7	8.7	6.2	Within range
35	Red snapper (0yr)	-	-	-	18.4	Multi-stanza
36	Red snapper (1-2yr)	-	-	-	7.9	Multi-stanza
37	Red snapper (3+yr)	4.6	5.3	6.2	3.3	
38	Vermilion snapper	3.8	4.5	5.4	4.5	Average *Q*/*B*
39	Mutton snapper	4.3	5	5.8	5.8	Max *Q*/*B*
40	Other snapper	3	5.3	10.6	6.0	Within range
41	Coastal piscivores	2.7	5.8	9.3	6.5	Within range
42	Sea trout	3.2	6.2	9.1	7.0	Within range
43	Oceanic piscivores	1.2	6.6	24.2	8.5	Within range
44	Benthic piscivores	2.3	6.8	11	5.0	Within range
45	Reef piscivores	1.8	6.3	15.2	5.4	Within range
46	Reef invertebrate feeders	2.5	11.5	64.6	5.8	Within range
47	Demersal coastal invertebrate feeders	2.1	7.1	22.4	5.9	Within range
48	Red drum	4	5	6.2	5.0	Average *Q*/*B*
49	Benthic coastal invertebrate feeders	2.8	13.4	40.2	5.8	Within range
50	Tilefish	2.2	2.6	3.5	3.5	Within range
51	Gray triggerfish	3.8	5.9	7.8	5.9	Average *Q*/*B*
52	Coastal omnivores	4.8	9.3	22.6	8.8	Within range
53	Reef omnivores	4.2	19.8	52.3	8.4	Within range

Table 7-Continued. Range of consumption to biomass (*Q*/*B*) estimates for each fish functional group as calculated using the empirical equations of Pauly *et al.* (1990), Palomares and Pauly (1989), and Palomares and Pauly (1998). Average *Q*/*B* values were input as starting points whereas minimum and maximum *Q*/*B* values were used as bounds of reasonable parameters during model balancing. Final *Q*/*B* estimates are also shown along with their source. – indicates no data available.

No	Functional group	Q/B_{MIN}	$Q/B_{AVERAGE}$	Q/B_{MAX}	*Q*/*B*	Source
54	Surface pelagics	9.4	19.1	34.1	11.7	Within range
55	Large oceanic planktivores	0.6	1.3	3.7	1.3	Average *Q*/*B*
56	Oceanic planktivores	4.7	38.2	83.3	8.7	Within range
57	Sardine-herring-scad	4.3	10.5	30.6	10.5	Average *Q*/*B*
58	Menhaden (0yr)	-	-	-	42.4	Multi-stanza
59	Menhaden (1yr)	-	-	-	21.8	Multi-stanza
60	Menhaden (2yr)	5.7	10	31.4	15.4	Within range
61	Menhaden (3yr)	-	-	-	12.7	Multi-stanza
62	Menhaden (4+yr)	-	-	-	11.1	Multi-stanza
63	Anchovy-silverside-killifish	9.2	18.5	40.9	15.9	Within range
64	Mullet	7.4	15	25.3	8.0	Within range
65	Butterfish	5.6	8.9	12.5	8.1	Within range
66	Cephalopod	-	-	-	13.7	Chagaris *et al.* (2015)
67	Pink shrimp	-	-	-	19.2	Okey and Mahmoudi (2002)
68	Brown shrimp	-	-	-	19.2	Okey and Mahmoudi (2002)
69	White shrimp	-	-	-	19.2	Okey and Mahmoudi (2002)
70	Crab	-	-	-	10.5	Chagaris *et al.* (2015)
71	Sessile epifauna	-	-	-	9.0	Okey and Mahmoudi (2002)
72	Mobile epifauna	-	-	-	16.0	Chagaris *et al.* (2015)
73	Zooplankton	-	-	-	74.0	Chagaris *et al.* (2015)
74	Infauna	-	-	-	22.0	Chagaris *et al.* (2015)
75	Algae	-	-	-	-	-
76	Seagrass	-	-	-	-	-
77	Phytoplankton	-	-	-	-	-
78	Detritus	-	-	-	-	-

Table 8. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	1	2	3	4	5	6	7	8
1	Coastal dolphins						0.3	0.78	1.145
2	Offshore dolphins						0.3	0.78	
3	Baleen whales								
4	Seabird				0.111			0.0002	
5	Sea turtle							1.022	
6	Blacktip shark						0.263	3.489	1.742
7	Dusky shark						0.05	0.158	0.11
8	Sandbar shark						0.005	0.021	0.158
9	Large coastal sharks						0.256	2.701	0.192
10	Large oceanic sharks							0.144	0.075
11	Atlantic sharpnose shark	0.12				0.57	0.115	0.836	0.437
12	Small coastal sharks	0.005				0.102	0.015	0.133	0.2
13	Yellowfin tuna						0.026	0.093	0.037
14	Bluefin tuna						0.001	0.01	0.034
15	Other tunas						0.014	0.132	0.052
16	Billfish							0.193	
17	Swordfish							0.721	
18	Pelagic coastal piscivores	0.109	0.109	0.1	0.114	1.82	0.321	3.525	3.294
19	Amberjack	0.138	0.138		0.037	0.01	0.028	0.931	0.026
20	Cobia	0.01	0.01				0.121	0.005	0.006
21	King mackerel (0-1yr)	0.01			0.001		0.0004	0.005	0.004
22	King mackerel (1+yr)	1.433	1.433				0.012	0.138	0.1
23	Spanish mackerel (0-1yr)	0.01			0.001		0.002	0.056	0.041
24	Spanish mackerel (1+yr)	0.09	0.09				1.3	0.479	0.347
25	Skates-rays	0.166	0.166			0.174	0.23	3.772	2.489
26	Gag grouper (0-3yr)				0.003		0.014	0.107	
27	Gag grouper (3+yr)						0.243	0.108	
28	Red grouper (0-3yr)				0.003		0.02	0.088	
29	Red grouper (3+yr)						0.112	0.138	
30	Yellowedge grouper (0-3yr)							0.002	
31	Yellowedge grouper (3+yr)							0.141	
32	Goliath grouper				0.0005		0.002	0.016	
33	Deep-water grouper							0.02	
34	Shallow-water grouper				0.035		0.053	0.232	
35	Red snapper (0yr)						0.002		0.002
36	Red snapper (1-2yr)						0.002		0.002
37	Red snapper (3+yr)						0.015		0.13
38	Vermilion snapper						0.134		0.119
39	Mutton snapper						0.08		0.106
40	Other snapper						0.03		0.271

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	9	10	11	12	13	14	15	16
1	Coastal dolphins	1.362							
2	Offshore dolphins		0.99					0.3	
3	Baleen whales		0.3						
4	Seabird	0.899	0.543						
5	Sea turtle	0.281	0.543						0.869
6	Blacktip shark	3.011	0.631						
7	Dusky shark	0.058	0.193						
8	Sandbar shark	0.032	0.055						
9	Large coastal sharks	1.235	0.61			0.564			
10	Large oceanic sharks	1.078	1.229						
11	Atlantic sharpnose shark	0.508	0.695	0.626	1.043				
12	Small coastal sharks	0.025	0.117	0.011	0.155		0.164		
13	Yellowfin tuna	0.072	0.029			0.402	0.005	0.057	0.015
14	Bluefin tuna	0.017	0.012			0.016	0.005	0.013	0.014
15	Other tunas	0.1	0.085			0.776	0.007	0.079	1.036
16	Billfish	0.019	0.014			0.214		0.018	0.02
17	Swordfish	0.112	0.145			0.162		0.058	0.161
18	Pelagic coastal piscivores	1.711	1.064	0.3	1.631	5.684	0.599	0.262	4.741
19	Amberjack	0.153	0.089	0.051	0.032	0.241	0.003	0.356	0.145
20	Cobia	0.008	0.002	0.026	0.011	0.006	0.001	0.007	0.006
21	King mackerel (0-1yr)	0.009	0.004	0.01	0.0004	0.016	0.002	0.002	0.015
22	King mackerel (1+yr)	0.264	0.099	0.025	0.011	0.434	0.048	0.065	0.422
23	Spanish mackerel (0-1yr)	0.02	0.04	0.016	0.014	0.176	0.019	0.026	0.171
24	Spanish mackerel (1+yr)	1.719	0.343	0.173	0.142	1.503	0.166	0.225	1.464
25	Skates-rays	2.596	0.863	0.197	1.544		0.233		
26	Gag grouper (0-3yr)	0.011				0.037	0.009	0.048	0.095
27	Gag grouper (3+yr)	0.111				0.042	0.01	0.054	0.107
28	Red grouper (0-3yr)	0.09				0.031	0.008	0.04	0.08
29	Red grouper (3+yr)	0.142				0.053	0.013	0.069	0.138
30	Yellowedge grouper (0-3yr)	0.002					0.012	0.006	0.012
31	Yellowedge grouper (3+yr)	0.146				0.055	0.014	0.07	0.141
32	Goliath grouper	0.002				0.006	0.002	0.008	0.016
33	Deep-water grouper	0.02				0.008	0.002	0.01	0.02
34	Shallow-water grouper	0.114			0.155	0.086	0.021	0.111	0.223
35	Red snapper (0yr)	0.001		0.003		0.001		0.001	0.001
36	Red snapper (1-2yr)	0.001		0.003		0.001		0.001	0.001
37	Red snapper (3+yr)	0.112	0.008	0.024		0.069		0.091	0.099
38	Vermilion snapper	0.103	0.007	0.223		0.063		0.084	0.091
39	Mutton snapper	0.092	0.006	0.06		0.056		0.075	0.081
40	Other snapper	0.234	0.016	0.107		0.144		0.191	0.206

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	17	18	19	20	22	23	24	25
1	Coastal dolphins								
2	Offshore dolphins								
3	Baleen whales								
4	Seabird								
5	Sea turtle								
6	Blacktip shark								
7	Dusky shark								
8	Sandbar shark								
9	Large coastal sharks								
10	Large oceanic sharks								
11	Atlantic sharpnose shark								
12	Small coastal sharks	0.019			0.234				
13	Yellowfin tuna	0.076	0.01		0.075	0.015			
14	Bluefin tuna	0.01			0.01	0.001			
15	Other tunas	0.103	0.011		0.106	0.018			
16	Billfish		0.011						
17	Swordfish								
18	Pelagic coastal piscivores	2.973	0.071	0.25	2.625	0.122		0.128	0.031
19	Amberjack	0.023	0.121	0.037	0.12	0.024		0.148	0.032
20	Cobia	0.01	0.044	0.009	0.022	0.022		0.11	0.04
21	King mackerel (0-1yr)	0.003	0.009	0.007	0.001	0.015		0.01	0.006
22	King mackerel (1+yr)	0.09	1.207	0.186	0.021			0.865	
23	Spanish mackerel (0-1yr)	0.036	0.01	0.075	0.13	0.001		0.001	0.0003
24	Spanish mackerel (1+yr)	0.311	0.111	0.643	1.114	0.014			
25	Skates-rays	0.934		2.077	2.701				0.2
26	Gag grouper (0-3yr)		0.012	0.012	0.015	0.003			
27	Gag grouper (3+yr)		0.012	0.125	0.172	0.026			
28	Red grouper (0-3yr)		0.01	0.102	0.128	0.021			
29	Red grouper (3+yr)		0.158	0.16	0.22	0.034			
30	Yellowedge grouper (0-3yr)			0.002					
31	Yellowedge grouper (3+yr)		0.162	0.164	0.226				
32	Goliath grouper		0.002	0.002	0.016	0.0004			
33	Deep-water grouper		0.022	0.023	0.031				
34	Shallow-water grouper		0.027	0.27	0.357	0.017			
35	Red snapper (0yr)		0.001	0.003	0.015	0.026			0.002
36	Red snapper (1-2yr)		0.001	0.003	0.015	0.026			0.002
37	Red snapper (3+yr)		0.011	0.023	0.12	0.01			0.019
38	Vermilion snapper		0.051	0.223		0.138			0.178
39	Mutton snapper		0.044	0.185		0.011			0.016
40	Other snapper		0.012	0.473		0.029			0.04

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	26	27	28	29	30	31	32	33
1	Coastal dolphins								
2	Offshore dolphins								
3	Baleen whales								
4	Seabird								
5	Sea turtle							3.753	
6	Blacktip shark								
7	Dusky shark								
8	Sandbar shark								
9	Large coastal sharks								
10	Large oceanic sharks								
11	Atlantic sharpnose shark		0.059		0.145		0.016	0.018	
12	Small coastal sharks		0.105		0.026		0.028	0.031	
13	Yellowfin tuna		0.095		0.04		0.001	0.015	
14	Bluefin tuna		0.018		0.037		0	0.014	
15	Other tunas		0.133		0.056		0.003	0.021	
16	Billfish								
17	Swordfish								
18	Pelagic coastal piscivores		1.144		0.714		0.043	0.048	0.39
19	Amberjack		0.049		0.121		0.001	0.001	0.066
20	Cobia		0.046		0.051		0.005	0.005	0.062
21	King mackerel (0-1yr)		0.009		0.004			0.002	
22	King mackerel (1+yr)		0.258		0.219			0.047	
23	Spanish mackerel (0-1yr)		0.105		0.044			0.005	
24	Spanish mackerel (1+yr)		0.896		0.377			0.044	
25	Skates-rays		3.283		0.517		0.31	4.75	
26	Gag grouper (0-3yr)	0.035	0.023	0.093	0.02	0.058	0.009	0.023	0.11
27	Gag grouper (3+yr)		0.257		0.226		0.009	0.026	
28	Red grouper (0-3yr)	0.025	0.019	0.07	0.017	0.044	0.017	0.018	0.092
29	Red grouper (3+yr)		0.329		0.29		0.017	0.031	
30	Yellowedge grouper (0-3yr)	0.007	0.003	0.017	0.003	0.1	0.003		
31	Yellowedge grouper (3+yr)						0.035		0.01
32	Goliath grouper	0.032	0.004	0.066	0.003	0.033		0.01	
33	Deep-water grouper						0.002		0.023
34	Shallow-water grouper	0.092	0.053	0.205	0.047	0.11	0.052	0.059	0.123
35	Red snapper (0yr)				0.01		0.0004		
36	Red snapper (1-2yr)				0.01		0.0004		
37	Red snapper (3+yr)				0.077		0.034	0.491	
38	Vermilion snapper	0.019	3.373	0.075	0.704	0.056	0.052	0.451	0.496
39	Mutton snapper	0.017	0.119	0.067	0.063	0.05		0.401	0.16
40	Other snapper	1.912	0.338	0.265	0.16	0.718	0.285	1.025	0.409

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	34	35	36	37	38	39	40	41
1	Coastal dolphins								
2	Offshore dolphins								
3	Baleen whales								
4	Seabird								
5	Sea turtle								
6	Blacktip shark								
7	Dusky shark								
8	Sandbar shark								
9	Large coastal sharks								
10	Large oceanic sharks								
11	Atlantic sharpnose shark								
12	Small coastal sharks								
13	Yellowfin tuna								
14	Bluefin tuna								
15	Other tunas								
16	Billfish								
17	Swordfish								
18	Pelagic coastal piscivores	0.594	2.613	0.701		0.033			0.05
19	Amberjack	0.101	0.05	0.05		0.052			0.012
20	Cobia	0.063				0.049			
21	King mackerel (0-1yr)								
22	King mackerel (1+yr)								
23	Spanish mackerel (0-1yr)								0.0004
24	Spanish mackerel (1+yr)								
25	Skates-rays								
26	Gag grouper (0-3yr)	0.039	0.205	0.02	0.026		0.017	0.029	
27	Gag grouper (3+yr)								
28	Red grouper (0-3yr)	0.032	0.167	0.017	0.022		0.145	0.024	
29	Red grouper (3+yr)								
30	Yellowedge grouper (0-3yr)	0.005	0.003				0.002		
31	Yellowedge grouper (3+yr)								
32	Goliath grouper	0.006	0.031	0.003	0.004		0.025	0.002	
33	Deep-water grouper				0.053			0.005	
34	Shallow-water grouper	0.12	0.221	0.022	0.029		0.194	0.032	
35	Red snapper (0yr)	0.005	0.116	0.116			0.003		
36	Red snapper (1-2yr)	0.005	1.165	1.46			0.003		
37	Red snapper (3+yr)	0.431			0.009				
38	Vermilion snapper	0.515	0.026	0.109	0.084	0.002	0.264		
39	Mutton snapper	0.352	0.243	0.033	0.074		0.02		
40	Other snapper	0.15	0.621	0.221	0.19		0.6		0.012

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	42	43	44	45	46	47	50	57
1	Coastal dolphins								
2	Offshore dolphins								
3	Baleen whales								
4	Seabird								
5	Sea turtle								
6	Blacktip shark								
7	Dusky shark								
8	Sandbar shark								
9	Large coastal sharks								
10	Large oceanic sharks								
11	Atlantic sharpnose shark								
12	Small coastal sharks		0.008					0.093	
13	Yellowfin tuna		0.01						
14	Bluefin tuna		0.001						
15	Other tunas		0.02						
16	Billfish								
17	Swordfish								
18	Pelagic coastal piscivores	0.175	0.081	0.111	0.815	0.056	0.001	0.258	0.001
19	Amberjack	0.017	0.032	0.049	0.067	0.006	0.026	0.044	
20	Cobia		0.012		0.063			0.041	
21	King mackerel (0-1yr)		0.004		0.002				
22	King mackerel (1+yr)		0.116		0.018				
23	Spanish mackerel (0-1yr)	0.0001	0.0005		0.024				
24	Spanish mackerel (1+yr)		0.403		0.064				
25	Skates-rays								
26	Gag grouper (0-3yr)							0.073	
27	Gag grouper (3+yr)							0.082	
28	Red grouper (0-3yr)							0.061	
29	Red grouper (3+yr)							0.105	
30	Yellowedge grouper (0-3yr)							0.009	
31	Yellowedge grouper (3+yr)							0.107	
32	Goliath grouper							0.012	
33	Deep-water grouper							0.015	
34	Shallow-water grouper							0.17	
35	Red snapper (0yr)					0.005			
36	Red snapper (1-2yr)					0.005			
37	Red snapper (3+yr)								
38	Vermilion snapper			1.025	0.056	0.096			
39	Mutton snapper			0.043	0.05	0.016			
40	Other snapper	0.029	0.014	0.034	0.197				

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	1	2	3	4	5	6	7
41	Coastal piscivores	2.618			1.972	0.025	0.222	1.346
42	Sea trout	0.444			0.229	0.079	1.48	0.975
43	Oceanic piscivores	0.145	0.255		0.197		1.225	0.934
44	Benthic piscivores	0.109			0.051	1.905	0.211	0.101
45	Reef piscivores						0.12	0.961
46	Reef invertebrate feeders	1.078			0.507	1.944	1.251	3.046
47	Demersal coastal invertebrate feeders	2.813			0.954	2.112	2.286	1.354
48	Red drum	0.122					1.565	
49	Benthic coastal invertebrate feeders	1.067			0.526	3.952	2.237	1.459
50	Tilefish							
51	Gray triggerfish	0.03					0.164	1.095
52	Coastal omnivores	0.242			0.302		0.277	1.905
53	Reef omnivores	0.231			0.112		0.103	1.052
54	Surface pelagics	5.5	6		2.456		0.863	0.948
55	Large oceanic planktivores							
56	Oceanic planktivores	2.173	0.55	0.5	0.226	1.863	0.689	0.056
57	Sardine-herring-scad	8.417	6.5	0.2	8.343	2.133	6.409	3.503
58	Menhaden (0yr)				4.48			
59	Menhaden (1yr)	4.56			5.033	0.24	6.912	1.622
60	Menhaden (2yr)	5.74			3.103	0.103	4.912	0.697
61	Menhaden (3yr)	3.514			2.374	0.005	2.292	0.036
62	Menhaden (4yr)	0.005			0.023	0.0004	0.908	0.003
63	Anchovy-silverside-killifish	8.871	5	0.2	8.112	2.215	5.027	2.277
64	Mullet	4.759			1.408	1.94	1.87	2.294
65	Butterfish	3.034	2.934	2	2.067	0.162	1.463	0.996
66	Cephalopod	12.188	56.7	42	11.959	3.633	6.676	4.393
67	Pink shrimp	2.021			1.667	0.047	1.594	2.922
68	Brown shrimp	0.103			0.242	0.775	1.789	1.495
69	White shrimp	3.449			2.114	1.163	1.235	1.579
70	Crab	2.149			2.203	23.622	1.212	1.44
71	Sessile epifauna				3.723	28.829		1.515
72	Mobile epifauna	2.66		10	3.671	6.813	8.37	2.477
73	Zooplankton	2.806	13	45	3.325	2.808	0.81	1.329
74	Infauna	2.85			4.589	3.395	0.441	1.822
75	Algae	2.066				2.157	1.159	
76	Seagrass				1.938	1.849	1.159	0.923
77	Phytoplankton							
78	Detritus	8.742	0.5		10.628		8.961	2.444
79	Import	3.359	6.6		11.184	3.539	20.037	30.032

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	8	9	10	11	12	13	14
41	Coastal piscivores	0.015	0.949	0.549	3.083	1.588		0.002
42	Sea trout	1.392	1.115		1.887	1.748		0.165
43	Oceanic piscivores	1.255	0.937	1.505	1.843	1.584	0.851	0.163
44	Benthic piscivores	2.36	0.148	0.733	0.144	0.172	0.622	0.169
45	Reef piscivores	1.276	1.373	0.561	1.845	1.585	0.599	0.162
46	Reef invertebrate feeders	2.637	3.51	0.621	3.351	0.847	1.267	0.325
47	Demersal coastal invertebrate feeders	5.385	2.558	0.926	4.383	4.571	1.189	0.379
48	Red drum		0.035		1.262			
49	Benthic coastal invertebrate feeders	6.684	2.138	1.183	3.971	2.469	0.787	2.261
50	Tilefish			0.055			0.554	
51	Gray triggerfish	0.15	0.124	0.117			0.118	0.02
52	Coastal omnivores	2.469	1.986	1.507	2.602	1.81	2.395	0.319
53	Reef omnivores	1.367	1.098	0.599		1.798	0.751	0.017
54	Surface pelagics	1.238	0.998	1.648			2.329	0.226
55	Large oceanic planktivores		0.162	0.134			0.603	
56	Oceanic planktivores	0.063	1.126	0.752			9.856	0.167
57	Sardine-herring-scad	2.812	2.287	2.34	6.905	5.14	2.047	0.97
58	Menhaden (0yr)							
59	Menhaden (1yr)	2.394	1.205		3.371	2.292		
60	Menhaden (2yr)	1.029	3.018	0.987	3.91	0.986	0.971	0.286
61	Menhaden (3yr)	0.053	0.279	0.051	2.683	0.051	0.05	0.015
62	Menhaden (4yr)	0.004	0.022	0.004	0.006	0.004	0.004	0.001
63	Anchovy-silverside-killifish	3.634	2.807	1.214	4.494	3.481	0.998	0.242
64	Mullet	0.109	1.36	0.611	5.148	1.747	0.113	0.173
65	Butterfish	1.296	1.025	0.584	0.429	1.737	0.637	0.279
66	Cephalopod	7.907	6.9	11.831	6.812	2.299	3.971	0.413
67	Pink shrimp	0.043	0.032	0.014	0.169	0.057	0.015	0.004
68	Brown shrimp	0.713	0.531	0.236	0.815	0.35	0.256	0.071
69	White shrimp	1.071	0.797	0.354	2.83	2.026	0.385	0.106
70	Crab	4.608	1.128	0.601	3.199	24.218	0.748	0.179
71	Sessile epifauna	1.512	1.468	1.366	3.348	2.592	0.667	0.299
72	Mobile epifauna	6.342	2.542	1.173	7.042	7.817	1.603	0.257
73	Zooplankton	1.856	0.702	1.091	3.734	3.279	1.181	0.237
74	Infauna	1.988	1.789	1.209	6.124	4.985	1.159	0.257
75	Algae	1.194	0.902	0.55	1.741	1.671	0.551	0.16
76	Seagrass	1.195	0.917	0.543	1.746	2.538	0.536	0.162
77	Phytoplankton							
78	Detritus	2.859	5.242	5.525	7.475	6.783	1.37	0.108
79	Import	20.018	30.365	50.071	1.766	3.08	49.983	90.065

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	15	16	17	18	19	20	21
41	Coastal piscivores	0.019	0.883		1.028		0.054	
42	Sea trout	0.788	0.916		1.066		1.335	
43	Oceanic piscivores	0.816	1.35	2.498	1.054		1.249	
44	Benthic piscivores	0.185	1.198		0.013	1.763	2.301	0.146
45	Reef piscivores	0.743	0.904	2.916	0.104			
46	Reef invertebrate feeders	1.648	2.428	1.11	1.277	5.645	3.203	0.181
47	Demersal coastal invertebrate feeders	1.561	1.654	1.994	0.562	4.736	7.233	2.554
48	Red drum				0.11			
49	Benthic coastal invertebrate feeders	0.984	1.821	1.748	1.3	4.274	9.782	0.346
50	Tilefish							
51	Gray triggerfish	0.864	0.128	0.131	0.124	0.255	1.371	
52	Coastal omnivores	1.931	1.902	1.973	1.078	2.51	3.315	4.527
53	Reef omnivores	0.895	1.003	1.201	0.134	0.197	1.708	
54	Surface pelagics	3.91	1.19	1	4.996	0.44		
55	Large oceanic planktivores	0.741	0.9		0.012			
56	Oceanic planktivores	2.183	0.931	2.059	0.172	2.125		0.679
57	Sardine-herring-scad	6.534	2.116	1.825	7.728	24.84	6.531	7.458
58	Menhaden (0yr)							
59	Menhaden (1yr)	0.422			3.34	0.933	1.747	15.119
60	Menhaden (2yr)	0.181	1.54	1.213	4.006	0.401	1.051	10.491
61	Menhaden (3yr)	0.009	0.074	0.063	2.022	0.207	0.388	7.78
62	Menhaden (4yr)	0.001	0.006	0.005	0.003	0.002	0.003	5.015
63	Anchovy-silverside-killifish	6.514	1.95	1.418	4.835	9.306	3.969	13.43
64	Mullet	0.842	1.201		1.212	4.719	1.557	1.585
65	Butterfish	1.432	1.028	1.154	1.66	0.141	1.6	3.25
66	Cephalopod	2.226	4.208	13.256	8.848	6.414	1.921	7.221
67	Pink shrimp	0.032	0.021	0.024	0.039	0.058	0.123	0.102
68	Brown shrimp	0.539	0.356	0.407	0.644	0.969	2.042	0.17
69	White shrimp	0.809	0.534	0.611	0.966	1.455	3.065	4.048
70	Crab	0.791	0.907	0.995	1.308	2.108	20.17	
71	Sessile epifauna	0.97	1.198		2.407	2.02	2.003	
72	Mobile epifauna	1.77	1.638	1.476	3.152	2.593	6.536	0.032
73	Zooplankton	3.265	1.109	3.153	6.229	7.875	2.597	8.696
74	Infauna	1.584	0.634	0.77	3.86	4.861	2.276	
75	Algae	0.721	0.869		1.2			
76	Seagrass		0.869	0.907	1.033	2.272		
77	Phytoplankton				1.513			
78	Detritus	1.75	2.193	1.538	8.694	1.831	2.378	6.3
79	Import	50.052	49.958	49.949	20.098			0.884

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	22	23	24	25	26	27	28
41	Coastal piscivores	0.056	0.293	0.351	0.017	1.613		0.101
42	Sea trout	0.239	0.175	0.263	0.019			
43	Oceanic piscivores	0.2		0.186				
44	Benthic piscivores	0.074		0.058	0.159	1.855	0.324	0.537
45	Reef piscivores	0.173						
46	Reef invertebrate feeders	1.407	0.241	1.628	0.337	5.492	5.882	10.004
47	Demersal coastal invertebrate feeders	0.79	1.56	0.885	0.501	5.66	5.816	3.456
48	Red drum							
49	Benthic coastal invertebrate feeders	2.442	0.399	6.771	1.094	18.22	4.175	6.776
50	Tilefish	0.007						
51	Gray triggerfish	0.171						
52	Coastal omnivores	0.222	3.799	0.499	0.203	4.022	5.818	3.99
53	Reef omnivores	0.168		0.321	0.202	4.296	1.262	2.572
54	Surface pelagics	2.832		5.871	0.043			
55	Large oceanic planktivores							
56	Oceanic planktivores				0.019			
57	Sardine-herring-scad	10.76	4.37	13.675	3.204	5.821	18.267	8.492
58	Menhaden (0yr)							
59	Menhaden (1yr)	6.51	14.314	8.21		2.823	3.88	
60	Menhaden (2yr)	7.733	11.214	5.56		1.214	3.668	
61	Menhaden (3yr)	5.278	9.863	4.924		0.063	1.625	
62	Menhaden (4yr)	6.7	4.514	3.385		0.005	0.4	
63	Anchovy-silverside-killifish	7.826	18.965	15.224	3.293	5.339		1.876
64	Mullet	0.408	0.214	1.563	0.2		3.338	
65	Butterfish	3.654	4.524	2.303	0.02			
66	Cephalopod	12.963	1.597	9.951	5.648	3.709	4.07	2.933
67	Pink shrimp	1.05	0.595	1.361	0.101	0.242	0.064	0.229
68	Brown shrimp	0.914	0.054	0.139	0.167	0.402	1.065	0.381
69	White shrimp	1.373	10.5	4.886	1.751	4.629	1.599	3.672
70	Crab	1.78	1.206	1.66	4.596	3.336	3.544	10.846
71	Sessile epifauna				7.701	1.377	2.513	2.883
72	Mobile epifauna	4.622	0.024	2.397	20.708	3.666	4.833	17.196
73	Zooplankton	5.857	7.014	1.788	4.159	3.63	3.364	2.735
74	Infauna	2.871	0.064	2.702	11.549	5.994	4.398	12.338
75	Algae				1.857	1.528		
76	Seagrass	1.64			2.144	1.884		2.589
77	Phytoplankton							
78	Detritus	8.699	4.5	2.133	27.9	9.534	9.391	5.5
79	Import				1.857	1.532		

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	29	30	31	32	33	34	35
41	Coastal piscivores		0.274					
42	Sea trout							
43	Oceanic piscivores			0.058				2.389
44	Benthic piscivores	1.437	0.231	0.055		0.532	1.083	0.52
45	Reef piscivores	0.412		0.054	3.758	0.225	2.756	2.394
46	Reef invertebrate feeders	12.628	1.554	0.929	6.832	5.656	11.296	5.784
47	Demersal coastal invertebrate feeders	7.418	3.71	1.622	4.554	6.918	7.881	5.107
48	Red drum							
49	Benthic coastal invertebrate feeders	5.082	1.728	0.536	4.304	6.578	8.979	5.455
50	Tilefish							
51	Gray triggerfish							
52	Coastal omnivores	1.113	2.617	1.95	3.953		4.328	2.763
53	Reef omnivores	0.761	4.082	0.505	3.859		0.202	0.276
54	Surface pelagics							
55	Large oceanic planktivores							
56	Oceanic planktivores							0.192
57	Sardine-herring-scad	8.515	9.788	5.982	3.74	4.991	8.25	3.769
58	Menhaden (0yr)							
59	Menhaden (1yr)							
60	Menhaden (2yr)							
61	Menhaden (3yr)							
62	Menhaden (4yr)							
63	Anchovy-silverside-killifish		5.082		3.748	3.893	5.6	4.188
64	Mullet				3.792			
65	Butterfish					5.877		2.629
66	Cephalopod	9.833	3.107	2.144	3.741	21.937	3.48	4.123
67	Pink shrimp	0.318	0.384	0.061	0.219	0.126	0.068	0.096
68	Brown shrimp	0.196	0.138	1.01	3.645	2.086	1.131	1.593
69	White shrimp	2.094	2.772	1.517	5.472	3.132	0.17	2.391
70	Crab	4.955	4.902	0.108	13.853	6.871	10.348	5.281
71	Sessile epifauna	6	0.012	14.664		6.434	6.1	6.303
72	Mobile epifauna	6.55	49.694	43.938	11.715	9.938	7	9.739
73	Zooplankton	6.216	0.067		3.952	5.234	3.813	5.977
74	Infauna	4.718	0.163	21.431	5.624	4.501	5.256	7.159
75	Algae							2.336
76	Seagrass							
77	Phytoplankton						3.117	
78	Detritus	17.778	8.5	2.544	1.953	3.15	6.695	9.467
79	Import							4.654

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	36	37	38	39	40	41	42
41	Coastal piscivores						0.516	0.11
42	Sea trout						0.127	0.105
43	Oceanic piscivores	2.389	1.272	0.277				
44	Benthic piscivores	1.096	0.151		0.28	0.031	0.103	0.011
45	Reef piscivores	0.239	0.329					
46	Reef invertebrate feeders	8.98	5.906		4.944	4.675	0.235	0.331
47	Demersal coastal invertebrate feeders	5.107	4.201	0.614	4.701	2.76	1.16	0.225
48	Red drum						0.082	
49	Benthic coastal invertebrate feeders	8.255	10.992	0.942	7.576	2.53	0.232	0.197
50	Tilefish							
51	Gray triggerfish					0.058		
52	Coastal omnivores	2.763	3.853		2.463	0.447	0.097	0.238
53	Reef omnivores	0.276	0.664		0.254	0.752	0.238	0.101
54	Surface pelagics					3.349	0.241	0.277
55	Large oceanic planktivores							
56	Oceanic planktivores	0.192	0.308					
57	Sardine-herring-scad	4.669	8.41	1.792	1.186	9.679	7.097	7.894
58	Menhaden (0yr)					1.657	3.764	3.874
59	Menhaden (1yr)					0.763	4.673	5.678
60	Menhaden (2yr)					0.328	3.547	4.693
61	Menhaden (3yr)					0.017	1.131	2.003
62	Menhaden (4yr)					0.001	0.002	0.002
63	Anchovy-silverside-killifish	5.188	4.564		2.492	5.701	7.043	9.924
64	Mullet				2.035	0.823	1.006	0.506
65	Butterfish	2.629	0.476		0.271	0.324		
66	Cephalopod	3.923	5.555	7.035	10.761	5.811	10.68	7.701
67	Pink shrimp	0.096	0.088	0.305	0.068	0.106	1.083	0.171
68	Brown shrimp	1.593	1.454	0.251	1.13	0.164	1.439	0.103
69	White shrimp	0.239	2.184	2.461	0.17	0.605	1.67	0.526
70	Crab	5.281	4.548	3.814	9.499	6.683	2.069	2.932
71	Sessile epifauna	3.803	6.117	7.892	6.462	1.322	6.508	4.434
72	Mobile epifauna	14.739	9.083	13.962	9.507	8.088	6.194	7.742
73	Zooplankton	5.677	4.891	29.808	6.843	6.17	7.787	4.907
74	Infauna	7.159	7.005	14.986	10.574	8.584	10.487	5.79
75	Algae	2.336	3.177	2.58	1.716	2.835	2.134	2.942
76	Seagrass				6.287	5.219	2.304	5.263
77	Phytoplankton				2.319	2.936	2.688	5.386
78	Detritus	5.967	10.3	13.167	7.207	12.283	11.179	12.628
79	Import	4.654	3.949			5.221	2.4	3.078

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	43	44	45	46	47	48	49
41	Coastal piscivores	0.03	0.042		0.01	0.096		0.05
42	Sea trout	1.422	0.252		0.096	0.096		
43	Oceanic piscivores	1.478	2.452		0.01	< 0.0001		
44	Benthic piscivores	0.099	0.403	0.103	0.01	< 0.0001	0.089	0.001
45	Reef piscivores	0.136	0.244	0.28				
46	Reef invertebrate feeders	1.969	2.796	5.586	0.056	0.096	0.395	0.083
47	Demersal coastal invertebrate feeders	2.849	8.64	0.569	0.096	0.096	0.389	0.083
48	Red drum							
49	Benthic coastal invertebrate feeders	3.939	9.59	6.021	0.026	0.096	0.662	0.083
50	Tilefish	0.049						
51	Gray triggerfish	0.181						
52	Coastal omnivores	0.282	2.947	0.94	0.096	0.096	0.398	0.083
53	Reef omnivores	0.159		0.901	0.096	0.096	0.391	
54	Surface pelagics	3.276	3.175	3.691	0.096	0.096		0.083
55	Large oceanic planktivores	0.014						
56	Oceanic planktivores	1.454	0.176	0.993	0.096	0.096		
57	Sardine-herring-scad	6.297	6.425	11.293	0.202	0.096		0.083
58	Menhaden (0yr)		3.134			0.057	5.273	0.05
59	Menhaden (1yr)	0.788	1.444			0.026	7.129	0.023
60	Menhaden (2yr)	0.339	0.621			0.011	4.044	0.01
61	Menhaden (3yr)	0.018	0.032			0.001	2.4	0.001
62	Menhaden (4yr)	0.001	0.003			0.00005	2.1	0.00004
63	Anchovy-silverside-killifish	5.482	4.874	6.737	0.096	0.096	8.991	0.083
64	Mullet	1.67	2.681	3.076		0.096	1.338	
65	Butterfish	1.514	2.652			0.096		
66	Cephalopod	7.899	3.238	5.912	4.116	3.007	9.411	3.942
67	Pink shrimp	0.047	0.086	0.123	0.172	1.401	0.166	0.141
68	Brown shrimp	0.788	0.143	0.205	0.103	1.329	0.276	0.01
69	White shrimp	1.184	1.514	2.977	0.228	2.097	6.548	0.226
70	Crab	1.537	3.105	6.297	1.7	1.068	3.773	2.116
71	Sessile epifauna	2.438	3.173	3.297	12.898	13.186	10.567	13.159
72	Mobile epifauna	5.102	6.695	8.09	13.565	14.402	14.412	18.4
73	Zooplankton	3.325	3.856	7.4	15.181	10.813	4.602	13.717
74	Infauna	3.086	5.805	5.497	15.937	20.557	6.312	14.469
75	Algae	1.315	2.377		3.242	4.039	2.244	4.696
76	Seagrass	1.315	2.413	2.783	3.616	8.262	2.227	3.741
77	Phytoplankton			3.468	7.387	5.205		5.868
78	Detritus	7.712	11.012	9.68	14.179	10.009	5.835	15.033
79	Import	30.079	2.707	2.71	6.545	3.259		3.793

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	50	51	52	53	54	55	56
41	Coastal piscivores							
42	Sea trout							
43	Oceanic piscivores	0.161						
44	Benthic piscivores	0.55						
45	Reef piscivores	0.149						
46	Reef invertebrate feeders	0.773						
47	Demersal coastal invertebrate feeders	8.654		0.118				
48	Red drum							
49	Benthic coastal invertebrate feeders	1.404	5.411	0.118	0.104			
50	Tilefish	0.012						
51	Gray triggerfish							
52	Coastal omnivores							
53	Reef omnivores	0.944						
54	Surface pelagics		3.093			0.571		
55	Large oceanic planktivores							
56	Oceanic planktivores	0.438					11.681	0.029
57	Sardine-herring-scad	1.505		0.118		2.559		
58	Menhaden (0yr)							
59	Menhaden (1yr)							
60	Menhaden (2yr)							
61	Menhaden (3yr)							
62	Menhaden (4yr)							
63	Anchovy-silverside-killifish			0.118		3.352		
64	Mullet							
65	Butterfish	0.677						
66	Cephalopod	7.069	2.996	5.13		5.464	6.47	9.382
67	Pink shrimp	0.211	0.135	0.106	0.113	0.135		0.195
68	Brown shrimp	3.504	0.224	0.011	0.011	0.105		0.032
69	White shrimp	5.26	5.359	0.305	0.382	0.437		0.486
70	Crab	7.973	3.313	0.466	2.338	0.673		
71	Sessile epifauna	11.92	10.211	13.563	27.01	11.385		
72	Mobile epifauna	16.114	9.198	10.095	8.594	9.279	4.852	18.989
73	Zooplankton	10.066	9.274	15.959	13.389	26.106	75.24	45.41
74	Infauna	16.407	12.676	15.33	11.509	11.988		17.907
75	Algae		2.652	8.498	12.784	6.549		
76	Seagrass		2.648	9.339	5.1	7.287	1.757	
77	Phytoplankton		3.384	6.032	6.775	1.47		
78	Detritus	5.15	26.766	10.931	11.892	12.622		
79	Import		2.649	3.734				7.613

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	57	58	59	60	61	62	63
41	Coastal piscivores							
42	Sea trout							
43	Oceanic piscivores							
44	Benthic piscivores	0.0001						
45	Reef piscivores							
46	Reef invertebrate feeders	0.141						
47	Demersal coastal invertebrate feeders	0.141						
48	Red drum							
49	Benthic coastal invertebrate feeders							
50	Tilefish							
51	Gray triggerfish							
52	Coastal omnivores	0.014						
53	Reef omnivores							
54	Surface pelagics	0.141						
55	Large oceanic planktivores							
56	Oceanic planktivores	0.014						
57	Sardine-herring-scad	0.001						
58	Menhaden (0yr)							
59	Menhaden (1yr)							
60	Menhaden (2yr)							
61	Menhaden (3yr)							
62	Menhaden (4yr)							
63	Anchovy-silverside-killifish	0.141						0.01
64	Mullet							
65	Butterfish							
66	Cephalopod	4.018						
67	Pink shrimp	0.11						0.14
68	Brown shrimp	0.012						0.013
69	White shrimp	0.127						0.05
70	Crab	0.03						
71	Sessile epifauna	11.242						9.342
72	Mobile epifauna	11.485	2.185	2.185	2.185	2.185	2.185	12.986
73	Zooplankton	20.031	20.239	20.239	20.239	20.239	20.239	19.021
74	Infauna	16.58	0.874	0.874	0.874	0.874	0.874	12.889
75	Algae	3.712	6.124	6.124	6.124	6.124	6.124	5.335
76	Seagrass	3.713						5.7
77	Phytoplankton	6.598	50.3	50.3	50.3	50.3	50.3	15.4
78	Detritus	15.727	20.26	20.26	20.26	20.26	20.26	12.575
79	Import	6.052						6.548

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	64	65	66	67	68	69
41	Coastal piscivores						
42	Sea trout						
43	Oceanic piscivores						
44	Benthic piscivores						
45	Reef piscivores						
46	Reef invertebrate feeders			0.052			
47	Demersal coastal invertebrate feeders			0.036			
48	Red drum						
49	Benthic coastal invertebrate feeders						
50	Tilefish						
51	Gray triggerfish						
52	Coastal omnivores			0.004			
53	Reef omnivores			0.013			
54	Surface pelagics						
55	Large oceanic planktivores						
56	Oceanic planktivores						
57	Sardine-herring-scad			0.186			
58	Menhaden (0yr)						
59	Menhaden (1yr)						
60	Menhaden (2yr)						
61	Menhaden (3yr)						
62	Menhaden (4yr)						
63	Anchovy-silverside-killifish			2.9			
64	Mullet						
65	Butterfish						
66	Cephalopod			0.913			
67	Pink shrimp		0.143				
68	Brown shrimp		0.038				
69	White shrimp		0.236				
70	Crab						
71	Sessile epifauna		17.297		2.55	1.55	1.55
72	Mobile epifauna	10.486	9.992	17.333	2.652	1.229	0.573
73	Zooplankton	12.718	34.68	64.768			
74	Infauna	12.605	10.206	2.549	36.31	2.553	2.553
75	Algae	11.829	5.263		14.96	18.46	18.16
76	Seagrass	13.791	5.263				
77	Phytoplankton	22.768	8.447		12.36	12.36	12.36
78	Detritus	9.875	8.462	11.25	31.2	63.8	64.8
79	Import	5.928					

Table 8-Continued. Final diet compositions (%) for functional groups in the 1980 US Gulf-wide Ecopath model. Note that some adjustments from initial inputs were necessary to obtain model balance. Predators are in columns and prey are in rows.

No	Prey \ predator	70	71	72	73	74
41	Coastal piscivores					
42	Sea trout					
43	Oceanic piscivores					
44	Benthic piscivores					
45	Reef piscivores					
46	Reef invertebrate feeders	0.054				
47	Demersal coastal invertebrate feeders					
48	Red drum					
49	Benthic coastal invertebrate feeders					
50	Tilefish					
51	Gray triggerfish					
52	Coastal omnivores	0.048		0.01		0.01
53	Reef omnivores					
54	Surface pelagics					
55	Large oceanic planktivores					
56	Oceanic planktivores					
57	Sardine-herring-scad	0.53				
58	Menhaden (0yr)					
59	Menhaden (1yr)					
60	Menhaden (2yr)					
61	Menhaden (3yr)					
62	Menhaden (4yr)					
63	Anchovy-silverside-killifish	0.43				
64	Mullet	0.017				
65	Butterfish					
66	Cephalopod	0.02		0.231		
67	Pink shrimp	0.062				
68	Brown shrimp	0.01				
69	White shrimp	0.154				
70	Crab	0.2				
71	Sessile epifauna			3.009		
72	Mobile epifauna	18.48	0.089	1.18		0.316
73	Zooplankton		0.743		4.439	
74	Infauna	60.219	0.198	7.479		3.905
75	Algae	0.01		15.267		
76	Seagrass			7.817		
77	Phytoplankton		51.807	19.499	71.64	44.449
78	Detritus	19.809	47.163	45.5	23.9	51.32
79	Import					

Table 9. Retained bycatch estimates (t km^{-2}) of the menhaden purse seine fishery based on Guillory and Hutton (1982) and de Silva and Condrey (1997), which sampled retained bycatch between 1980-1981 and 1994-1995, respectively.

Functional group	1980 (de Silva and Condrey 1997)	1980 (Guillory and Hutton)	Average
Anchovies-silversides-killifish	9.65E-06		9.65E-06
Atlantic sharpnose shark		2.07E-05	2.07E-05
Benthic coastal invertebrate feeders	1.50E-05	1.13E-04	6.41E-05
Benthic piscivores	2.42E-07		2.42E-07
Blacktip shark	9.59E-05	5.44E-04	3.20E-04
Crab	1.00E-04	1.70E-04	1.35E-04
Brown shrimp	2.66E-05		2.66E-05
Butterfish	1.40E-03	9.61E-04	1.18E-03
Cephalopods	8.61E-05	5.66E-05	7.13E-05
Coastal omnivores	1.06E-04	1.13E-04	1.10E-04
Coastal piscivores	2.78E-02	3.39E-04	1.41E-02
Demersal coastal invertebrate feeders	9.12E-05	3.18E-02	1.59E-02
Dusky shark		1.63E-04	1.63E-04
King mackerel		1.70E-04	1.70E-04
Large coastal sharks		2.60E-04	2.60E-04
Mobile epifauna	1.64E-06	5.66E-05	2.91E-05
Mullet	2.42E-03	5.66E-05	1.24E-03
Oceanic piscivores	1.14E-04	6.22E-04	3.68E-04
Pelagic coastal piscivores	7.85E-04	1.92E-03	1.35E-03
Red drum	2.05E-05		2.05E-05
Reef invertebrate feeders	2.42E-07	3.96E-04	1.98E-04
Sandbar shark		1.18E-05	1.18E-05
Sardine-herring-scad	8.62E-04	2.94E-03	1.90E-03
Seatrout	1.54E-02	1.39E-02	1.47E-02
Skates-rays		3.39E-04	3.39E-04
Small coastal sharks		1.18E-05	1.18E-05
Spanish mackerel	1.25E-03	1.47E-03	1.36E-03
Surface pelagics	2.90E-05		2.90E-05
White shrimp	3.27E-05		3.27E-05
Zooplankton	1.96E-03		1.96E-03
Total	5.26E-02	5.64E-02	5.61E-02

Table 10A. Commercial catches by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial landings to lowest commercial landings.

No	Functional group	Dredge/ Dig	Handline	Longline (Fish)	Longline (Pelagic)	Longline (Shark)	Nets	Total
60	Menhaden (2yr)	0	0	0	0	0	4.97E-04	1.26E+00
59	Menhaden (1yr)	0	0	0	0	0	2.63E-04	7.59E-01
61	Menhaden (3yr)	0	0	0	0	0	7.00E-05	2.16E-01
68	Brown shrimp	0	0	0	0	0	1.79E-03	1.31E-01
69	White shrimp	0	0	0	0	0	2.22E-03	6.52E-02
70	Crab	3.23E-06	4.60E-04	0	0	0	1.88E-04	6.40E-02
47	Demersal coastal invertebrate feeders	0	3.20E-04	5.54E-03	0	0	9.93E-03	4.45E-02
64	Mullet	0	3.23E-06	0	0	0	4.17E-02	4.34E-02
72	Mobile epifauna	1.62E-04	3.76E-06	0	0	0	1.82E-04	3.39E-02
62	Menhaden (4+yr)	0	0	0	0	0	1.18E-05	3.17E-02
71	Sessile epifauna	2.26E-02	0	0	0	0	0	2.77E-02
67	Pink shrimp	0	0	0	0	0	0	2.69E-02
42	Sea trout	0	4.41E-04	0	0	0	3.84E-03	2.23E-02
41	Coastal piscivores	0	1.29E-05	1.15E-04	0	0	1.96E-03	1.74E-02
18	Pelagic coastal piscivores	0	5.03E-04	9.68E-06	0	0	7.42E-03	9.86E-03
57	Sardine-herring-scad	0	0	0	0	0	3.46E-03	7.59E-03
48	Red drum	0	1.51E-04	0	0	0	4.14E-03	6.51E-03
29	Red grouper (3+yr)	0	5.63E-03	3.98E-09	0	0	0	5.70E-03
17	Swordfish	0	7.10E-05	2.63E-03	2.78E-03	0	0	5.48E-03
37	Red snapper (3+yr)	0	4.75E-03	2.00E-04	0	0	0	4.95E-03
24	Spanish mackerel (1+yr)	0	1.43E-04	0	0	0	2.67E-03	4.17E-03
22	King mackerel (1+yr)	0	2.51E-03	0	0	0	1.38E-03	4.06E-03
46	Reef invertebrate feeders	0	8.05E-04	6.45E-06	0	0	7.37E-04	3.03E-03
15	Other tunas	0	4.84E-07	4.52E-05	1.46E-05	0	0	2.95E-03

Table 10A-Continued. Commercial catches by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial landings to lowest commercial landings.

No	Functional group	Dredge/ Dig	Handline	Longline (Fish)	Longline (Pelagic)	Longline (Shark)	Nets	Total
27	Gag grouper (3+yr)	0	2.38E-03	1.40E-04	0	0	0	2.52E-03
58	Menhaden (0yr)	0	0	0	0	0	1.07E-03	2.39E-03
13	Yellowfin tuna	0	0	7.74E-05	1.92E-03	0	0	2.00E-03
73	Zooplankton	0	0	0	0	0	0	1.96E-03
36	Red snapper (1-2yr)	0	1.70E-03	1.82E-06	0	0	0	1.70E-03
31	Yellowedge grouper (3+yr)	0	5.53E-04	7.22E-04	0	0	0	1.27E-03
65	Butterfish	0	0	0	0	0	0	1.18E-03
40	Other snapper	0	7.13E-04	6.45E-06	0	0	2.58E-04	1.01E-03
39	Mutton snapper	0	3.36E-04	1.46E-04	0	0	0	5.18E-04
16	Billfish	0	0	0	4.89E-04	0	0	4.89E-04
38	Vermilion snapper	0	4.51E-04	6.50E-07	0	0	0	4.51E-04
43	Oceanic piscivores	0	0	0	0	0	0	3.68E-04
6	Blacktip shark	0	6.29E-05	0	0	1.10E-04	1.11E-05	3.53E-04
25	Skates-rays	0	0	0	0	0	0	3.39E-04
54	Surface pelagics	0	0	0	0	0	3.23E-06	3.26E-04
32	Goliath grouper	0	2.68E-04	0	0	0	0	2.94E-04
19	Amberjack	0	2.51E-04	7.05E-06	0	0	6.45E-06	2.65E-04
9	Large coastal sharks	0	0	0	0	0	0	2.60E-04
33	Deep-water grouper	0	1.48E-04	2.58E-05	0	0	0	1.77E-04
7	Dusky shark	0	0	0	0	0	0	1.62E-04
66	Cephalopod	0	0	0	0	0	0	1.56E-04
51	Gray triggerfish	0	1.36E-04	5.41E-06	0	0	0	1.41E-04
20	Cobia	0	1.04E-04	9.68E-06	0	0	1.94E-05	1.33E-04
23	Spanish mackerel (0-1yr)	0	8.57E-07	0	0	0	1.32E-04	1.33E-04
52	Coastal omnivores	0	0	0	0	0	0	1.10E-04

Table 10A-Continued. Commercial catches by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial landings to lowest commercial landings.

No	Functional group	Dredge/ Dig	Handline	Longline (Fish)	Longline (Pelagic)	Longline (Shark)	Nets	Total
50	Tilefish	0	6.02E-05	4.08E-05	0	0	0	1.01E-04
49	Benthic coastal invertebrate feeders	0	0	0	0	0	0	6.41E-05
8	Sandbar shark	0	1.84E-06	0	0	0	0	3.04E-05
26	Gag grouper (0-3yr)	0	2.67E-05	1.73E-07	0	0	0	2.69E-05
11	Atlantic sharpnose shark	0	0	0	0	9.28E-09	0	2.07E-05
14	Bluefin tuna	0	0	1.61E-05	0	0	0	1.61E-05
12	Small coastal sharks	0	2.44E-08	0	0	1.82E-06	0	1.37E-05
74	Infauna	9.68E-06	0	0	0	0	0	9.68E-06
63	Anchovy-silverside-killifish	0	0	0	0	0	0	9.65E-06
10	Large oceanic sharks	0	5.66E-07	0	0	0	0	5.66E-07
44	Benthic piscivores	0	0	0	0	0	0	2.42E-07
30	Yellowedge grouper (0-3yr)	0	1.40E-08	1.71E-09	0	0	0	1.57E-08
35	Red snapper (0yr)	0	1.97E-09	3.06E-09	0	0	0	5.04E-09

Table 10B. Commercial catches by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial landings to lowest commercial landings.

No	Functional group	Pots and Traps	Purse Seine (Menhaden)	Purse Seine (Other)	Bottom Trawl (Other)	Bottom Trawl (Shrimp)	Other	Total
60	Menhaden (2yr)	0	1.25E+00	8.59E-04	0	0	0	1.26E+00
59	Menhaden (1yr)	0	7.59E-01	3.25E-04	0	0	0	7.59E-01
61	Menhaden (3yr)	0	2.16E-01	1.13E-04	0	0	0	2.16E-01
68	Brown shrimp	0	2.66E-05	0	2.78E-02	1.01E-01	0	1.31E-01
69	White shrimp	0	3.27E-05	0	6.13E-05	6.29E-02	0	6.52E-02
70	Crab	4.46E-02	1.35E-04	0	9.68E-06	1.86E-02	0	6.40E-02
47	Demersal coastal invertebrate feeders	1.39E-03	1.59E-02	0	1.58E-04	1.13E-02	9.68E-06	4.45E-02
64	Mullet	0	1.24E-03	1.87E-04	0	2.18E-04	3.23E-06	4.34E-02
72	Mobile epifauna	1.33E-02	2.91E-05	6.45E-06	1.01E-03	1.91E-02	2.58E-04	3.39E-02
62	Menhaden (4+yr)	0	3.17E-02	1.32E-05	0	0	0	3.17E-02
71	Sessile epifauna	0	0	0	0	5.09E-03	0	2.77E-02
67	Pink shrimp	0	0	0	5.61E-04	2.63E-02	0	2.69E-02
42	Sea trout	0	1.47E-02	0	4.19E-05	3.29E-03	0	2.23E-02
41	Coastal piscivores	0	1.41E-02	1.25E-03	3.23E-06	0	0	1.74E-02
18	Pelagic coastal piscivores	0	1.35E-03	5.77E-04	0	3.52E-06	0	9.86E-03
57	Sardine-herring-scad	0	1.90E-03	2.23E-03	0	0	0	7.59E-03
48	Red drum	0	2.05E-05	0	0	2.20E-03	0	6.51E-03
29	Red grouper (3+yr)	6.53E-05	0	0	0	0	0	5.70E-03
17	Swordfish	0	0	0	0	0	0	5.48E-03
37	Red snapper (3+yr)	0	0	0	0	0	0	4.95E-03
24	Spanish mackerel (1+yr)	0	1.36E-03	0	0	0	0	4.17E-03
22	King mackerel (1+yr)	0	1.70E-04	0	0	0	0	4.06E-03
46	Reef invertebrate feeders	8.71E-05	1.98E-04	3.23E-06	6.45E-06	1.18E-03	1.94E-05	3.03E-03
15	Other tuna	0	0	2.88E-03	0	0	0	2.95E-03

Table 10B-Continued. Commercial catches by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial landings to lowest commercial landings.

No	Functional group	Pots and Traps	Purse Seine (Menhaden)	Purse Seine (Other)	Bottom Trawl (Other)	Bottom Trawl (Shrimp)	Other	Total
27	Gag grouper (3+yr)	0	0	0	0	0	0	2.52E-03
58	Menhaden (0yr)	0	1.32E-03	2.04E-06	0	0	0	2.39E-03
13	Yellowfin tuna	0	0	0	0	0	5.81E-05	2.00E-03
73	Zooplankton	0	1.96E-03	0	0	0	0	1.96E-03
36	Red snapper (1-2yr)	0	0	0	0	0	0	1.70E-03
31	Yellowedge grouper (3+yr)	0	0	0	0	0	0	1.27E-03
65	Butterfish	0	1.18E-03	0	0	0	0	1.18E-03
40	Other snapper	3.55E-05	0	0	0	0	1.94E-05	1.01E-03
39	Mutton snapper	3.55E-05	0	0	0	0	6.45E-06	5.18E-04
16	Billfish	0	0	0	0	0	2.26E-06	4.89E-04
38	Vermilion snapper	0	0	0	0	0	0	4.51E-04
43	Oceanic piscivores	0	3.68E-04	0	0	0	0	3.68E-04
6	Blacktip shark	0	1.68E-04	0	0	0	0	3.53E-04
25	Skates-rays	0	3.39E-04	0	0	0	0	3.39E-04
54	Surface pelagics	0	2.90E-05	2.94E-04	0	0	0	3.26E-04
32	Goliath grouper	0	0	0	0	2.67E-05	0	2.94E-04
19	Amberjack	0	0	0	0	0	0	2.65E-04
9	Large coastal sharks	0	2.60E-04	0	0	0	0	2.60E-04
33	Deep-water grouper	3.23E-06	0	0	0	0	0	1.77E-04
7	Dusky shark	0	1.62E-04	0	0	0	0	1.62E-04
66	Cephalopod	0	7.13E-05	0	1.94E-05	6.54E-05	0	1.56E-04
51	Gray triggerfish	0	0	0	0	0	0	1.41E-04
20	Cobia	0	0	0	0	0	0	1.33E-04
23	Spanish mackerel (0-1yr)	0	0	0	0	0	0	1.33E-04
52	Coastal omnivores	0	1.10E-04	0	0	0	0	1.10E-04

Table 10B-Continued. Commercial catches by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial landings to lowest commercial landings.

No	Functional group	Pots and Traps	Purse Seine (Menhaden)	Purse Seine (Other)	Bottom Trawl (Other)	Bottom Trawl (Shrimp)	Other	Total
50	Tilefish	0	0	0	0	0	0	1.01E-04
49	Benthic coastal invertebrate feeders	0	6.41E-05	0	0	0	1.81E-04	6.41E-05
8	Sandbar shark	0	2.86E-05	0	0	0	0	3.04E-05
26	Gag grouper (0-3yr)	0	0	0	0	0	0	2.69E-05
11	Atlantic sharpnose shark	0	2.07E-05	0	0	0	0	2.07E-05
14	Bluefin tuna	0	0	0	0	0	0	1.61E-05
12	Small coastal sharks	0	1.18E-05	0	0	0	0	1.37E-05
74	Infauna	0	0	0	0	0	0	9.68E-06
63	Anchovy-silverside-killifish	0	9.65E-06	0	0	0	0	9.65E-06
10	Large oceanic sharks	0	0	0	0	0	0	5.66E-07
44	Benthic piscivores	0	2.42E-07	0	0	0	0	2.42E-07
30	Yellowedge grouper (0-3yr)	0	0	0	0	0	0	1.57E-08
35	Red snapper (0yr)	0	0	0	0	0	0	5.04E-09

Table 11. Released bycatch estimates (t km^{-2}) of the menhaden purse seine fishery based on the de Silva and Condrey (1997) study, which sampled released bycatch during 1994 and 1995. The 1994-1995 column is a weighted average of species-specific bycatch estimates across both years, weighted by number of sets, and the 1980 column is the 1994-1995 estimates scaled back to 1980 using the ratio of total menhaden landings between years.

Functional group	Released bycatch estimates	
	1994-1995	1980
Benthic coastal invertebrate feeders	5.68E-09	6.51E-09
Benthic piscivores	4.62E-12	5.30E-12
Blacktip shark	3.70E-07	4.24E-07
Coastal piscivores	6.15E-09	7.05E-09
Demersal coastal invertebrate feeders	1.97E-06	2.26E-06
Dusky shark	8.84E-07	1.01E-06
Large coastal sharks	6.37E-07	7.31E-07
Oceanic piscivores	5.52E-08	6.34E-08
Pelagic coastal piscivores	1.03E-07	1.18E-07
Red drum	1.68E-08	1.92E-08
Sandbar shark	9.75E-10	1.12E-09
Small coastal sharks	5.91E-10	6.78E-10
Sea trout	6.48E-07	7.43E-07
Spanish mackerel	3.09E-07	3.54E-07

Table 12. Commercial discards by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial discards to lowest commercial discards.

No	Functional group	Handline	Longline (Fish)	Longline (Pelagic)	Longline (Shark)	Nets	Pots and Traps	Purse Seine (Menhaden)	Bottom Trawl (Shrimp)	Total
47	Demersal coastal invertebrate feeders	0	0	0	0	0	0	2.26E-06	1.47E-02	1.47E-02
11	Atlantic sharpnose shark	1.10E-07	0	0	9.28E-09	0	0	0	6.68E-03	6.68E-03
51	Gray triggerfish	0	0	0	0	0	0	0	6.16E-03	6.16E-03
24	Spanish mackerel (1+yr)	1.44E-07	0	0	0	0	0	0	6.05E-03	6.05E-03
42	Sea trout	0	0	0	0	0	0	7.43E-07	4.22E-03	4.22E-03
38	Vermilion snapper	0	0	0	0	0	0	0	2.24E-03	2.24E-03
23	Spanish mackerel (0-1yr)	9.58E-10	0	0	0	0	0	0	1.47E-03	1.47E-03
46	Reef invertebrate feeders	9.80E-04	0	0	0	0	0	0	5.33E-05	1.03E-03
35	Red snapper (0yr)	5.45E-08	5.34E-08	0	0	0	0	0	9.11E-04	9.11E-04
20	Cobia	3.23E-10	0	0	0	0	0	0	5.61E-04	5.61E-04
29	Red grouper (3+yr)	5.01E-05	1.89E-04	0	0	1.68E-07	1.38E-05	0	0	2.53E-04
36	Red snapper (1-2yr)	1.03E-05	1.06E-04	0	0	0	0	0	6.18E-05	1.78E-04
12	Small coastal sharks	0	0	0	1.57E-06	8.07E-06	0	2.94E-10	1.64E-04	1.74E-04
37	Red snapper (3+yr)	4.01E-08	1.67E-04	0	0	0	0	0	1.35E-13	1.67E-04
48	Red drum	0	0	0	0	0	0	1.92E-08	1.59E-04	1.59E-04
44	Benthic piscivores	0	0	0	0	0	0	5.30E-12	1.14E-04	1.14E-04
6	Blacktip shark	1.95E-06	0	0	0	0	0	4.24E-07	8.49E-05	8.72E-05
21	King mackerel (0-1yr)	0	0	0	0	0	0	0	7.35E-05	7.35E-05
13	Yellowfin tuna	1.09E-06	0	2.93E-05	0	0	0	0	0	3.04E-05
9	Large coastal sharks	5.45E-07	0	0	2.34E-05	0	0	7.31E-07	7.85E-07	2.55E-05
14	Bluefin tuna	0	0	2.33E-05	0	0	0	0	0	2.33E-05
17	Swordfish	0	0	2.28E-05	0	0	0	0	0	2.28E-05
15	Other tunas	0	0	1.99E-05	0	0	0	0	0	1.99E-05
50	Tilefish	0	1.36E-05	0	0	0	0	0	0	1.36E-05

Table 12-Continued. Commercial discards by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total commercial discards to lowest commercial discards.

No	Functional group	Handline	Longline (Fish)	Longline (Pelagic)	Longline (Shark)	Nets	Pots and Traps	Purse Seine (Menhaden)	Bottom Trawl (Shrimp)	Total
18	Pelagic coastal piscivores	5.82E-06	0	0	0	1.22E-06	0	1.18E-07	0	7.16E-06
22	King mackerel (1+yr)	0	0	0	0	2.91E-06	0	0	0	2.91E-06
27	Gag grouper (3+yr)	2.07E-06	2.90E-08	0	0	0	0	0	0	2.10E-06
26	Gag grouper (0-3yr)	2.00E-06	1.07E-08	0	0	0	0	0	0	2.01E-06
39	Mutton snapper	1.66E-06	0	0	0	0	0	0	0	1.66E-06
7	Dusky shark	0	0	0	0	0	0	1.01E-06	0	1.01E-06
28	Red grouper (0-3yr)	4.71E-08	2.22E-07	0	0	0	1.90E-07	0	0	4.59E-07
19	Amberjack	3.68E-07	2.58E-10	0	0	0	0	0	0	3.69E-07
43	Oceanic piscivores	0	0	0	0	0	0	6.34E-08	0	6.34E-08
41	Coastal piscivores	0	0	0	0	0	0	7.05E-09	0	7.05E-09
49	Benthic coastal invertebrate feeders	0	0	0	0	0	0	6.51E-09	0	6.51E-09
8	Sandbar shark	0	0	0	0	0	0	1.12E-09	0	1.12E-09

Table 13. Recreational catches (t km^{-2}) by fishing mode and combined in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total recreational landings to lowest recreational landings.

No	Functional group	Headboat	Shore	Charter	Private	Total
15	Sea trout	3.32E-06	7.88E-03	8.83E-04	1.41E-02	2.29E-02
57	Demersal coastal invertebrate feeders	8.46E-05	2.86E-03	7.56E-05	9.07E-03	1.21E-02
43	Reef invertebrate feeders	1.52E-04	1.54E-03	4.90E-04	7.62E-03	9.80E-03
16	Red drum	1.21E-06	8.30E-04	9.88E-05	5.02E-03	5.95E-03
10	Amberjack	2.00E-04	0	4.90E-03	7.26E-04	5.82E-03
35	Red snapper (3+yr)	1.87E-03	0	1.90E-03	1.90E-03	5.67E-03
49	Pelagic coastal piscivores	6.09E-05	9.64E-04	1.79E-03	2.82E-03	5.63E-03
63	King mackerel (1+yr)	8.02E-04	7.44E-04	1.13E-03	2.60E-03	5.28E-03
26	Reef piscivores	2.62E-06	3.95E-05	2.09E-04	4.72E-03	4.98E-03
39	Shallow-water grouper	7.68E-06	1.32E-03	1.61E-03	1.18E-03	4.11E-03
38	Coastal omnivores	1.12E-05	1.15E-03	0	1.42E-03	2.58E-03
27	Benthic piscivores	3.34E-07	1.05E-03	4.30E-06	9.93E-04	2.05E-03
32	Gag grouper (3+yr)	1.19E-04	1.71E-04	5.63E-04	1.06E-03	1.91E-03
24	Spanish mackerel (1+yr)	3.81E-07	5.11E-04	0	1.37E-03	1.88E-03
6	Cobia	8.86E-06	5.56E-06	0	1.57E-03	1.59E-03
14	Gray triggerfish	8.59E-05	1.31E-05	6.45E-04	7.95E-04	1.54E-03
41	Coastal piscivores	5.88E-07	7.81E-04	3.25E-04	4.22E-04	1.53E-03
42	Mullet	0	1.19E-03	0	3.29E-04	1.52E-03
31	Red grouper (3+yr)	2.07E-04	0	3.82E-04	6.51E-04	1.24E-03
8	Other snapper	1.72E-05	2.22E-04	2.35E-04	7.01E-04	1.17E-03
20	Billfish	4.48E-07	2.17E-04	1.89E-04	5.42E-04	9.48E-04
50	Deep-water grouper	9.56E-06	0	1.95E-05	7.09E-04	7.38E-04
53	Atlantic sharpnose shark	7.78E-05	0	1.21E-05	5.55E-04	6.45E-04
7	Gag grouper (0-3yr)	2.52E-05	0	9.56E-05	4.56E-04	5.77E-04
36	Other tunas	7.01E-06	1.51E-04	1.40E-04	1.03E-04	4.01E-04
62	Red snapper (1-2yr)	3.76E-04	0	0	0	3.76E-04
47	Mutton snapper	0	2.63E-04	2.56E-05	8.46E-05	3.73E-04
11	Large coastal sharks	2.51E-06	5.47E-05	7.87E-07	2.40E-04	2.98E-04
25	Blacktip shark	2.48E-05	0	2.88E-05	1.45E-04	1.98E-04
64	Tilefish	5.95E-07	1.95E-04	0	8.22E-07	1.96E-04
12	Vermilion snapper	5.86E-05	0	1.44E-05	1.08E-04	1.81E-04
34	Yellowfin tuna	1.15E-07	0	1.43E-04	0	1.43E-04
9	Sandbar shark	8.43E-06	3.46E-05	4.95E-05	1.49E-05	1.07E-04
45	Skates-rays	7.96E-08	6.61E-05	3.79E-06	1.31E-05	8.31E-05
29	Dusky shark	7.49E-07	0	0	8.07E-05	8.15E-05
44	Small coastal sharks	2.67E-07	0	4.12E-05	3.58E-05	7.72E-05

Table 13-Continued. Recreational catches (t km^{-2}) by fishing mode and combined in the 1980 US GoM-wide Ecopath model. Rows have been sorted by highest total landings to lowest total landings.

No	Functional group	Headboat	Shore	Charter	Private	Total
13	Benthic coastal invertebrate feeders	1.38E-05	1.73E-05	7.98E-06	3.50E-05	7.40E-05
51	Reef omnivores	5.01E-07	1.61E-05	6.25E-07	5.63E-05	7.35E-05
18	Sardine-herring-scad	1.29E-08	1.24E-08	0	5.53E-05	5.54E-05
22	Bluefin tuna	1.78E-08	0	1.54E-05	0	1.55E-05
33	Goliath grouper	1.90E-06	0	0	0	1.90E-06
46	Oceanic piscivores	0	1.72E-06	0	0	1.72E-06
52	Large oceanic sharks	1.23E-07	0	1.07E-06	0	1.19E-06
40	Yellowedge grouper (3+yr)	1.06E-06	0	0	0	1.06E-06
48	Menhaden (4+yr)	0	2.77E-07	0	0	2.77E-07
19	Anchovy-silverside-killifish	0	3.28E-08	0	0	3.28E-08
37	Red snapper (0yr)	2.91E-10	0	0	0	2.91E-10

Table 14. Recreational discards by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model. Rows have been sorted from highest total recreational discards to lowest recreational discards.

No	Functional group	Headboat	Shore	Charter	Private	Total
47	Demersal coastal invertebrate feeders	0	4.81E-04	7.09E-06	3.16E-03	3.65E-03
18	Pelagic coastal piscivores	0	4.58E-04	7.15E-05	5.13E-04	1.04E-03
42	Sea trout	0	9.87E-05	5.22E-06	5.93E-04	6.97E-04
9	Large coastal sharks	0	2.47E-04	1.80E-05	2.89E-04	5.54E-04
65	Butterfish	0	5.32E-04	0	1.26E-06	5.34E-04
46	Reef invertebrate feeders	5.81E-06	1.48E-04	2.89E-05	2.84E-04	4.66E-04
34	Shallow-water grouper	0	1.71E-04	8.57E-05	1.40E-04	3.97E-04
41	Coastal piscivores	0	6.01E-05	2.41E-04	7.60E-05	3.77E-04
62	Menhaden (4+yr)	0	2.73E-04	2.43E-07	0	2.73E-04
6	Blacktip shark	0	0	3.19E-06	2.63E-04	2.66E-04
49	Benthic coastal invertebrate feeders	0	7.64E-05	6.21E-06	1.58E-04	2.41E-04
52	Coastal omnivores	0	1.60E-04	1.13E-06	6.12E-05	2.22E-04
29	Red grouper (3+yr)	1.45E-05	0	0	1.92E-04	2.07E-04
44	Benthic piscivores	0	4.62E-05	1.08E-07	1.18E-04	1.64E-04
19	Amberjack	1.08E-06	1.64E-05	1.16E-04	8.78E-06	1.42E-04
25	Skates-rays	0	6.81E-05	1.68E-06	3.92E-05	1.09E-04
8	Sandbar shark	0	0	8.59E-06	9.93E-05	1.08E-04
48	Red drum	0	2.38E-05	1.64E-05	6.50E-05	1.05E-04

Table 14-Continued. Recreational discards by fleet (t km^{-2}) in the 1980 US GoM-wide Ecopath model and sort from high to low. Rows have been sorted by highest recreational discards to lowest recreational discards.

No	Functional group	Headboat	Shore	Charter	Private	Total
40	Other snapper	0	2.77E-05	4.54E-06	4.78E-05	8.00E-05
24	Spanish mackerel (1+yr)	9.19E-11	2.34E-05	1.38E-05	4.24E-05	7.96E-05
45	Reef piscivores	0	1.60E-06	4.45E-05	3.24E-05	7.85E-05
16	Billfish	0	0	3.66E-06	7.07E-05	7.44E-05
26	Gag grouper (0-3yr)	2.38E-06	1.51E-05	3.90E-06	2.79E-05	4.93E-05
51	Gray triggerfish	1.57E-05	0	1.57E-05	1.57E-05	4.71E-05
28	Red grouper (0-3yr)	1.21E-06	1.58E-05	3.01E-06	3.01E-06	2.30E-05
22	King mackerel (1+yr)	0	0	1.61E-06	1.73E-05	1.89E-05
20	Cobia	8.13E-06	4.89E-07	0	1.01E-05	1.87E-05
64	Mullet	0	1.26E-05	0	2.32E-06	1.49E-05
57	Sardine-herring-scad	0	3.49E-06	3.96E-08	5.02E-06	8.55E-06
53	Reef omnivores	0	3.12E-06	0	3.12E-06	6.24E-06
39	Mutton snapper	0	0	5.84E-06	0	5.84E-06
15	Other tunas	0	0	4.37E-06	0	4.37E-06
7	Dusky shark	0	0	0	4.15E-06	4.15E-06
27	Gag grouper (3+yr)	5.00E-07	0	1.04E-06	2.25E-06	3.79E-06
38	Vermilion snapper	0	0	2.69E-06	0	2.69E-06
36	Red snapper (1-2yr)	5.65E-08	0	3.12E-07	3.12E-07	6.80E-07
35	Red snapper (0yr)	1.46E-09	0	5.54E-08	5.54E-08	1.12E-07
43	Oceanic piscivores	0	0	2.56E-08	0	2.56E-08
37	Red snapper (3+yr)	3.35E-09	0	6.88E-09	6.88E-09	1.71E-08
32	Goliath grouper	0	0	2.38E-09	0	2.38E-09
23	Spanish mackerel (0-1yr)	2.74E-10	0	0	0	2.74E-10

Table 15. Total landings (t km^{-2} yr^{-1}), discards (t km^{-2} yr^{-1}), and catch (landings + discards; t km^{-2} yr^{-1}) for the US Gulf-wide Ecopath fishing fleets in 1980. The trophic level (*TL*) of the catch is also shown and is discussed further in the results section.

Fishing fleet	Landings	Discards	Catch	*TL* of the Catch
Commercial				
Dredge/Dig	0.0228	0	0.0228	2.012
Handline	0.0230	1.0563E-03	0.0241	3.282
Longline (Fish)	0.0098	4.7678E-04	0.0102	3.150
Longline (Pelagic)	0.0052	9.5361E-05	0.0053	3.787
Longline (Shark)	0.0001	2.4989E-05	0.0001	3.421
Nets	0.0840	1.2360E-05	0.0840	2.673
Other	0.0006	0	0.0006	2.616
Pots and Traps	0.0596	1.3970E-05	0.0596	2.697
Purse Seine (Menhaden)	2.3179	6.0000E-06	2.3179	2.263
Purse Seine (Other)	0.0087	0	0.0087	3.052
Bottom Trawl (Other)	0.0297	0	0.0297	2.072
Bottom Trawl (Shrimp)	0.2512	4.3673E-02	0.2949	2.346
Recreational				
Headboat	0.0042	3.3608E-05	0.0043	3.310
Shore	0.0223	2.9624E-03	0.0252	3.037
Charter	0.0160	7.1533E-04	0.0167	3.369
Private	0.0623	6.3482E-03	0.0686	3.100
Total	2.9174	0.0554	2.9727	

Table 16. Sources of time series for catch, biomass, and fishing mortality for each EwE functional group. NOAA refers to catches (landings in weight) from NOAA commercial and recreational sources, as described in the text. For Catch and Biomass, values in parentheses represent the weight assigned to each time series and the type (6 = catches, 61 = relative catches, 0 = relative biomass). Fishing mortality always input as a driver (type = 4).

No	Functional group	Catch (*C*)	Biomass (*B*)	Fishing mortality (*F*)
6	Blacktip shark	NOAA (0.5, 6)	SEDAR 29 Update (1, 0)	SEDAR 29 Update
7	Dusky shark	NOAA (0.5, 61 - catches deemed unreliable for use in assessment)	SEDAR 21 Update (1, 0)	SEDAR 21 Update
8	Sandbar shark	NOAA (0.5, 6)	SEDAR 54 (HMS) (1, 0)	SEDAR 54
9	Large coastal sharks	NOAA (0.5, 6)	SEDAR 11 (1, 0)	-
10	Large oceanic sharks	NOAA (0.5, 6)	ICCAT 2017a for shortfin mako (1, 0)	ICCAT 2017a for shortfin mako
11	Atlantic sharpnose shark	NOAA (0.5, 6)	SEDAR 34 (1, 0)	SEDAR 34
12	Small coastal sharks	NOAA (0.5, 6)	SEDAR 34 for bonnethead (1, 0)	-
13	Yellowfin tuna	NOAA (1, 6)	Pelagic longline index (1, 0)	ICCAT 2019
14	Bluefin tuna	NOAA (1, 6)	Pelagic longline index (1, 0)	ICCAT 2017c
15	Other tuna	NOAA (1, 6)	Pelagic longline index (1, 0)	-
16	Billfish	ICCAT (1, 6)	Pelagic longline index (3.78, 0)	ICCAT 2018
17	Swordfish	NOAA (1, 61)	Pelagic longline index (9.04, 0)	ICCAT 2017b
18	Pelagic coastal piscivores	NOAA (1, 6)	SEAMAP Bottom trawl (0.55, 0)	-
19	Amberjacks	SEDAR 33 Update (7.85, 6)	SEDAR 33 Update (10.68, 0)	SEDAR 33 Update *C*/*B*
20	Cobia	SEDAR 28 (2.91, 6)	SEDAR 28 (7.88, 0)	SEDAR 28 *C*/*B*
21	King mackerel (0-1yr)	-	SEDAR 38 (12.29, 0)	-
22	King mackerel (1+yr)	SEDAR 38 (17.73, 6)	SEDAR 38 (15.03, 0)	SEDAR 38 *C*/*B*
23	Spanish mackerel (0-1yr)	-	SEDAR 28 (5.11, 0)	-
24	Spanish mackerel (1+yr)	SEDAR 28 (5.71, 6)	SEDAR 28 (10.78, 0)	SEDAR 28 *C*/*B*
25	Skates-rays	NOAA (1, 6)	SEAMAP Bottom trawl (2.61, 0)	-
26	Gag grouper (0-3yr)	-	SEDAR 33 Update (15.32, 0)	-

Table 16-Continued. Sources of time series for catch, biomass, and fishing mortality for each EwE functional group. NOAA refers to catches (landings in weight) from NOAA commercial and recreational sources, as described in the text. For Catch and Biomass, values in parentheses represent the weight assigned to each time series and the type (6 = catches, 61 = relative catches, 0 = relative biomass). Fishing mortality always input as a driver (type = 4).

No	Functional group	Catch (*C*)	Biomass (*B*)	Fishing mortality (*F*)
27	Gag grouper (3+yr)	SEDAR 33 Update (7.41, 6)	SEDAR 33 Update (22.12, 0)	SEDAR 33 Update *C*/*B*
28	Red grouper (0-3yr)	-	SEDAR 61 (4.54, 0)	-
29	Red grouper (3+yr)	SEDAR 61 (4.98, 6)	SEDAR 61 (7.23, 0)	SEDAR 61 Update *C*/*B*
30	Yellowedge grouper (0-3yr)	-	SEDAR 22 (7.79, 0)	-
31	Yellowedge grouper (3+yr)	SEDAR 22 (27.14, 6)	SEDAR 22 (20.71, 0)	SEDAR 22 *C*/*B*
32	Goliath grouper	NOAA (1, 6)	SEDAR 47 (13.17, 0)	SEDAR 47
33	Deep-water grouper	NOAA (1, -6)	-	-
34	Shallow-water grouper	NOAA (1, -6)	SEDAR 49 video index for yellowmouth grouper (1, 0)	-
35	Red snapper (0-1yr)	-	SEDAR 52 (15.87, 0)	-
36	Red snapper (1-2yr)	SEDAR 52 (20, 61)	SEDAR 52 (14.57, 0)	SEDAR 52 *C*/*B*
37	Red snapper (3+yr)	SEDAR 52 (20, 6)	SEDAR 52 (13.27, 0)	SEDAR 52 *C*/*B*
38	Vermilion snapper	SEDAR 67 (10.24, 6)	SEDAR 67 (21.17, 0)	SEDAR 67 *C*/*B*
39	Mutton snapper	SEDAR 15 Update (1, 6)	SEDAR 15 Update (13.17, 0)	SEDAR 15 Update *C*/*B*
40	Other snapper	NOAA (1, 6)	SEAMAP Bottom trawl (0.69, 0)	-
41	Coastal piscivores	NOAA (1, 6)	-	-
42	Seatrout	NOAA (1, 6)	SEAMAP Bottom trawl (5.57, 0)	-
43	Oceanic piscivores	NOAA (1, 6)	SEAMAP Bottom trawl (3.27, 0)	-
44	Benthic piscivores	NOAA (1, 6)	SEAMAP Bottom trawl (14.36, 0)	-
45	Reef piscivores	NOAA (1, 6)	SEAMAP Bottom trawl (3.05, 0)	-
46	Reef invertebrate feeders	NOAA (1, 6)	SEAMAP Bottom trawl (9.22, 0)	-
47	Demersal coastal invertebrate feeders	NOAA (1, 6)	SEAMAP Bottom trawl (5.06, 0)	-
48	Red drum	SEDAR 49 (1980-2013) and NOAA (2014+) (1, -6)	SEDAR 49 (Dauphin Island Sea Lab longline index) (1, 0)	-

Table 16-Continued. Sources of time series for catch, biomass, and fishing mortality for each EwE functional group. NOAA refers to catches (landings in weight) from NOAA commercial and recreational sources, as described in the text. For Catch and Biomass, values in parentheses represent the weight assigned to each time series and the type (6 = catches, 61 = relative catches, 0 = relative biomass). Fishing mortality always input as a driver (type = 4).

No	Functional group	Catch (*C*)	Biomass (*B*)	Fishing mortality (*F*)
49	Benthic coastal invertebrate feeders	NOAA (1, 6)	SEAMAP Bottom trawl (11.37, 0)	-
50	Tilefish	NOAA (3.21, 6)	SEDAR 22 (3.64, 0)	SEDAR 22 *C/B*
51	Gray triggerfish	SEDAR 43 (10.68, 6)	SEDAR 43 (5.74, 0)	SEDAR 43 *C/B*
52	Coastal omnivores	NOAA (1, 6)	SEAMAP Bottom trawl (10.39, 0)	-
53	Reef omnivores	NOAA (1, 6)	-	-
54	Surface pelagics	NOAA (1, 6)	-	-
55	Large oceanic planktivores	-	-	-
56	Oceanic planktivores	NOAA	-	-
57	Sardine-herring-scad	NOAA (1, 6)	SEAMAP Bottom trawl (3.03, 0)	-
58	Menhaden (0yr)	-	SEDAR 63 (1, 0)	-
59	Menhaden (1yr)	SEDAR 63 (5.5, 61)	SEDAR 63 (13.17, 0)	SEDAR 63 *C/B*
60	Menhaden (2yr)	SEDAR 63 (5.5, 6)	SEDAR 63 (13.17, 0)	SEDAR 63 *C/B*
61	Menhaden (3yr)	SEDAR 63 (5.5, 61)	SEDAR 63 (13.17, 0)	SEDAR 63 *C/B*
62	Menhaden (4+yr)	SEDAR 63 (5.5, 61)	SEDAR 63 (13.17, 0)	SEDAR 63 *C/B*
63	Anchovies-silversides-killifish	-	SEAMAP Bottom trawl (2.74, 0)	-
64	Mullet	NOAA (1, -6)	-	-
65	Butterfish	-	SEAMAP Bottom trawl (1.42, 0)	-
66	Cephalopods	-	SEAMAP Bottom trawl (4.99, 0)	-
67	Pink shrimp	2018 Update (0.97, 6)	2018 Update (13.17, 0)	2018 Update *C/B*
68	Brown shrimp	2018 Update (10.62, 6)	2018 Update (13.17, 0)	2018 Update *C/B*
69	White shrimp	2018 Update (7.98, 6)	2018 Update (13.17, 0)	2018 Update *C/B*
70	Crab	NOAA (1, 6)	SEAMAP Bottom trawl (0.55, 0)	GDAR 01
71	Sessile epifauna	NOAA	-	-
72	Mobile epifauna	NOAA (1, 6)	SEAMAP Bottom trawl (0.63, 0)	-

Table 17. Source of fishing effort time series for each fishing fleet. Fishing effort always input as a driver (type = 3).

Fishing fleet	Effort source
Commercial Dredge/Dig	NMFS Vessel Operating Units, sum of gear number (number of dredges)
Commercial Handline	Number of commercial vertical line trips (SEDAR 49)
Commercial Longline (Fish)	Number of commercial bottom longline trips (SEDAR 49)
Commercial Longline (Pelagic)	Relative pelagic longline fishery effort (SEDAR 29 Update)
Commercial Longline (Shark)	Relative bottom longline fishery effort (SEDAR 29 Update)
Commercial Nets	NMFS Vessel Operating Units, sum of gear number (number of nets)
Commercial Other	NMFS Vessel Operating Units, sum of gear number
Commercial Pots and Traps	NMFS Vessel Operating Units, sum of gear number (number in use at one time)
Commercial Purse Seine (Menhaden)	Vessel-ton-weeks (SEDAR 63)
Commercial Purse Seine (Other)	NMFS Vessel Operating Units, sum of gear number (number of nets)
Commercial Bottom Trawl (Other)	NMFS Vessel Operating Units, sum of gear number (number of nets)
Commercial Bottom Trawl (Shrimp)	Days fished (SEDAR 52 effort)
Recreational Headboat	Number of trips (SRHS)
Recreational Shore	Number of trips (MRIP)
Recreational Charter	Number of trips (MRIP + TPWD)
Recreational Private	Number of trips (MRIP + TPWD)

Table 18. Ecopath parameters from the balanced 1980 Ecopath model. *TL* is the trophic level, *B* is the biomass (t km^{-2}), *P*/*B* is the ratio of production to biomass (yr^{-1}), *Q*/*B* is the ratio of consumption to biomass (yr^{-1}), *EE* is the ecotrophic efficiency, *P*/*Q* is the ratio of production to consumption, and *BA* is the biomass accumulation (t km^{-2} yr^{-1}). Values in italics were estimated by the model.

No	Functional group	*TL*	*B*	*Z*	*P*/*B*	*Q*/*B*	*EE*	*P*/*Q*	*BA*	*BA* rate
1	Coastal dolphins	*3.44*	0.0207		0.16	15.0	*0.82*	*0.01*	0	0
2	Offshore dolphins	*3.79*	0.0207		0.16	15.0	*0.60*	*0.01*	0	0
3	Baleen whales	*3.47*	0.0207		0.16	15.0	*0.07*	*0.01*	0	0
4	Seabird	*3.31*	0.0146		0.25	33.0	*0.54*	*0.01*	0	0
5	Sea turtle	*3.42*	0.0128		0.12	3.5	*0.83*	*0.03*	0	0
6	Blacktip shark	*3.37*	0.0946		0.32	3.2	*0.21*	*0.10*	0	0
7	Dusky shark	*3.75*	0.0090		0.28	2.8	*0.26*	*0.10*	0	0
8	Sandbar shark	*3.64*	0.0015		0.34	3.2	*0.69*	*0.11*	0	0
9	Large coastal sharks	*3.64*	0.0380		0.30	3.0	*0.40*	*0.10*	0	0
10	Large oceanic sharks	*3.61*	0.0275		0.29	2.7	*0.28*	*0.11*	0	0
11	Atlantic sharpnose shark	*3.39*	0.0195		0.58	5.8	*0.94*	*0.10*	0	0
12	Small coastal sharks	*3.47*	0.0018		0.50	5.0	*0.97*	*0.10*	0	0
13	Yellowfin tuna	*3.85*	0.0028		1.08	8.4	*0.96*	*0.13*	0	0
14	Bluefin tuna	*3.71*	0.0005		0.43	4.3	*0.80*	*0.10*	0	0
15	Other tunas	*3.62*	0.0060		0.89	8.9	*0.83*	*0.10*	0	0
16	Billfish	*3.74*	0.0030		0.60	4.9	*0.95*	*0.12*	0	0
17	Swordfish	*3.75*	0.0139		0.44	3.8	*0.98*	*0.12*	0	0
18	Pelagic coastal piscivores	*3.33*	0.0617		0.76	6.3	*0.84*	*0.12*	0	0
19	Amberjack	*3.57*	0.0291		0.44	3.9	*0.85*	*0.11*	0	0
20	Cobia	*3.66*	0.0111		0.62	4.1	*0.57*	*0.15*	0	0
21	King mackerel (0-1yr)	*3.35*	0.0006	1.46		14.3	*0.37*	*0.10*	0	0
22	King mackerel (1+yr)	*3.36*	0.1400	0.22		3.5	*0.90*	*0.06*	0	0
23	Spanish mackerel (0-1yr)	*3.33*	0.0012	2.00		19.8	*0.93*	*0.10*	0.0000	0.014
24	Spanish mackerel (1+yr)	*3.54*	0.0629	0.52		5.2	*0.74*	*0.10*	0.0009	0.014
25	Skates-rays	*2.88*	0.0339		0.48	4.8	*0.93*	*0.10*	0	0
26	Gag grouper (0-3yr)	*3.40*	0.0027	0.57		9.3	*0.82*	*0.06*	0.0003	0.1
27	Gag grouper (3+yr)	*3.47*	0.0181	0.37		3.6	*0.93*	*0.10*	0.0018	0.1
28	Red grouper (0-3yr)	*3.38*	0.0030	0.43		9.2	*0.79*	*0.05*	0.0002	0.05
29	Red grouper (3+yr)	*3.33*	0.0267	0.37		3.7	*0.97*	*0.10*	0.0013	0.05
30	Yellowedge grouper (0-3yr)	*3.28*	0.0002	0.32		18.1	*0.69*	*0.02*	0.0000	0.01
31	Yellowedge grouper (3+yr)	*3.17*	0.0483	0.10		3.7	*0.53*	*0.03*	0.0005	0.01
32	Goliath grouper	*3.59*	0.0014		0.33	3.3	*0.93*	*0.10*	0	0
33	Deep-water grouper	*3.56*	0.0067		0.40	4.0	*0.44*	*0.10*	0	0
34	Shallow-water grouper	*3.48*	0.0126		0.62	6.2	*0.85*	*0.10*	0	0
35	Red snapper (0yr)	*3.38*	0.0029	1.00		18.4	*0.47*	*0.05*	0.0002	0.08
36	Red snapper (1-2yr)	*3.42*	0.0204	1.60		7.9	*0.17*	*0.20*	0.0016	0.08
37	Red snapper (3+yr)	3.32	0.0423	0.33		3.3	0.84	0.10	0.0034	0.08

Table 18-Continued. Ecopath parameters from the balanced 1980 Ecopath model. *TL* is the trophic level, *B* is the biomass (t km^{-2}), *P*/*B* is the ratio of production to biomass (yr^{-1}), *Q*/*B* is the ratio of consumption to biomass (yr^{-1}), *EE* is the ecotrophic efficiency, *P*/*Q* is the ratio of production to consumption, and *BA* is the biomass accumulation (t km^{-2} yr^{-1}). Values in italics were estimated by the model.

No	Functional group	*TL*	*B*	*Z*	*P*/*B*	*Q*/*B*	*EE*	*P*/*Q*	*BA*	*BA* rate
38	Vermilion snapper	*3.02*	0.0720		0.52	4.5	*0.31*	*0.12*	0	0
39	Mutton snapper	*3.24*	0.0154		0.58	5.8	*0.33*	*0.10*	0	0
40	Other snapper	*3.15*	0.0136		0.60	6.0	*0.93*	*0.10*	0	0
41	Coastal piscivores	*3.13*	0.0852		0.67	6.5	*0.96*	*0.10*	0	0
42	Sea trout	*3.03*	0.1076		0.73	7.0	*0.98*	*0.10*	0	0
43	Oceanic piscivores	*3.36*	0.0355		1.00	8.5	*0.99*	*0.12*	0	0
44	Benthic piscivores	*3.32*	0.0265		0.70	5.0	*0.97*	*0.14*	0	0
45	Reef piscivores	*3.30*	0.0250		0.84	5.4	*0.93*	*0.16*	0	0
46	Reef invertebrate feeders	*2.80*	0.1828		1.05	5.8	*0.90*	*0.18*	0	0
47	Demersal coastal invertebrate feeders	*2.81*	0.2551		1.00	5.9	*0.90*	*0.17*	0	0
48	Red drum	*3.18*	0.1145		0.50	5.0	*0.35*	*0.10*	0	0
49	Benthic coastal invertebrate feeders	*2.80*	0.1700		1.25	5.8	*0.97*	*0.22*	0	0
50	Tilefish	*3.27*	0.0070		0.35	3.5	*0.27*	*0.10*	0	0
51	Gray triggerfish	*2.79*	0.0547		0.59	5.9	*0.38*	*0.10*	0	0
52	Coastal omnivores	*2.73*	0.1650		0.88	8.8	*0.99*	*0.10*	0	0
53	Reef omnivores	*2.68*	0.0200		1.40	8.4	*0.95*	*0.17*	0	0
54	Surface pelagics	*2.86*	0.1250		1.45	11.7	*0.91*	*0.12*	0	0
55	Large oceanic planktivores	*3.22*	0.0174		0.16	1.3	*0.38*	*0.12*	0	0
56	Oceanic planktivores	*3.16*	0.0450		0.87	8.7	*0.94*	*0.10*	0	0
57	Sardine-herring-scad	*2.77*	0.6300		1.05	10.5	*0.91*	*0.10*	0	0
58	Menhaden (0yr)	*2.25*	1.8929	1.67		42.9	*0.04*	*0.04*	0.6246	0.33
59	Menhaden (1yr)	*2.25*	4.4136	1.51		22.0	*0.15*	*0.07*	1.4565	0.33
60	Menhaden (2yr)	*2.25*	2.0070	1.73		15.4	*0.43*	*0.11*	0.6623	0.33
61	Menhaden (3yr)	*2.25*	0.4956	1.52		12.7	*0.45*	*0.12*	0.1635	0.33
62	Menhaden (4+yr)	*2.25*	0.1433	1.42		11.1	*0.46*	*0.13*	0.0473	0.33
63	Anchovy-silverside-killifish	*2.62*	0.7050		1.59	15.9	*0.84*	*0.10*	0	0
64	Mullet	*2.41*	0.2870		0.80	8.0	*0.60*	*0.10*	0	0
65	Butterfish	*2.76*	0.0730		1.36	8.1	*0.98*	*0.17*	0	0
66	Cephalopod	*2.97*	1.0000		2.80	13.7	*0.82*	*0.20*	0	0
67	Pink shrimp	*2.43*	0.0800		3.77	19.2	*0.41*	*0.20*	0	0
68	Brown shrimp	*2.06*	0.0607		5.22	19.2	*0.64*	*0.27*	0	0
69	White shrimp	*2.05*	0.5000		3.32	19.2	*0.18*	*0.17*	0	0
70	Crab	*2.86*	0.2500		1.60	10.5	*0.94*	*0.15*	0	0
71	Sessile epifauna	*2.01*	12.0000		1.60	9.0	*0.63*	*0.18*	0	0
72	Mobile epifauna	*2.13*	18.0000		2.60	16.0	*0.35*	*0.16*	0	0

Table 18-Continued. Ecopath parameters from the balanced 1980 Ecopath model. *TL* is the trophic level, *B* is the biomass (t km^{-2}), *P*/*B* is the ratio of production to biomass (yr^{-1}), *Q*/*B* is the ratio of consumption to biomass (yr^{-1}), *EE* is the ecotrophic efficiency, *P*/*Q* is the ratio of production to consumption, and *BA* is the biomass accumulation (t km^{-2} yr^{-1}). Values in italics were estimated by the model.

No	Functional group	*TL*	*B*	*Z*	*P*/*B*	*Q*/*B*	*EE*	*P*/*Q*	*BA*	*BA* rate
73	Zooplankton	*2.05*	15.0000		10.00	74.0	*0.72*	*0.14*	0	0
74	Infauna	*2.04*	18.5000		5.17	22.0	*0.49*	*0.24*	0	0
75	Algae	*1.00*	29.8000		27.50	0.0	*0.07*		0	0
76	Seagrass	*1.00*	150.0000		25.00	0.0	*0.01*		0	0
77	Phytoplankton	*1.00*	25.0000		160.00	0.0	*0.30*		0	0
78	Detritus	*1.00*	100.0000				*0.09*		0	0

Table 19. Predator prey ratios for biomass (t km^{-2}) and vital rates (*P*/*B*, *Q*/*B*, *R*/*B*, yr^{-1}) for model diagnostics of the US Gulf-wide Ecopath model. Parameters are as defined in Table 18 and Guilds are as defined in Table 1.

Guild	*B*	*P*/*B*	*Q*/*B*	*R*/*B*
Demersal / Benthic invertebrates (D/BI)	0.03	0.20	0.39	0.46
Demersal and Medium pelagic piscivores / Small pelagics (DMPP/SP)	0.06	0.48	0.48	0.47
Marine mammals and birds / Small Pelagics (MMB/SP)	0.01	0.12	1.25	1.41
Planktivores / Zooplankton (PLK/ZOO)	0.04	0.05	0.07	0.07
Sharks / Small pelagics (S and H/SP)	0.02	0.33	0.29	0.29
Small pelagics / Zooplankton (SP/ZOO)	0.70	0.15	0.21	0.22
Small pelagics / Phytoplankton (SP/PHY)	0.42	0.01	-	-
Zooplankton / Phytoplankton (ZOO/PHY)	0.60	0.06	-	-

Table 20. Estimates of group biomass relative to primary producers (*B*/PP), production relative to primary producers (*P*/PP), *P/B (or Z)* relative to primary producers ((*P*/*B*)/PP), the ratio of the predation losses of each functional group to its production ($Q_{oftaxa}/P_{bytaxa;}$, equivalent to *M2*/*Z*), the ratio of the consumption by each functional group to its production (Q_{bytaxa}/P_{bytaxa}, equivalent to the inverse of *P*/*Q*).

No	Functional group	*B*/PP	*P*/PP	(*P*/*B*)/PP	Q_{oftaxa}/P_{bytaxa}	Q_{bytaxa}/P_{bytaxa}
1	Coastal dolphins	1.01E-04	1.16E-06	0.002	0.819	93.75
2	Offshore dolphins	1.01E-04	1.16E-06	0.002	0.604	93.75
3	Baleen whales	1.01E-04	1.16E-06	0.002	0.067	93.75
4	Seabird	7.13E-05	1.28E-06	0.004	0.537	132
5	Sea turtle	6.25E-05	5.38E-07	0.002	0.834	29.167
6	Blacktip shark	4.62E-04	1.07E-05	0.005	0.185	9.907
7	Dusky shark	4.39E-05	8.82E-07	0.004	0.162	10
8	Sandbar shark	7.32E-06	1.79E-07	0.005	0.208	9.412
9	Large coastal sharks	1.86E-04	3.99E-06	0.004	0.303	10
10	Large oceanic sharks	1.34E-04	2.77E-06	0.004	0.275	9.375
11	Atlantic sharpnose shark	9.52E-05	3.96E-06	0.008	0.293	10
12	Small coastal sharks	8.79E-06	3.15E-07	0.007	0.671	10
13	Yellowfin tuna	1.37E-05	1.06E-06	0.015	0.218	7.778
14	Bluefin tuna	2.44E-06	7.53E-08	0.006	0.545	10
15	Other tunas	2.93E-05	1.87E-06	0.013	0.201	10
16	Billfish	1.46E-05	6.30E-07	0.008	0.105	8.167
17	Swordfish	6.79E-05	2.14E-06	0.006	0.083	8.636
18	Pelagic coastal piscivores	3.01E-04	1.64E-05	0.011	0.486	8.289
19	Amberjack	1.42E-04	4.46E-06	0.006	0.360	8.904
20	Cobia	5.42E-05	2.41E-06	0.009	0.240	6.613
21	King mackerel (0-1yr)	2.97E-06	3.11E-07	0.021	0.286	9.816
22	King mackerel (1+yr)	6.84E-04	1.07E-05	0.003	0.593	16.055
23	Spanish mackerel (0-1yr)	5.71E-06	8.18E-07	0.028	0.242	9.886
24	Spanish mackerel (1+yr)	3.07E-04	1.14E-05	0.007	0.366	10
25	Skates-rays	1.66E-04	5.70E-06	0.007	0.902	10
26	Gag grouper (0-3yr)	1.32E-05	5.38E-07	0.008	0.399	16.251
27	Gag grouper (3+yr)	8.84E-05	2.34E-06	0.005	0.264	9.73
28	Red grouper (0-3yr)	1.48E-05	4.56E-07	0.006	0.772	21.29
29	Red grouper (3+yr)	1.30E-04	3.46E-06	0.005	0.225	10
30	Yellowedge grouper (0-3yr)	8.82E-07	2.02E-08	0.005	0.692	56.469
31	Yellowedge grouper (3+yr)	2.36E-04	1.69E-06	0.001	0.265	37
32	Goliath grouper	6.84E-06	1.62E-07	0.005	0.287	10
33	Deep-water grouper	3.27E-05	9.38E-07	0.006	0.096	10
34	Shallow-water grouper	6.15E-05	2.73E-06	0.009	0.272	10
35	Red snapper (0yr)	1.43E-05	1.03E-06	0.014	0.162	18.43

Table 20-Continued. Estimates of group biomass relative to primary producers (*B*/PP), production relative to primary producers (*P*/PP), *P/B (or Z)* relative to primary producers ((*P*/*B*)/PP), the ratio of the predation losses of each functional group to its production ($Q_{oftaxa}/P_{bytaxa;}$, equivalent to *M2*/*Z*), the ratio of the consumption by each functional group to its production (Q_{bytaxa}/P_{bytaxa}, equivalent to the inverse of *P*/*Q*).

No	Functional group	*B*/PP	*P*/PP	(*P*/*B*)/PP	Q_{oftaxa}/P_{bytaxa}	Q_{bytaxa}/P_{bytaxa}
36	Red snapper (1-2yr)	9.95E-05	1.14E-05	0.023	0.099	4.963
37	Red snapper (3+yr)	2.07E-04	4.89E-06	0.005	0.072	10
38	Vermilion snapper	3.52E-04	1.31E-05	0.007	0.236	8.654
39	Mutton snapper	7.52E-05	3.13E-06	0.008	0.230	10
40	Other snapper	6.64E-05	2.86E-06	0.008	0.653	10
41	Coastal piscivores	4.16E-04	2.00E-05	0.009	0.626	9.701
42	Sea trout	5.25E-04	2.75E-05	0.010	0.342	9.589
43	Oceanic piscivores	1.73E-04	1.24E-05	0.014	0.980	8.5
44	Benthic piscivores	1.29E-04	6.49E-06	0.010	0.848	7.143
45	Reef piscivores	1.22E-04	7.35E-06	0.012	0.692	6.429
46	Reef invertebrate feeders	8.93E-04	6.72E-05	0.015	0.826	5.524
47	Demersal coastal invertebrate feeders	1.25E-03	8.93E-05	0.014	0.607	5.9
48	Red drum	5.59E-04	2.00E-05	0.007	0.130	10
49	Benthic coastal invertebrate feeders	8.30E-04	7.44E-05	0.018	0.962	4.64
50	Tilefish	3.42E-05	8.58E-07	0.005	0.146	10
51	Gray triggerfish	2.67E-04	1.13E-05	0.008	0.140	10
52	Coastal omnivores	8.06E-04	5.08E-05	0.012	0.967	10
53	Reef omnivores	9.77E-05	9.80E-06	0.020	0.945	6
54	Surface pelagics	6.10E-04	6.35E-05	0.020	0.912	8.069
55	Large oceanic planktivores	8.50E-05	9.75E-07	0.002	0.375	8.125
56	Oceanic planktivores	2.20E-04	1.37E-05	0.012	0.941	10
57	Sardine-herring-scad	3.08E-03	2.32E-04	0.015	0.901	10
58	Menhaden (0yr)	9.24E-03	1.11E-03	0.024	0.034	25.671
59	Menhaden (1yr)	2.16E-02	2.33E-03	0.021	0.039	14.552
60	Menhaden (2yr)	9.80E-03	1.21E-03	0.024	0.063	8.92
61	Menhaden (3yr)	2.42E-03	2.64E-04	0.021	0.162	8.338
62	Menhaden (4+yr)	7.00E-04	7.11E-05	0.020	0.298	7.867
63	Anchovy-silverside-killifish	3.44E-03	3.92E-04	0.022	0.844	10
64	Mullet	1.40E-03	8.04E-05	0.011	0.402	10
65	Butterfish	3.56E-04	3.48E-05	0.019	0.963	5.956
66	Cephalopod	4.88E-03	9.80E-04	0.040	0.815	4.893

Table 20-Continued. Estimates of group biomass relative to primary producers (*B*/PP), production relative to primary producers (*P*/PP), *P/B (or Z)* relative to primary producers ((*P*/*B*)/PP), the ratio of the predation losses of each functional group to its production ($Q_{oftaxa}/P_{bytaxa;}$, equivalent to *M2*/*Z*), the ratio of the consumption by each functional group to its production (Q_{bytaxa}/P_{bytaxa}, equivalent to the inverse of *P*/*Q*).

No	Functional group	*B*/PP	*P*/PP	(*P*/*B*)/PP	Q_{oftaxa}/P_{bytaxa}	Q_{bytaxa}/P_{bytaxa}
67	Pink shrimp	3.91E-04	1.06E-04	0.053	0.318	5.093
68	Brown shrimp	2.96E-04	1.11E-04	0.074	0.228	3.678
69	White shrimp	2.44E-03	5.81E-04	0.047	0.143	5.783
70	Crab	1.22E-03	1.40E-04	0.023	0.783	6.562
71	Sessile epifauna	5.86E-02	6.72E-03	0.023	0.624	5.625
72	Mobile epifauna	8.79E-02	1.64E-02	0.037	0.354	6.154
73	Zooplankton	7.32E-02	5.25E-02	0.141	0.725	7.4
74	Infauna	9.03E-02	3.35E-02	0.073	0.489	4.255
75	Algae	-	-	0.388	0.075	NA
76	Seagrass	-	-	0.353	0.006	NA
77	Phytoplankton	-	-	2.259	0.3	NA

Table 21. Estimates of fishing (*F*), predation (*M2*), and other (*M0*) mortality rates. Also shown is the ratio of *F*/*Z, F*/*M2*, and the ratio of total fishing removals to consumption of taxa (Catch/*Q*).

No	Functional group	*F*	*M2*	*M0*	*F*/*Z*	*F*/*M2*	Catch/*Q*
1	Coastal dolphins	0	0.131	0.029	0	0	0
2	Offshore dolphins	0	0.097	0.063	0	0	0
3	Baleen whales	0	0.011	0.149	0	0	0
4	Seabird	0	0.134	0.116	0	0	0
5	Sea turtle	0	0.100	0.020	0	0	0
6	Blacktip shark	0.010	0.060	0.254	0.030	0.160	0.003
7	Dusky shark	0.028	0.045	0.207	0.099	0.612	0.010
8	Sandbar shark	0.164	0.071	0.105	0.482	2.314	0.051
9	Large coastal sharks	0.030	0.091	0.179	0.100	0.329	0.010
10	Large oceanic sharks	0	0.079	0.209	0	0.001	0
11	Atlantic sharpnose shark	0.377	0.170	0.033	0.650	2.215	0.065
12	Small coastal sharks	0.147	0.336	0.017	0.294	0.438	0.029
13	Yellowfin tuna	0.797	0.235	0.048	0.738	3.386	0.095
14	Bluefin tuna	0.110	0.234	0.086	0.255	0.468	0.026
15	Other tunas	0.562	0.179	0.149	0.631	3.140	0.063
16	Billfish	0.505	0.063	0.033	0.841	8.037	0.103
17	Swordfish	0.396	0.037	0.007	0.900	10.800	0.104
18	Pelagic coastal piscivores	0.268	0.369	0.123	0.353	0.726	0.043
19	Amberjack	0.214	0.158	0.066	0.489	1.358	0.055
20	Cobia	0.207	0.149	0.264	0.334	1.394	0.051
21	King mackerel (0-1yr)	0.121	0.418	0.921	0.083	0.290	0.008
22	King mackerel (1+yr)	0.067	0.129	0.022	0.307	0.517	0.019
23	Spanish mackerel (0-1yr)	1.371	0.483	0.146	0.685	2.836	0.069
24	Spanish mackerel (1+yr)	0.194	0.189	0.134	0.375	1.023	0.037
25	Skates-rays	0.016	0.433	0.032	0.033	0.036	0.003
26	Gag grouper (0-3yr)	0.243	0.227	0.100	0.426	1.070	0.026
27	Gag grouper (3+yr)	0.245	0.098	0.027	0.663	2.509	0.068
28	Red grouper (0-3yr)	0.008	0.332	0.090	0.018	0.023	0.001
29	Red grouper (3+yr)	0.277	0.083	0.010	0.749	3.325	0.075
30	Yellowedge grouper (0-3yr)	0	0.221	0.099	0	0	0
31	Yellowedge grouper (3+yr)	0.026	0.027	0.047	0.264	0.996	0.007
32	Goliath grouper	0.212	0.095	0.023	0.641	2.231	0.064
33	Deep-water grouper	0.137	0.039	0.225	0.342	3.548	0.034
34	Shallow-water grouper	0.358	0.168	0.094	0.577	2.124	0.058
35	Red snapper (0yr)	0.310	0.162	0.527	0.310	1.913	0.017
36	Red snapper (1-2yr)	0.111	0.158	1.331	0.069	0.700	0.014
37	Red snapper (3+yr)	0.255	0.024	0.051	0.773	10.730	0.077
38	Vermilion snapper	0.040	0.123	0.357	0.077	0.325	0.009

Table 21-Continued. Estimates of fishing (*F*), predation (*M2*), and other (*M0*) mortality rates. Also shown is the ratio of *F/Z, F/M2*, and the ratio of total fishing removals to consumption of taxa (Catch/*Q*).

No	Functional group	*F*	*M2*	*M0*	*F/Z*	*F/M2*	Catch/*Q*
39	Mutton snapper	0.059	0.133	0.388	0.101	0.441	0.010
40	Other snapper	0.168	0.392	0.040	0.280	0.429	0.028
41	Coastal piscivores	0.227	0.420	0.024	0.338	0.540	0.035
42	Sea trout	0.465	0.250	0.015	0.637	1.863	0.066
43	Oceanic piscivores	0.010	0.980	0.009	0.010	0.011	0.001
44	Benthic piscivores	0.088	0.593	0.019	0.125	0.148	0.018
45	Reef piscivores	0.202	0.581	0.057	0.241	0.348	0.037
46	Reef invertebrate feeders	0.078	0.867	0.105	0.075	0.091	0.014
47	Demersal coastal invertebrate feeders	0.294	0.607	0.099	0.294	0.484	0.050
48	Red drum	0.111	0.065	0.324	0.222	1.704	0.022
49	Benthic coastal invertebrate feeders	0.003	1.203	0.044	0.003	0.003	0.001
50	Tilefish	0.044	0.051	0.254	0.127	0.867	0.013
51	Gray triggerfish	0.144	0.082	0.364	0.245	1.749	0.024
52	Coastal omnivores	0.018	0.851	0.011	0.020	0.021	0.002
53	Reef omnivores	0.004	1.323	0.073	0.003	0.003	0
54	Surface pelagics	0.003	1.322	0.125	0.002	0.002	0
55	Large oceanic planktivores	0	0.060	0.100	0	0	0
56	Oceanic planktivores	0	0.818	0.052	0	0	0
57	Sardine-herring-scad	0.012	0.946	0.092	0.012	0.013	0.001
58	Menhaden (0yr)	0.001	0.057	1.612	0.001	0.022	0
59	Menhaden (1yr)	0.172	0.059	1.277	0.114	2.900	0.008
60	Menhaden (2yr)	0.626	0.108	0.993	0.362	5.787	0.041
61	Menhaden (3yr)	0.436	0.246	0.838	0.287	1.768	0.034
62	Menhaden (4+yr)	0.223	0.423	0.771	0.158	0.528	0.020
63	Anchovy-silverside-killifish	0	1.342	0.248	0	0	0
64	Mullet	0.157	0.321	0.322	0.196	0.487	0.020
65	Butterfish	0.023	1.310	0.026	0.017	0.018	0.003
66	Cephalopod	0	2.283	0.517	0	0	0
67	Pink shrimp	0.336	1.198	2.236	0.089	0.281	0.018
68	Brown shrimp	2.152	1.191	1.878	0.412	1.807	0.112
69	White shrimp	0.130	0.473	2.716	0.039	0.276	0.007
70	Crab	0.256	1.253	0.091	0.160	0.204	0.024
71	Sessile epifauna	0.002	0.998	0.600	0.001	0.002	0
72	Mobile epifauna	0.002	0.920	1.679	0.001	0.002	0
73	Zooplankton	0	7.246	2.754	0	0	0

Table 21-Continued. Estimates of fishing (*F*), predation (*M2*), and other (*M0*) mortality rates. Also shown is the ratio of *F*/*Z*, *F*/*M2*, and the ratio of total fishing removals to consumption of taxa (Catch/*Q*).

No	Functional group	*F*	*M2*	*M0*	*F*/*Z*	*F*/*M2*	Catch/*Q*
74	Infauna	0	2.528	2.642	0	0	0
75	Algae	0	2.049	25.451	0	0	NA
76	Seagrass	0	0.162	24.838	0	0	NA
77	Phytoplankton	0	48.079	111.92	0	0	NA

Table 22. Ecosystem summary statistics, flows, and ecological indicators for the US Gulf-wide Ecopath model compared to other Ecopath models in the GoM and other LMEs worldwide (modified after Table 5 in Sagarese *et al.*, 2017).

Metric	US Gulf-wide (Current model)	GoM (Sagarese *et al.*, 2017)	GoM (Walters *et al.*, 2008)	GoM (Geers *et al.*, 2016)	GoM (WFS) (Chagaris *et al.*, 2015)	Gulf of California (Arreguın-Sánchez *et al.*, 2002)	Peru (Tam *et al.*, 2008)	British Columbia (Ainsworth *et al.*, 2002)
Ecopath year	1980	2005-2009	2004	2009	2009	1978-1979	1995-1998	2000
Number of biomass pools	78	75	31	47	70	27	33	44
Sum of consumption (t km^{-2} yr^{-1})	2,194	1,908	2,707	2,164	16,613	2,208	28,478	2,172
Sum of exports (t km^{-2} yr^{-1})	7,440	7,530	5,897	6,075	1,750	66.4	2,004	1,434
Sum of respiratory flows (t km^{-2} yr^{-1})	1,131	1,046	998	806	5,229	1,664.2	14,688	1,344
Sum of flows into detritus (t km^{-2} yr^{-1})	8,151	8,078	6,655	6,623	18,591	284	10,519	2,619
Total system throughput (t km^{-2} yr^{-1})	18,918	18,563	16,257	15,668	42,184	4,224	23,847	7,570
Sum of production (t km^{-2} yr^{-1})	8,905	9,050	7,610	7,472	13,831	2,269	16,653	3,171
Mean *TL* of catch	2.3	2.8	2.9	2.6	3.5	2.9	2.6	3.3
Total PP/total respiration	7.6	8.0	7.0	9.0	1.0	1.0	1.1	2.1
Net system production (t km^{-2} yr^{-1})	7,438	7,523	5,883	6,075	1,755	1,728	1,965	1,433

Table 22-Continued. Ecosystem summary statistics, flows, and ecological indicators for the US Gulf-wide Ecopath model compared to other Ecopath models in the GoM and other LMEs worldwide (modified after Table 5 in Sagarese *et al.*, 2017).

Metric	US Gulf-wide (Current model)	GoM (Sagarese *et al.*, 2017)	GoM (Walters *et al.*, 2008)	GoM (Geers *et al.*, 2016)	GoM (WFS) (Chagaris *et al.*, 2015)	Gulf of California (Arreguın-Sánchez *et al.*, 2002)	Peru (Tam *et al.*, 2008)	British Columbia (Ainsworth *et al.*, 2002)
Total PP/total biomass	30.3	30.0	19.0	21.0	14.0	27.4	55.1	21.2
Total biomass/total throughput	0.015	0.016	0.022	0.021	0.012	0.015	0.005	0.017
Total catch ($t\ km^{-2}\ yr^{-1}$)	2.97	3.18	21.86	4.02	0.41	4.59	42.70	1.60
Connectance Index	0.374	0.396	0.131	0.303	0.231	0.245	0.168	0.210
System Omnivory Index	0.30	0.41	0.12	0.19	0.20	0.33	0.20	0.21
Relative ascendency	37.4%	39.7%	-	-	-	17.7%	46.2%	33.2%
Transfer efficiency	7.90%	20.41%	-	-	-	23.54%	10.17%	14.55%

Table 23. Absolute trophic flows (t km^{-2} yr^{-1}) across the discrete trophic levels (I-IX). Discrete trophic level represents the fraction of biomass that originated from a given source in a given trophic path.

No	Functional group	I	II	III	IV	V	VI	VII	VIII	IX	SUM
1	Coastal dolphins	0	0.0355	0.126	0.131	0.0169	0.0013	0.000082	0.000004	0	0.31
2	Offshore dolphins	0	0.00168	0.0855	0.201	0.0211	0.00141	0.000083	0.000004	0	0.31
3	Baleen whales	0	0	0.178	0.121	0.0104	0.000602	0.000033	0.000001	0	0.31
4	Seabird	0	0.0693	0.22	0.173	0.0183	0.0013	0.000078	0.000003	0	0.48
5	Sea turtle	0	0.00189	0.0252	0.0156	0.00197	0.000183	0.000013	0.000001	0	0.04
6	Blacktip shark	0	0.0438	0.13	0.108	0.019	0.00184	0.000134	0.000008	0	0.30
7	Dusky shark	0	0.0013	0.00939	0.0104	0.00352	0.000487	0.000044	0.000003	0	0.03
8	Sandbar shark	0	0.000329	0.00178	0.00214	0.000489	0.000055	0.000004	0	0	0.00
9	Large coastal sharks	0	0.0123	0.0371	0.0485	0.0142	0.00178	0.000152	0.00001	0	0.11
10	Large oceanic sharks	0	0.0104	0.0196	0.0343	0.00879	0.00107	0.000091	0.000006	0	0.07
11	Atlantic sharpnose shark	0	0.013	0.0529	0.0395	0.00704	0.000643	0.000045	0.000003	0	0.11
12	Small coastal sharks	0	0.00104	0.00353	0.00379	0.000573	0.000055	0.000004	0	0	0.01
13	Yellowfin tuna	0	0.00125	0.0059	0.0125	0.0034	0.000404	0.000032	0.000002	0	0.02
14	Bluefin tuna	0	0.000098	0.000769	0.00102	0.000238	0.000025	0.000002	0	0	0.00
15	Other tunas	0	0.00275	0.021	0.0247	0.00442	0.000421	0.00003	0.000002	0	0.05
16	Billfish	0	0.00123	0.00449	0.00669	0.00203	0.000236	0.000018	0.000001	0	0.01
17	Swordfish	0	0.00271	0.0159	0.0279	0.00564	0.000587	0.000044	0.000003	0	0.05
18	Pelagic coastal piscivores	0	0.0618	0.168	0.137	0.0206	0.00173	0.000115	0.000006	0	0.39
19	Amberjack	0	0.00483	0.0489	0.0516	0.00746	0.000645	0.000044	0.000002	0	0.11
20	Cobia	0	0.00112	0.0184	0.0219	0.0037	0.000364	0.000027	0.000002	0	0.05
21	King mackerel (0-1yr)	0	0.000563	0.00487	0.00302	0.000243	0.000015	0.000001	0	0	0.01
22	King mackerel (1+yr)	0	0.0515	0.235	0.185	0.0178	0.00127	0.000077	0.000004	0	0.49
23	Spanish mackerel (0-1yr)	0	0.00106	0.0142	0.0073	0.000528	0.000032	0.000002	0	0	0.02
24	Spanish mackerel (1+yr)	0	0.00712	0.156	0.145	0.0159	0.00117	0.000072	0.000003	0	0.33
25	Skates-rays	0	0.0532	0.0793	0.0275	0.00253	0.000177	0.00001	0	0	0.16
26	Gag grouper (0-3yr)	0	0.00337	0.0102	0.00979	0.00148	0.000125	0.000008	0	0	0.02
27	Gag grouper (3+yr)	0	0.0063	0.0279	0.0264	0.00417	0.000375	0.000026	0.000001	0	0.07
28	Red grouper (0-3yr)	0	0.00229	0.0143	0.00989	0.00116	0.000092	0.000006	0	0	0.03

Table 23-Continued. Absolute trophic flows (t km^{-2} yr^{-1}) across the discrete trophic levels (I-IX). Discrete trophic level represents the fraction of biomass that originated from a given source in a given trophic path.

No	Functional group	I	II	III	IV	V	VI	VII	VIII	IX	SUM
29	Red grouper (3+yr)	0	0.018	0.0382	0.0365	0.00559	0.000509	0.000036	0.000002	0	0.10
30	Yellowedge grouper (0-3yr)	0	0.000282	0.00192	0.000957	0.000101	0.000008	0	0	0	0.00
31	Yellowedge grouper (3+yr)	0	0.00458	0.144	0.0269	0.00287	0.000224	0.000014	0.000001	0	0.18
32	Goliath grouper	0	0.000092	0.00218	0.00196	0.000349	0.000033	0.000002	0	0	0.00
33	Deep-water grouper	0	0.000858	0.0119	0.0125	0.00137	0.000104	0.000007	0	0	0.03
34	Shallow-water grouper	0	0.00789	0.032	0.0328	0.00499	0.000449	0.000031	0.000002	0	0.08
35	Red snapper (0yr)	0	0.00691	0.0254	0.0179	0.00352	0.000378	0.000029	0.000002	0	0.05
36	Red snapper (1-2yr)	0	0.0145	0.0782	0.0589	0.00922	0.000908	0.000068	0.000004	0	0.16
37	Red snapper (3+yr)	0	0.0201	0.0638	0.0489	0.00625	0.000504	0.000032	0.000002	0	0.14
38	Vermilion snapper	0	0.0512	0.222	0.0466	0.00414	0.000287	0.000017	0	0	0.32
39	Mutton snapper	0	0.0159	0.0403	0.0296	0.00331	0.000247	0.000015	0.000001	0	0.09
40	Other snapper	0	0.0204	0.0327	0.0257	0.00265	0.000188	0.000011	0	0	0.08
41	Coastal piscivores	0	0.105	0.292	0.143	0.0128	0.000841	0.000048	0.000002	0	0.55
42	Sea trout	0	0.206	0.339	0.191	0.016	0.00103	0.000058	0.000003	0	0.75
43	Oceanic piscivores	0	0.0459	0.118	0.119	0.0169	0.00141	0.000092	0.000005	0	0.30
44	Benthic piscivores	0	0.0221	0.0554	0.0477	0.00662	0.000569	0.000038	0.000002	0	0.13
45	Reef piscivores	0	0.0226	0.0582	0.0479	0.00577	0.000454	0.000029	0.000001	0	0.13
46	Reef invertebrate feeders	0	0.323	0.636	0.0939	0.00771	0.000494	0.000028	0	0	1.06
47	Demersal coastal invertebrate feeders	0	0.428	0.947	0.12	0.0093	0.000581	0.000032	0	0	1.50
48	Red drum	0	0.0595	0.364	0.138	0.01	0.000586	0.000032	0.000001	0	0.57
49	Benthic coastal invertebrate feeders	0	0.301	0.591	0.0877	0.00652	0.000387	0.000021	0	0	0.99
50	Tilefish	0	0.00127	0.0164	0.00609	0.000698	0.000058	0.000004	0	0	0.02
51	Gray triggerfish	0	0.118	0.16	0.0405	0.00439	0.000304	0.000017	0	0	0.32
52	Coastal omnivores	0	0.525	0.806	0.111	0.00844	0.000485	0.000024	0	0	1.45
53	Reef omnivores	0	0.0614	0.0992	0.00693	0.000424	0.000024	0.000001	0	0	0.17
54	Surface pelagics	0	0.41	0.873	0.165	0.0132	0.000807	0.000044	0	0	1.46

Table 23-Continued. Absolute trophic flows (t km^{-2} yr^{-1}) across the discrete trophic levels (I-IX). Discrete trophic level represents the fraction of biomass that originated from a given source in a given trophic path.

No	Functional group	I	II	III	IV	V	VI	VII	VIII	IX	SUM
55	Large oceanic planktivores	0	0.000401	0.0176	0.00415	0.000479	0.000033	0.000002	0	0	0.02
56	Oceanic planktivores	0	0	0.334	0.0529	0.00393	0.000222	0.000012	0	0	0.39
57	Sardine-herring-scad	0	2.095	4.02	0.463	0.0345	0.00201	0.000101	0	0	6.61
58	Menhaden (0yr)	0	62.28	17.95	0.925	0.044	0.00204	0	0	0	81.20
59	Menhaden (1yr)	0	74.32	21.42	1.104	0.0525	0.00243	0	0	0	96.90
60	Menhaden (2yr)	0	23.71	6.833	0.352	0.0167	0.000775	0	0	0	30.91
61	Menhaden (3yr)	0	4.816	1.388	0.0715	0.0034	0.000157	0	0	0	6.28
62	Menhaden (4+yr)	0	1.225	0.353	0.0182	0.000865	0.00004	0	0	0	1.60
63	Anchovy-silverside-killifish	0	4.679	6.159	0.352	0.0184	0.00102	0.000044	0	0	11.21
64	Mullet	0	1.422	0.817	0.0542	0.00287	0.000159	0.000007	0	0	2.30
65	Butterfish	0	0.162	0.409	0.0192	0.000961	0.00005	0.000002	0	0	0.59
66	Cephalopod	0	1.544	11.11	0.987	0.0564	0.00307	0.000142	0	0	13.70
67	Pink shrimp	0	0.899	0.609	0.0274	0.00139	0.000074	0	0	0	1.54
68	Brown shrimp	0	1.103	0.059	0.00298	0.000161	0.000008	0	0	0	1.17
69	White shrimp	0	9.151	0.43	0.0175	0.000909	0.000032	0	0	0	9.60
70	Crab	0	0.52	1.957	0.139	0.00811	0.000484	0.000023	0	0	2.62
71	Sessile epifauna	0	106.9	1.056	0.0534	0.00246	0	0	0	0	108.01
72	Mobile epifauna	0	253.7	32.29	1.885	0.119	0.00645	0	0	0	288.00
73	Zooplankton	0	1061	47.1	2.091	0.0929	0.00309	0	0	0	1110.29
74	Infauna	0	389.8	16.37	0.805	0.0421	0.00157	0	0	0	407.02
75	Algae	819.5	0	0	0	0	0	0	0	0	819.50
76	Seagrass	3,750	0	0	0	0	0	0	0	0	3,750.00
77	Phytoplankton	4,000	0	0	0	0	0	0	0	0	4,000.00
78	Detritus	8,152	0	0	0	0	0	0	0	0	8,152.00

Table 24. Estimates of fishing mortality rates for achieving maximum sustainable yield (F_{MSY}) derived from EwE (i.e., stationary vs. compensatory) and from stock assessments. *Value represents the upper bound of the search algorithm since F_{MSY} was not determined

Functional group	F base	F_{MSY} stationary	F_{MSY} compensatory	F_{MSY} assessment	Source
Dusky shark	0.028	0.091	0.091	0.035	SEDAR 21 Update
Sandbar shark	0.164	0.164	0.164	0.021	SEDAR 54
Large coastal sharks	0.030	0.112	0.112	0.024	SEDAR 11
Atlantic sharpnose shark	0.377	0.377	0.377	0.331	SEDAR 34
Small coastal sharks	0.147	0.214	0.214	0.202	SEDAR 34
Yellowfin tuna	0.797	0.072	0.072	0.160	ICCAT 2019
Bluefin tuna	0.110	0.010	0.010	0.090	ICCAT 2017c
Amberjack	0.214	0.214	0.214	0.220	SEDAR 33 Update
Cobia	0.207	0.490	0.490	0.340	SEDAR 28
King mackerel (1+yr)	0.067	0.432	0.584	0.160	SEDAR 38
Spanish mackerel (1+yr)	0.194	0.546	0.634	0.360	SEDAR 28
Gag grouper (3+yr)	0.245	0.357	0.357	0.196	SEDAR 33 Update
Red grouper (3+yr)	0.277	0.277	0.277	0.259	SEDAR 61
Yellowedge grouper (3+yr)	0.026	0.038	0.038	0.050	SEDAR 22
Goliath grouper	0.212	0.115	0.115	0.182	SEDAR 47
Red snapper (3+yr)	0.255	0.023	0.023	0.059	SEDAR 52
Vermilion snapper	0.040	0.476	0.495	0.135	SEDAR 67
Mutton snapper	0.059	0.246	0.246	0.180	SEDAR 15 Update
Tilefish	0.044	0.327	0.327	0.120	SEDAR 22
Gray triggerfish	0.144	0.275	0.275	0.153	SEDAR 43
Menhaden (3yr)	0.436	5.783	6.377	4.500*	SEDAR 63

Table 25. Comparison of biomass (*B*, t km^{-2}) and catch (*C*, t km^{-2}) in the starting year (1980) and ending year (2016).

No	Functional group	*B* (start)	*B* (end)	*B* (end/start)	*C* (start)	*C* (end)	*C* (end/start)
1	Coastal dolphins	0.021	0.028	1.353			
2	Offshore dolphins	0.021	0.028	1.337			
3	Baleen whales	0.021	0.022	1.032			
4	Seabird	0.015	0.029	1.900			
5	Sea turtle	0.013	0.021	1.633			
6	Blacktip shark	0.098	0.171	1.746	0.001	0.000	0.218
7	Dusky shark	0.009	0.010	1.078	0.000	0.001	4.194
8	Sandbar shark	0.002	0.003	1.936	0.000	0.000	1.829
9	Large coastal sharks	0.039	0.049	1.254	0.001	0.002	1.725
10	Large oceanic sharks	0.028	0.001	0.035	0.001	0.000	0.460
11	Atlantic sharpnose shark	0.022	0.054	2.450	0.005	0.007	1.500
12	Small coastal sharks	0.002	0.002	1.264	0.000	0.000	1.145
13	Yellowfin tuna	0.004	0.037	9.146	0.001	0.008	10.136
14	Bluefin tuna	0.000	0.001	1.398	0.000	0.000	0.530
15	Other tunas	0.006	0.002	0.240	0.004	0.002	0.536
16	Billfish	0.003	0.001	0.414	0.001	0.001	0.854
17	Swordfish	0.017	0.084	4.984	0.001	0.011	8.454
18	Pelagic coastal piscivores	0.065	0.064	0.983	0.017	0.015	0.856
19	Amberjack	0.031	0.030	0.958	0.005	0.008	1.631
20	Cobia	0.011	0.013	1.156	0.003	0.003	1.097
21	King mackerel (0-1yr)	0.001	0.002	2.904	0.000	0.000	2.004
22	King mackerel (1+yr)	0.159	0.342	2.150	0.008	0.016	2.099
23	Spanish mackerel (0-1yr)	0.001	0.003	2.543	0.002	0.003	1.651
24	Spanish mackerel (1+yr)	0.073	0.160	2.174	0.010	0.013	1.313
25	Skates-rays	0.035	0.044	1.248	0.001	0.001	1.364
26	Gag grouper (0-3yr)	0.003	0.005	1.690	0.001	0.002	2.184
27	Gag grouper (3+yr)	0.020	0.041	2.034	0.005	0.003	0.613
28	Red grouper (0-3yr)	0.003	0.006	1.843	0.000	0.000	3.858

Table 25-Continued. Comparison of biomass (B, t km^{-2}) and catch (C, t km^{-2}) in the starting year (1980) and ending year (2016).

No	Functional group	*B* (start)	*B* (end)	*B* (end/start)	*C* (start)	*C* (end)	*C* (end/start)
29	Red grouper (3+yr)	0.030	0.068	2.270	0.007	0.011	1.568
30	Yellowedge grouper (0-3yr)	0.000	0.000	1.060	0.000	0.000	0.646
31	Yellowedge grouper (3+yr)	0.052	0.038	0.735	0.001	0.002	1.684
32	Goliath grouper	0.001	0.004	2.879	0.000	0.000	0.231
33	Deep-water grouper	0.008	0.016	2.048	0.000	0.000	2.294
34	Shallow-water grouper	0.013	0.093	6.974	0.005	0.001	0.222
35	Red snapper (0yr)	0.003	0.007	2.022	0.001	0.001	1.396
36	Red snapper (1-2yr)	0.021	0.049	2.344	0.010	0.000	0.029
37	Red snapper (3+yr)	0.048	0.204	4.242	0.012	0.018	1.510
38	Vermilion snapper	0.080	0.068	0.856	0.001	0.010	10.309
39	Mutton snapper	0.016	0.021	1.314	0.002	0.001	0.612
40	Other snapper	0.014	0.015	1.080	0.002	0.003	1.162
41	Coastal piscivores	0.093	0.212	2.266	0.021	0.037	1.742
42	Sea trout	0.117	0.188	1.607	0.054	0.091	1.677
43	Oceanic piscivores	0.038	0.081	2.113	0.000	0.000	1.204
44	Benthic piscivores	0.028	0.029	1.037	0.002	0.004	1.782
45	Reef piscivores	0.028	0.012	0.445	0.006	0.003	0.538
46	Reef invertebrate feeders	0.192	0.206	1.070	0.015	0.019	1.253
47	Demersal coastal invertebrate feeders	0.287	0.773	2.696	0.084	0.177	2.099
48	Red drum	0.124	0.193	1.550	0.004	0.005	1.307
49	Benthic coastal invertebrate feeders	0.194	0.138	0.712	0.001	0.001	1.259
50	Tilefish	0.007	0.006	0.743	0.000	0.001	33.077
51	Gray triggerfish	0.061	0.106	1.724	0.002	0.007	2.878
52	Coastal omnivores	0.176	0.231	1.309	0.003	0.007	2.221
53	Reef omnivores	0.023	0.033	1.416	0.000	0.000	2.087
54	Surface pelagics	0.146	0.241	1.643	0.000	0.001	3.519

Table 25-Continued. Comparison of biomass (B, t km^{-2}) and catch (C, t km^{-2}) in the starting year (1980) and ending year (2016).

No	Functional group	*B* (start)	*B* (end)	*B* (end/start)	*C* (start)	*C* (end)	*C* (end/start)
55	Large oceanic planktivores	0.018	0.015	0.856			
56	Oceanic planktivores	0.047	0.032	0.667			
57	Sardine-herring-scad	0.686	0.689	1.005	0.008	0.008	0.917
58	Menhaden (0yr)	2.677	7.467	2.789	0.005	0.006	1.114
59	Menhaden (1yr)	5.697	12.035	2.112	1.417	1.101	0.777
60	Menhaden (2yr)	2.508	5.407	2.156	1.571	2.512	1.599
61	Menhaden (3yr)	0.636	1.693	2.661	0.318	0.620	1.951
62	Menhaden (4+yr)	0.175	0.772	4.415	0.076	0.248	3.240
63	Anchovy-silverside-killifish	0.798	2.884	3.613	0.000	0.000	2.051
64	Mullet	0.298	0.358	1.204	0.043	0.020	0.467
65	Butterfish	0.079	0.110	1.392	0.002	0.003	1.569
66	Cephalopod	1.636	2.728	1.667	0.000	0.000	1.397
67	Pink shrimp	0.096	0.145	1.505	0.016	0.005	0.335
68	Brown shrimp	0.077	0.171	2.222	0.152	0.125	0.820
69	White shrimp	0.585	0.910	1.555	0.048	0.066	1.381
70	Crab	0.211	0.124	0.588	0.172	0.177	1.024
71	Sessile epifauna	14.313	55.703	3.892	0.033	0.118	3.564
72	Mobile epifauna	19.221	27.239	1.417	0.036	0.045	1.230
73	Zooplankton	16.717	18.786	1.124	0.002	0.001	0.631
74	Infauna	17.331	17.941	1.035	0.000	0.000	1.001
75	Algae	30.486	49.192	1.614			
76	Seagrass	153.692	248.364	1.616			
77	Phytoplankton	21.990	28.852	1.312			
78	Detritus	100.936	141.307	1.400			
	Total	393.441	627.209	1.594	4.203	5.555	1.322

Table 26. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Coastal dolphins	All protected under Marine Mammal Protection Act (MMPA)	27 (739)	-	3	Need species-specific biomass, incidental bycatch in fisheries, diet composition, and time series
Offshore dolphins	All protected resources as described above in MMPA		-	3	Need species-specific biomass, diet composition, and time series; consider disaggregating group and expanding spatial domain of model to capture more oceanic cetaceans (> 400 m) such as the Sperm Whale (Endangered in Endangered Species Act)
Baleen whales	All protected resources as described above in MMPA; Endangered species (ESA) include Sei, Fin, and Brydes Whales	0	-	3	Need species-specific biomass, diet composition, and time series
Sea birds	-	60 (74,403)	-	3	Need species-specific biomass, diet composition, and time series
Sea turtles	All endangered or threatened species according to ESA	15 (632)	-	3	Need species-specific biomass, incidental bycatch in fisheries, diet composition, and time series; consider disaggregating group to better capture differences in foraging behavior

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Blacktip Shark	Federally assessed	16 (1,923)	C, B, F	2	HMS, may not represent GOM trends (poor fits in Ecosim); consider additional data sources for relative abundance (e.g., longline survey)
Dusky Shark	Federally assessed	16 (2,505)	relC, B, F	2	HMS, may not represent GOM trends (poor fits in Ecosim); consider additional data sources for relative abundance (e.g., longline survey)
Sandbar Shark	Federally assessed	16 (2,396)	C, B, F	2	HMS, may not represent GOM trends (poor fits in Ecosim); consider additional data sources for relative abundance (e.g., longline survey)
Large coastal sharks	Federally assessed	58 (5,696)	C, B	2	HMS, may not represent GOM trends (poor fits in Ecosim); consider additional data sources for relative abundance (e.g., longline survey)
Large oceanic sharks	Internationally assessed; Oceanic whitetip shark is a Threatened species	32 (3,979)	C, B	2	HMS, may not represent GOM trends (poor fits in Ecosim); consider additional data sources for relative abundance (e.g., pelagic longline data)

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Atlantic sharpnose	Federally assessed	20 (1,039)	C, B, F	2	HMS, may not represent GOM trends (poor fits in Ecosim); consider additional data sources for relative abundance (indices in stock assessment)
Small coastal sharks	Federally assessed	33 (2,813)	C, B	2	HMS, may not represent GOM trends; consider additional data sources for relative abundance (indices in stock assessment)
Yellowfin Tuna	Internationally assessed	27 (9,457)	C, B, F	2	*F* from HMS, may not represent GOM trends (poor fits in Ecosim); consider expanding spatial domain to capture more oceanic habitat
Bluefin Tuna	Internationally assessed	18 (2,265)	C, B, F	2	*F* from HMS, may not represent GOM trends (poor fits in Ecosim); consider expanding spatial domain to capture more oceanic habitat
Other tunas	Internationally assessed	18 (2,857)	C, B	2	Consider expanding spatial domain to capture more oceanic habitat

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Billfish	Internationally assessed	43 (4,463)	C, B, F	2	*F* from HMS Assessment may not represent GOM trends (poor fits in Ecosim); consider expanding spatial domain to capture oceanic habitat
Swordfish	Internationally assessed	24 (2,458)	C, B, F	2	*F* from HMS Assessment may not represent GOM trends (poor fits in Ecosim); consider expanding spatial domain to capture oceanic habitat
Pelagic coastal piscivores	Bluefish - state assessed; Almaco jack - federal data-limited assessment	109 (17,514)	C, B	2	Need time series of biomass (poor fits in Ecosim); consider additional data sources for relative abundance (e.g., not bottom trawl)
Amberjacks	Federally assessed	12 (842)	C, B, F	1	-
Cobia	Federally assessed	14 (888)	C, B, F	1	-
King mackerel	Federally assessed	3 (188); 24 (14,328)	C, B, F	1	Need better juvenile diet composition
Spanish mackerel	Federally assessed	3 (289); 12 (9,225)	C, B, F	1	Need better juvenile diet composition
Skates/Rays	Smalltooth sawfish is an endangered species in ESA	44 (1,636)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Gag grouper	Federally assessed	21 (2,250); 9 (1,606)	C, B, F	1	Need better data on diet composition and predation on adults
Red grouper	Federally assessed	13 (459); 7 (415)	C, B, F	1	Need better data on diet composition and predation on adults
Yellowedge grouper	Federally assessed	0; 2 (3)	C, B, F	1	Need better data on diet composition and predation on adults
Goliath grouper	Federally assessed	9 (239)	C, B, F	1	Need better diet composition and predation on adults
Other deep grouper	Snowy grouper, speckled hind - federal data-limited assessment	8 (64)	C	2	Need time series of biomass and better data on diet composition; consider additional data sources for relative abundance (e.g., bottom longline survey)
Other shallow grouper	Scamp - federally assessed; Nassau grouper is a Threatened Species	39 (1,153)	C, B	2	Need time series of biomass (poor fits in Ecosim); consider additional data sources for relative abundance (e.g., bottom longline survey)
Red snapper	Federally assessed	40 (3,830); 25 (1,765)	C, B, F	1	Need better understanding of predation on adults
Vermilion snapper	Federally assessed	13 (1,017)	C, B, F	1	-

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Mutton snapper	Federally assessed	7 (419)	C, B, F	1	-
Other snapper	Gray snapper - federally assessed; wenchman - federal data-limited assessment	31 (1,859)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Coastal piscivores	Snook - state assessed	44 (4,882)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Sea trout	State assessed	61 (7,483)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Oceanic piscivores	-	45 (6,950)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Benthic piscivores	Gulf flounder, Southern flounder - state assessed	77 (4,571)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Reef/rubble-associated piscivores	-	35 (818)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Reef/rubble-associated invert feeders	Yellowtail snapper - federally assessed; lane snapper - federal data-limited assessment, sheepshead - state assessed	157 (8,320)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Demersal coastal invert feeders	-	240 (23,132)	C, B	1	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Red drum	State assessed, federal data-limited assessment	23 (3,419)	C, B	2	Need time series of biomass; consider additional data sources for relative abundance
Benthic coastal invert feeders	Gulf sturgeon is an Endangered species in ESA	89 (6,596)	C, B	1	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Tilefish	Federally assessed	9 (658)	C, B, F	1	-
Gray triggerfish	Federally assessed	14 (391)	C, B, F	1	Poor fit noted in Ecosim, re-evaluate trends after next stock assessment
Coastal omnivores	-	91 (7,289)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Reef omnivores	-	58 (1,174)	C	2	Need time series of biomass; consider data sources for relative abundance
Surface pelagics	-		C	2	Need time series of biomass; consider data sources for relative abundance
Oceanic planktivores	-	31 (1,565)	-	2	Need time series of biomass; consider data sources for relative abundance
Large oceanic planktivores	Giant manta ray is a Threatened species		C	3	Need species-specific biomass, and time series
Sardine-herring-scad	-	51 (2,797)	C, B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Menhaden	Federally assessed	8 (723)	C, B, F	1	Need better understanding of predators
Anchovy-silverside-killifish	-	62 (7,726)	B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Mullet	State assessed	29 (2,972)	C	3	Need time series of biomass; consider additional data sources for relative abundance
Butterfish	-	12 (873)	B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Cephalopod	-	-	B	2	Consider additional data sources for relative abundance (e.g., not bottom trawl)
Pink shrimp	Federally assessed	-	C, B, F	1	-
Brown shrimp	Federally assessed	-	C, B, F	1	-
White shrimp	Federally assessed	-	C, B, F	1	-
Blue crab	Federally assessed	-	C, B, F	2	Need time series of biomass (poor fits in Ecosim); consider additional data sources for relative abundance
Sessile epifauna	-	-	C	3	Need time series of biomass; consider additional data sources for relative abundance and disaggregating group
Mobile epifauna	Spiny lobster – federally assessed	-	C, B	3	Need time series of biomass; consider additional data sources for relative abundance and disaggregating group
Zooplankton	-	-		3	Consider new data sources to parameter biomass and disaggregating group
Infauna	-	-		3	Consider new data sources to parameter biomass and disaggregating group

Table 26-Continued. Summary of data needs and considerations for applying the U.S. Gulf-wide Ecopath with Ecosim model for each functional group. Usability score (Score) includes: (1) model could be readily modified within a typical model development-review cycle; (2) model needs additional data and a typical model development-review cycle; (3) extensive data needed (e.g., long-time series) or the model is not feasible. Number of diet observations (i.e., studies, see Figure S1.1 for details) and number of stomachs feeding into the diet matrix are shown, as well as time series currently included in the model.

Functional Group	Notable species and importance	Diet observations (Stomachs)	Time series	Score	Data Needs and Considerations
Algae	-	-		2	Consider new data sources to parameter biomass
Seagrass	-	-		2	Consider new data sources to parameter biomass
Phytoplankton	-	-		2	Consider new data sources to parameter biomass
Detritus	-	-		1	-

Appendix 1 – summary of diet approach and gut content studies used to develop the diet matrix

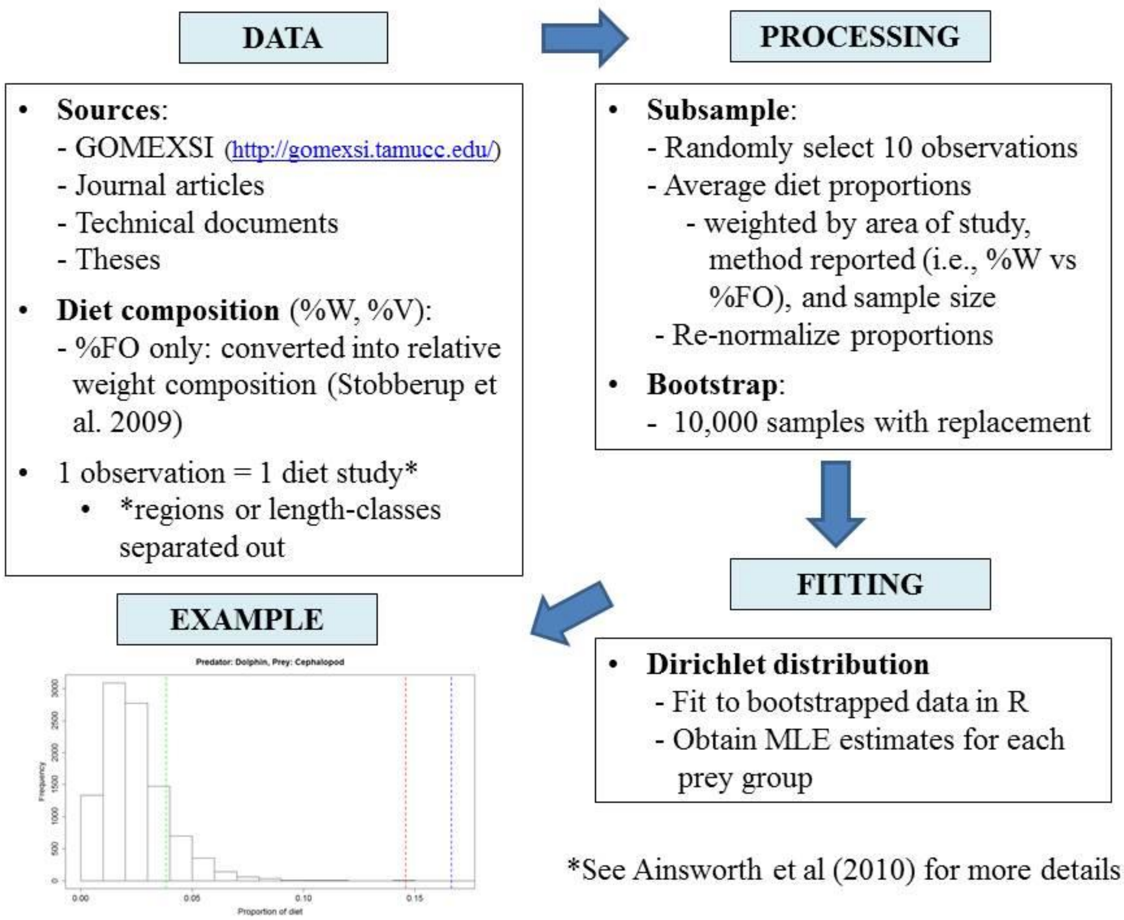

Figure S1.1. Bootstrap procedure followed for meta-analysis to quantify trophic interactions within the northern Gulf of Mexico and to identify the importance of Gulf Menhaden in predator diets (%W = percent weight; %V = percent volume; %FO = percent frequency of occurrence). Results from the maximum likelihood estimate (MLE) based on a probabilistic bootstrap approach (solid black line) are compared to the simple mean (dashed black line) and weighted mean (dashed gray line). The probabilistic approach was adapted from Ainsworth *et al.* (2010).

Table S1.1. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
(1) Coastal dolphins		27 (739)
Bottlenose dolphin	Barros 1992	1 (38)
	Barros 1993	2 (77)
	Barros and Odell 1990	4 (76)
	Barros and Wells 1998	1 (16)
	Berens McCabe *et al.* 2010	1 (15)
	Blanco *et al.* 2001	1 (15)
	Bowen 2011	1 (25)
	Di Beneditto 2001	1 (0)
	Gannon and Waples 2004	1 (146)
	Gonzalez *et al.* 1994	1 (14)
	Gunter 1942	1 (29)
	Leatherwood 1975	1 (1)
	Leatherwood *et al.* 1978	1 (8)
	Mead and Potter 1990	2 (64)
	Melo *et al.* 2010	1 (4)
	Pate and McFee 2012	2 (82)
	Santos *et al.* 2001	1 (10)
	Santos *et al.* 2007	1 (82)
	Spitz *et al.* 2006	1 (21)
Spotted dolphin	Di Beneditto 2001	1 (6)
	Melo *et al.* 2010	1 (10)
(4) Sea birds		60 (74,403)
Audouin's gull	Pedrocchi *et al.* 1996	2 (261)
Audubon shearwater	Catry *et al.* 2009	1 (60)
Bald eagle	Dugoni *et al.* 1986	1 (10)
	Markham and Watts 2008	1 (765)
	McEwan and Hirth 1980	1 (16)
	Ofelt 1975	1 (116)
	Retfalvi 1970	1 (61)
Brown pelican	Baldwin 1946	1 (0)
	Blus *et al.* 1979	1 (0)
	Fogarty *et al.* 1981	1 (113)
	Shorger 1962	1 (32)
Caspian tern	Lyons *et al.* 2005	2 (5,103)
	Thompson *et al.* 2002	1 (1,540)
Common loon	Barr 1996	1 (55)
Common tern	Bugoni an Vooren 2004	1 (714)
Cormorant	Anderson *et al.* 2004	1 (65)
	Blackwell *et al.* 1997	1 (329)
	Campo *et al.* 1993	1 (420)
	Liordos and Goutner 2007	3 (57)
	Rail and Chapdelaine 1998	2 (613)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Cormorant	Robertson 1974	1 (0)
	Seefelt and Gillingham 2008	1 (1,040)
	Withers and Brooks 2004	2 (76)
Cory shearwater	Grandeiro *et al.* 1998	1 (159)
	Xavier *et al.* 2011	1 (79)
Frigatebird	Calixto Albarran and Osorno 2000	1 (158)
	Schreiber and Hensley 1976	1 (89)
	Spear *et al.* 2007	1 (4)
Gannet	Berruti *et al.* 1993	2 (11,681)
	Moseley 2010	2 (78)
Gullbilled tern	Dies *et al.* 2005	1 (1,091)
	Erwin *et al.* 1998	1 (757)
Herring gull	Ewins *et al.* 1994	1 (151)
	Kubetzki and Garthe 2003	1 (323)
Lesser blackbacked gull	Kubetzki and Garthe 2003	1 (327)
Masked booby	Schreiber and Hensley 1976	1 (36)
	Spear *et al.* 2007	1 (18)
Mergenser	Bur *et al.* 2008	1 (144)
Neotropical cormorant	King 1989	1 (0)
Osprey	Glass Watts 2009	2 (29)
	McLean and Byrd 1991	1 (0)
Royal tern	Aygen 2005	1 (45,212)
Sandwich tern	Schealer 1998	1 (106)
Shearwater	Spear *et al.* 2007	1 (31)
Skimmer	Mariano *et al.* 2007	1 (55)
	Mariano Jelicich *et al.* 2003	1 (1,034)
Sooty tern	Hensley and Hensley 1995	1 (NA)
Storm petrel	Spear *et al.* 2007	2 (741)
Wedgetailed shearwater	Catry *et al.* 2009	1 (70)
White pelican	Findholt and Anderson 1995	1 (584)
(5) Sea turtles		15 (632)
Green turtle	Makowski *et al.* 2006	1 (6)
Hawksbill turtle	Leon and Bjorndal 2002	2 (48)
Kemps ridley turtle	Barichivich *et al.* 1999	1 (17)
	Burke *et al.* 1993	1 (12)
	Burke *et al.* 1994	1 (19)
	Seney and Musick 2003	1 (23)
	Shaver 1991	1 (101)
	Witzell and Schmid 2005	2 (65)
Loggerhead turtle	Burke *et al.* 1993	1 (25)
	Parker *et al.* 2005	1 (52)
	Plotkin *et al.* 1993	1 (82)
	Seney and Musick 2007	1 (128)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Loggerhead turtle	Tomas *et al.* 2001	1 (54)
(6) Blacktip shark		16 (1,923)
Blacktip shark	Barry 2002	1 (139)
	Barry 2008	2 (139)
	Bethea *et al.* 2004	2 (146)
	Castro 1996	1 (174)
	de Silva 2001	1 (19)
	Dudley and Cliff 1993	1 (655)
	Gurshin 2006	1 (14)
	Heupel and Hueter 2002	1 (464)
	Hoffmayer and Parsons 2003	1 (50)
	Hueter 1994	1 (65)
	Patokina and Litvinov 2005	2 (3)
	Tavares 2008	1 (52)
	Wrast 2008	1 (3)
(7) Dusky shark		16 (2,505)
Dusky shark	Bowman *et al.* 2000	4 (43)
	Clarke and von Schmidt 1965	1 (0)
	de Silva 2001	1 (2)
	Gelsleichter *et al.* 1999	1 (59)
	Hussey *et al.* 2011	3 (900)
	Rogers *et al.* 2012	1 (32)
	Simpfendorfer *et al.* 2001	3 (1,322)
	Smale 1991	2 (147)
(8) Sandbar shark		16 (2,396)
Sandbar shark	Bowman *et al.* 2000	1 (3)
	Clark and Von Schmidt 1965	1 (110)
	de Silva 2001	1 (1)
	Dudley and Cliff 1993	1 (92)
	Ellis and Musick 2007	3 (232)
	McElroy 1999	1 (650)
	McElroy *et al.* 2006	3 (263)
	Medved *et al.* 1985	1 (340)
	Papamastiou *et al.* 2006	1 (269)
	Stevens and McLoughlin 1991	1 (115)
	Stillwell and Kohler 1993	2 (321)
(9) Large coastal sharks		58 (5,696)
Bull shark	Cliff and Dudley 1991	2 (309)
	Darnell 1958	1 (2)
	de Silva 2001	1 (6)
	Hueter 1994	1 (6)
	Snelson *et al.* 1984	1 (50)
	Tuma 1976	2 (42)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Carcharhinus	Knapp 1949	1 (126)
Great hammerhead	Cliff 1995	2 (119)
	Hueter 1994	1 (5)
Lemon shark	Cortes and Gruber 1990	2 (142)
	Davis 2010	1 (30)
	Newman *et al.* 2010	2 (396)
	Randall 1967	1 (1)
	Schmidt 1986	1 (18)
Sand tiger shark	Bowman *et al.* 2000	2 (8)
	Clark and Von Schmidt 1965	1 (4)
	Gelsleichter *et al.* 1999	1 (42)
	Smale 2005	2 (0)
Scalloped hammerhead	Avendano Alvarez *et al.* 2013	1 (12)
	Bethea *et al.* 2011	1 (186)
	Bowman *et al.* 2000	1 (2)
	Bush 2003	1 (0)
	de Bruyn *et al.* 2005	1 (832)
	Galvan Magana *et al.* 2013	2 (213)
	Hueter 1994	1 (4)
	Hussey *et al.* 2011	3 (1,018)
	Patokina and Litvinov 2005	1 (7)
	Stevens and Lyle 1986	1 (518)
	Tores Rojas *et al.* 2010	1 (187)
Silky shark	Bowman *et al.* 2000	1 (18)
	Cabrera Chavez Costa *et al.* 2010	2 (142)
	de Silva 2001	1 (3)
	Galvan Magana *et al.* 2013	1 (142)
Spinner shark	Allen and Cliff 2000	1 (379)
	Avendano Alvarez *et al.* 2013	1 (33)
	Bethea *et al.* 2004	1 (0)
	de Silva 2001	1 (5)
	Hueter 1994	1 (1)
	Stevens and McLoughlin 1991	1 (51)
Tiger shark	Bowman *et al.* 2000	1 (40)
	Lowe *et al.* 1996	3 (217)
	Papamastiou *et al.* 2006	1 (217)
	Randall 1967	1 (2)
	Simpfendorfer *et al.* 2001	1 (84)
	Stevens and McLoughlin 1991	1 (77)
(10) Large oceanic sharks		32 (3,979)
Bigeye thresher	Bowman *et al.* 2000	1 (12)
	Galvan Magana *et al.* 2013	1 (107)
	Gorni *et al.* 2013	1 (16)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Bigeye thresher	Preti *et al.* 2008	1 (23)
Blue shark	Bowman *et al.* 2000	1 (582)
	Clark *et al.* 1996	1 (112)
	Henderson *et al.* 2001	1 (126)
	Kubodera *et al.* 2007	1 (57)
	Lopez *et al.* 2010	1 (172)
	Markaida and Sosa hishizaki 2010	1 (614)
	Preti *et al.* 2012	1 (114)
	Stevens 1973	1 (50)
	Vaske *et al.* 2009	2 (222)
	Young *et al.* 2010	2 (147)
Common thresher	Bowman *et al.* 2000	1 (18)
	Preti *et al.* 2001	1 (107)
	Preti *et al.* 2012	1 (157)
	Rogers *et al.* 2012	1 (17)
Shortfin mako	Bowman *et al.* 2000	1 (273)
	Cliff *et al.* 1990	2 (88)
	Gorni *et al.* 2013	1 (47)
	Maia *et al.* 2006	3 (99)
	Preti *et al.* 2012	1 (238)
	Rogers *et al.* 2012	1 (45)
	Stillwell and Kohler 1982	1 (399)
	Wood *et al.* 2009	1 (120)
	Young *et al.* 2010	1 (17)
(11) Atlantic sharpnose shark		20 (1,039)
Atlantic sharpnose shark	Avendano Alvarez *et al.* 2013	1 (25)
	Barry 2002	1 (25)
	Bethea *et al.* 2004	3 (185)
	Bethea *et al.* 2006	3 (222)
	Bowman *et al.* 2000	3 (63)
	Clark and Von Schmidt 1965	1 (22)
	Davis 2010	1 (25)
	Divita *et al.* 1983	1 (7)
	Gelsleichter *et al.* 1999	1 (129)
	Gurshin 2005	1 (86)
	Hoffmayer and Parsons 2003	1 (133)
	Hueter 1994	1 (10)
	McAllister 2012	2 (107)
(12) Small coastal sharks		33 (2,813)
Blacknose shark	Fischer *et al.* 2009	1 (19)
	Ford 2012	1 (38)
	Gomez *et al.* 2004	1 (13)
	Hueter 1994	1 (13)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Bonnethead shark	Bethea *et al.* 2007	7 (502)
	Cortes *et al.* 1996	1 (338)
	Divita *et al.* 1983	1 (4)
	Gurshin 2005	1 (5)
	Hueter 1994	1 (314)
	Lessa and Almeida 1998	1 (191)
	Lopez Peralta and Arcila 2002	1 (1)
	Wrast *et al.* 2008	1 (4)
Dusky smoothhound	Bowman *et al.* 2000	4 (667)
	Divita *et al.* 1983	1 (4)
	Gelsleichter *et al.* 1999	1 (64)
	Gomez *et al.* 2004	1 (8)
	McElroy 1999	1 (358)
	Rountree and Able 1996	1 (85)
	Steimle *et al.* 2000	1 (42)
Finetooth shark	Bethea *et al.* 2004	1 (55)
	Castro 1993	1 (49)
	de Silva 2001	1 (1)
	Gurshin 2005	1 (18)
	Hoffmayer and Parsons 2003	1 (20)
(13) Yellowfin tuna		27 (9,457)
Yellowfin tuna	Dissanayake *et al.* 2008	1 (71)
	Dragovich and Potthoff 1972	1 (126)
	Gorni *et al.* 2013	1 (29)
	Kim *et al.* 1997	1 (175)
	Landsdell and Young 2007	1 (368)
	Lewis and Axelson 1967	1 (12)
	Logan *et al.* 2013	1 (31)
	Maldeniya 1996	1 (NA)
	Manooch and Mason 1983	1 (196)
	Olsen and Boggs 1986	4 (3,581)
	Olsen *et al.* 2014	1 (3,362)
	Pimenta *et al.* 2001	1 (14)
	Potier *et al.* 2004	1 (161)
	Potier *et al.* 2007	1 (111)
	Rawlins *et al.* 2007	1 (34)
	Roger 1994	1 (51)
	Rohit *et al.* 2010	1 (146)
	Rudershausen *et al.* 2010	1 (34)
	Sabatie *et al.* 2003	1 (7)
	Satoh *et al.* 2004	1 (47)
	Vaske *et al.* 2003	1 (210)
	Young *et al.* 2001	1 (39)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Yellowfin tuna	Young *et al.* 2010	2 (652)
(14) Bluefin tuna		18 (2,265)
Bluefin tuna	Battaglia *et al.* 2013	1 (123)
	Butler 2007	2 (352)
	Chase 2002	5 (556)
	Eggleston and Bochenek 1989	1 (72)
	Karakulak *et al.* 2009	1 (85)
	Logan *et al.* 2011	3 (213)
	Pinkas 1971	1 (650)
	Pleizier *et al.* 2012	2 (54)
	Relini *et al.* 1995	1 (63)
	Sinopoli *et al.* 2004	1 (97)
(15) Other tuna		18 (2,857)
Bigeye tuna	Gorni *et al.* 2013	1 (63)
	Kim *et al.* 1997	1 (161)
	Logan *et al.* 2013	1 (14)
	Pimenta *et al.* 2001	1 (NA)
	Portier *et al.* 2004	1 (29)
	Satoh *et al.* 2004	1 (77)
	Vaske *et al.* 2012	1 (291)
	Young *et al.* 2010	2 (151)
Blackfin tuna	Headley *et al.* 2009	1 (184)
	Manooch and Mason 1983	1 (89)
Skipjack tuna	Ankenbrandt 1985	1 (605)
	Batts 1972	2 (317)
	Bernard *et al.* 1985	1 (31)
	Dragovich and Potthoff 1972	1 (711)
	Mendizabal 2013	1 (83)
	Roger 1994	1 (51)
(16) Billfish		43 (4,463)
Blue marlin	Abitia Cardenas *et al.* 1999	1 (176)
	Abitia Cardenas *et al.* 2010	1 (40)
	Brock 1984	1 (65)
	Cherel *et al.* 2007	1 (NA)
	Davies and Bortone 1976	1 (4)
	Ovchimmnikov 1970	3 (0)
	Pimenta *et al.* 2001	1 (NA)
	Rawlins *et al.* 2007	1 (7)
	Rudershausen *et al.* 2010	1 (70)
	Sabatie *et al.* 2003	1 (NA)
	Satoh *et al.* 2004	1 (17)
	Shimose *et al.* 2006	1 (507)
	Vaske *et al.* 2004	1 (41)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Blue marlin	Vaske *et al.* 2011	1 (156)
Sailfish	Arizmendi Rodriguez *et al.* 2006	1 (533)
	Bachok *et al.* 2004	1 (13)
	Casazza 2008	2 (38)
	Davies and Bortone 1976	1 (8)
	Jolley 1977	1 (568)
	Knapp 1949	1 (22)
	Ovchimmnikov 1970	1 (0)
	Rawlins *et al.* 2007	1 (8)
	Rosas Alayola *et al.* 2002	1 (576)
	Satoh *et al.* 2004	1 (42)
	Varghese *et al.* 2013	1 (252)
	Vaske *et al.* 2004	1 (98)
	Voss 1953	1 (241)
Spearfish	Ovchimmnikov 1970	1 (0)
	Satoh *et al.* 2004	1 (53)
	Vaske *et al.* 2004	1 (37)
Striped marlin	Abitia Cardenas *et al.* 1997	1 (350)
	Moteki *et al.* 2001	1 (48)
White marlin	Davies and Bortone 1976	1 (38)
	Gorni *et al.* 2012	1 (10)
	Mather *et al.* 1975	1 (59)
	Ovchimmnikov 1970	1 (0)
	Pinheiro *et al.* 2010	1 (220)
	Rawlins *et al.* 2007	1 (14)
	Satoh *et al.* 2004	1 (32)
	Vaske *et al.* 2004	1 (120)
(17) Swordfish		24 (2,458)
Swordfish	Bowman *et al.* 2000	1 (151)
	Chancollon *et al.* 2006	1 (83)
	Cherel *et al.* 2007	1 (NA)
	Clarke *et al.* 1995	1 (132)
	Gorni *et al.* 2013	1 (101)
	Hernandez Garcia 1995	1 (75)
	Landsdell and Young 2007	1 (NA)
	Logan *et al.* 2013	1 (69)
	Markaida and Hochberg 2005	1 (37)
	Moreira 1990	1 (37)
	Moteki *et al.* 2001	1 (25)
	Ovchimmnikov 1970	1 (0)
	Potier *et al.* 2007	1 (130)
	Relini *et al.* 1995	1 (126)
	Romeo *et al.* 2008	1 (95)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Swordfish	Sabatie *et al.* 2003	1 (9)
	Satoh *et al.* 2004	1 (32)
	Scott and Tibbo 1968	1 (135)
	Stillwell and Kohler 1985	1 (151)
	Watanabe *et al.* 2009	1 (434)
	Young *et al.* 2006	2 (196)
	Young *et al.* 2010	2 (440)
(18) Pelagic coastal piscivores		109 (17,514)
Almaco jack	Barreiros *et al.* 2003	1 (193)
	Casazza 2008	2 (82)
	Gomez *et al.* 2004	1 (3)
	Manooch and Haimovici 1983	1 (49)
Atlantic bonito	Bowman *et al.* 2000	1 (1)
Bar jack	Gomez *et al.* 2004	1 (1,164)
	Randall 1967	1 (70)
Black jack	Randall 1967	1 (2)
Blue runner	Casazza 2008	2 (1,274)
	Gomez *et al.* 2004	1 (0)
	Keenan 2002	1 (108)
	Randall 1967	1 (17)
	Sley *et al.* 2009	1 (689)
Bluefish	Bowman *et al.* 2000	1 (413)
	Buckel *et al.* 1999	8 (1,011)
	Gallaway *et al.* 1981	1 (0)
	Gartland *et al.* 2006	1 (331)
	Knapp 1949	1 (12)
	Naughton and Saloman 1984	15 (1,547)
Bluntnose jack	Gomez *et al.* 2004	1 (14)
Bonito	Campo *et al.* 2006	1 (173)
Cero	Gomez *et al.* 2004	1 (85)
	Randall 1967	1 (85)
Chub mackerel	Bowman *et al.* 2000	1 (24)
	Divita *et al.* 1983	1 (14)
Crevalle jack	Austin and Austin 1971	1 (1)
	Gomez *et al.* 2004	1 (75)
	Knapp 1949	1 (13)
	Saloman and Naughton 1984	7 (2,193)
	Wrast 2008	1 (7)
Dolphinfish	Casazza 2008	4 (160)
	Gomez *et al.* 2004	1 (0)
	Knapp 1949	1 (87)
	Lewis and Axelson 1967	1 (70)
	Logan *et al.* 2013	1 (11)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Dolphinfish	Manooch *et al.* 1984	1 (2,919)
	Massuti *et al.* 1998	1 (229)
	Oxenford and Hunte 1999	1 (352)
	Rose and Hassler 1974	1 (329)
	Rudershausen *et al.* 2010	1 (241)
	Satoh *et al.* 2004	1 (27)
Frigate tunny	Gomez *et al.* 2004	1 (43)
Horse eye jack	Austin and Austin 1971	1 (2)
	Gomez *et al.* 2004	1 (5)
	Randall 1967	1 (12)
Keeled needlefish	Randall 1967	1 (13)
Little tunny	Bahou *et al.* 2007	1 (166)
	Bowman *et al.* 2000	1 (3)
	Gomez *et al.* 2004	1 (65)
	Manooch *et al.* 1985	1 (1,212)
	Randall 1967	1 (15)
Needlefish	Carr and Adams 1973	5 (44)
Pompano dolphinfish	Casazza 2008	2 (22)
	Gibbs and Collette 1959	1 (46)
	Satoh *et al.* 2004	1 (2)
Rainbow runner	Garcia and Posada 2014	1 (35)
Remora	Cressey and Lachner 1970	1 (147)
	Gomez *et al.* 2004	1 (3)
	Randall 1967	1 (5)
Rudderfish	Bowman *et al.* 2000	1 (2)
	Gomez *et al.* 2004	1 (1)
Sharksucker	Divita *et al.* 1983	1 (2)
	Randall 1967	1 (5)
Timucu	Randall 1967	1 (15)
Wahoo	Franks *et al.* 2007	1 (127)
	Gomez *et al.* 2004	1 (466)
	Junior *et al.* 2003	1 (212)
	Manooch and Hogarth 1983	1 (56)
	Rudershausen *et al.* 2010	1 (67)
	Satoh *et al.* 2004	1 (21)
Yellow jack	Gomez *et al.* 2004	1 (619)
	Randall 1967	1 (6)
(19) Amberjack		12 (842)
Greater amberjack	Andaloro and Pipitone 1997	1 (185)
	Badalamenti *et al.* 1995	3 (166)
	Bowman *et al.* 2000	1 (3)
	Humphreys 1980	1 (125)
	Manooch and Haimovici 1983	1 (72)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Greater amberjack	Matallanas *et al.* 1995	2 (285)
	Patterson *et al.* 2012	2 (0)
	Randall 1967	1 (6)
(20) Cobia		14 (888)
Cobia	Arendt *et al.* 2001	1 (78)
	Bachok *et al.* 2004	1 (98)
	Bowman *et al.* 2000	1 (3)
	Franks *et al.* 1996	1 (39)
	Gomez *et al.* 2004	1 (49)
	Knapp 1949	1 (NA)
	Knapp 1951	1 (22)
	Meyers and Franks 1996	1 (287)
	Randall 1967	1 (1)
	Reid 1954	1 (NA)
	Rohit and Bhat 2012	1 (177)
	Salini *et al.* 1994	1 (24)
	Shaffer and Nakamura 1989	1 (NA)
	Smith 1995	1 (110)
(21) King mackerel - juvenile		3 (188)
King mackerel (0yr)	Finucane *et al.* 1990	1 (61)
	Naughton and Saloman 1981	1 (85)
	Pelaez Rodriguez *et al.* 2005	1 (42)
(22) King mackerel - adult		24 (14,328)
King mackerel (1+yr)	Beaumariage 1973	1 (179)
	Boschung 1957	1 (8)
	Bowman *et al.* 2000	1 (4)
	Browder *et al.* 1990	6 (6,696)
	DeVane 1978	1 (113)
	Gomez *et al.* 2004	1 (58)
	Kemp 1950	1 (92)
	Knapp 1949	1 (327)
	McMichael	1 (104)
	Menezes 1969	1 (633)
	Miles 1949	1 (119)
	Randall 1967	1 (13)
	Saloman and Naughton 1983	7 (5,982)
(23) Spanish mackerel - juvenile		3 (289)
Spanish mackerel (0yr)	Finucane *et al.* 1990	1 (91)
	Naughton and Saloman 1981	2 (198)
(24) Spanish mackerel - adult		12 (9,225)
Spanish mackerel (1+yr)	Bowman *et al.* 2000	1 (12)
	Browder *et al.* 1990	2 (1,027)
	Kemp 1950	1 (611)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Spanish mackerel (1+ yr)	Klima 1959	1 (181)
	Knapp 1950	1 (458)
	Saloman and Naughton 1983	5 (6,933)
	Wrast 2008	1 (3)
(25) Skates/rays		44 (1,636)
Atlantic stingray	Wrast 2008	1 (1)
Australian butterflyray	Jacobsen *et al.* 2009	1 (62)
Bluntnose stingray	Bowman *et al.* 2000	1 (22)
	Hess 1961	1 (30)
Bullnose ray	Bowman *et al.* 2000	1 (13)
	Szczepanski 2013	1 (133)
	Woodland *et al.* 2011	1 (34)
Clearnose skate	Bowman *et al.* 2000	7 (44)
	Sagarese *et al.* 2011	1 (18)
	Szczepanski 2013	1 (74)
Cownose ray	Ajemian and Powers 2011	1 (154)
	Bowman *et al.* 2000	1 (3)
	Collins *et al.* 2007	1 (37)
	Gomez *et al.* 2004	1 (1)
	Smith and Merriner 1985	1 (68)
Eagle ray	Gomez *et al.* 2004	1 (4)
	Randall 1967	1 (3)
	Schluessel *et al.* 2010	2 (105)
Guitarfish	Ismen *et al.* 2006	1 (141)
	Patokina and Litvinov 2005	2 (32)
Longnose stingray	Gomez *et al.* 2004	1 (16)
Nurse shark	Castro 2000	1 (41)
	Gomez *et al.* 2004	1 (9)
	Randall 1967	1 (9)
Roughtail stingray	Bowman *et al.* 2000	1 (4)
	Hess 1961	1 (49)
	Struhsaker 1969	1 (14)
Roundel skate	Divita *et al.* 1983	1 (6)
Shortnose guitarfish	Barbini *et al.* 2011	1 (279)
Smooth butterflyray	Yokota *et al.* 2013	1 (176)
Southern stingray	Bowman *et al.* 2000	1 (2)
	Gilliam and Sullivan 1993	1 (18)
	Gomez *et al.* 2004	1 (6)
	Randall 1967	1 (23)
Spiny butterflyray	Bowman *et al.* 2000	1 (4)
Stingray	Divita *et al.* 1983	1 (1)
(26) Gag grouper - juvenile		21 (2,250)
Gag grouper (0-3yr)	Adams 1976	1 (26)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Gag grouper (0-3yr)	Brule *et al.* 2011	4 (322)
	Bullock and Smith (from Peters 1991)	1 (134)
	Bullock and Smith 1991	1 (53)
	Lindberg *et al.* 2002	1 (99)
	Mena Loria *et al.* 2007	2 (322)
	Mullaney 1994	1 (209)
	Mullaney and Gale 1996	1 (209)
	Naughton and Saloman 1985	2 (158)
	Reid 1954	1 (0)
	Ross and Moser 1995	1 (150)
	Stallings *et al.* 2010	1 (329)
	Weaver 1996	4 (239)
(27) Gag grouper - adult		9 (1,606)
Gag grouper (+yr)	Naughton and Saloman 1985	6 (821)
	Patterson *et al.* 2012	2 (0)
	Tremain and Adams 2012	1 (785)
(28) Red grouper - juvenile		13 (459)
Red grouper (0-3yr)	Brule *et al.* 1993	3 (128)
	Brule and Canche 1993	4 (31)
	Brule and Canche 1994	1 (152)
	Bullock and Smith 1991	1 (23)
	Randall 1967	1 (2)
	Weaver 1996	3 (123)
(29) Red grouper - adult		7 (415)
Red grouper (3+yr)	Gomez *et al.* 2004	1 (87)
	Gudger 1929	1 (3)
	Longley and Hildebrand 1941	1 (0)
	Moe 1969	1 (0)
	Patterson *et al.* 2012	1 (0)
	Tremain and Adams 2012	1 (271)
	Weaver 1996	1 (54)
(31) Yellowedge grouper - adult		2 (3)
Yellowedge grouper (3+yr)	Bullock and Smith 1991	1 (0)
	Nelson 1988	1 (3)
(32) Goliath grouper		9 (239)
Goliath grouper	Beebe and Tee Van 1928	1 (1)
	Bullock and Smith 1991	2 (33)
	Gomez *et al.* 2004	1 (1)
Goliath grouper	Koenig and Coleman 2009	2 (191)
	Odum 1971	1 (2)
	Randall 1967	1 (9)
	Smith 1971	1 (2)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
(33) Deep-water grouper		8 (64)
Misty grouper	Bullock and Smith 1991	1 (1)
	Thompson and Monroe 1978	1 (1)
Snowy grouper	Bielsa and Labinsky 1987	3 (30)
	Manooch and Manooch 1993	1 (0)
Speckled hind	Bullock and Smith 1991	1 (31)
Warsaw grouper	Bullock and Smith 1991	1 (1)
(34) Shallow-water grouper		39 (1,153)
Black grouper	Brule *et al.* 2005	7 (72)
	Bullock and Smith (Peters unpub) 1991	1 (2)
	Gomez *et al.* 2004	1 (22)
	Randall 1967	1 (4)
Graysby	Randall 1967	1 (26)
Nassau grouper	Carter *et al.* 1994	1 (50)
	Eggleston *et al.* 1998	3 (58)
	Grover 1993	1 (120)
	Grover *et al.* 1998	1 (38)
	Randall 1965	1 (150)
	Randall 1967	1 (153)
Red hind	Bullock and Smith 1991	1 (1)
	Burnett Herkes 1975	1 (56)
	Gomez *et al.* 2004	1 (1)
	Menzel 1960	1 (0)
	Randall 1967	1 (50)
	Thompson and Munro 1978	1 (0)
Rock hind	Bullock and Smith 1991	1 (0)
	Gomez *et al.* 2004	1 (110)
	Nelson 1988	1 (0)
	Randall 1967	1 (31)
Scamp	Bowman *et al.* 2000	1 (2)
	Bullock and Smith 1991	1 (2)
	Matheson *et al.* 1986	1 (91)
	Tremain and Adams 2012	1 (11)
Yellowfin grouper	Bullock and Smith 1991	1 (0)
	Randall 1967	1 (51)
Yellowmouth grouper	Bullock and Murphy 1994	1 (25)
	Bullock and Smith 1991	1 (0)
	Randall 1967	1 (5)
Yellowmouth grouper/scamp	Nelson 1988	1 (22)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
(36) Red snapper - juvenile		40 (3,830)
Red snapper (ages 1-2)	Bailey 1995	1 (37)
	Beaumariage and Bullock 1976	1 (0)
	Bradley and Bryan 1975	11 (87)
	Camber 1955	1 (14)
	Divita *et al.* 1983	1 (48)
	Gallaway *et al.* 1981	1 (0)
	McCawley *et al.* 2003	1 (452)
	McCawley *et al.* 2006	1 (138)
	Moseley 1966	2 (73)
	Newton 2007	3 (906)
	Ouzts and Szedlmayer 2003	1 (164)
	Patterson *et al.* 2012	4 (0)
	Perez Diaz *et al.* 2007	1 (70)
	Schqartzkopf 2014	4 (117)
	Sheridan 2008	1 (192)
	Szedlmayer and Lee 2004	1 (789)
	Wells *et al.* 2008	5 (743)
(37) Red snapper - adult		25 (1,765)
Red snapper (ages 3+)	Bailey 1995	1 (8)
	Bradley and Bryan 1975	1 (190)
	Camber 1955	1 (24)
	Cowan *et al.* 2012	3 (309)
	Futch and Bruger 1976	1 (56)
	Gallaway 1981	1 (NA)
	Knapp 1949	1 (46)
	McCawley and Cowan 2007	1 (268)
	McCawley *et al.* 2003	1 (268)
	Patterson *et al.* 2012	2 (0)
	Perez Diaz *et al.* 2007	2 (138)
	Schqartzkopf 2014	7 (144)
	Simonsen 2013	3 (314)
(38) Vermilion snapper		13 (1,017)
Vermilion snapper	Bowman *et al.* 2000	1 (9)
	Darnell 1991	1 (16)
	Dixon 1975	1 (15)
	Gomez *et al.* 2004	1 (255)
	Grimes 1979	2 (179)
	Johnson *et al.* 2010	1 (288)
	Patterson *et al.* 2012	2 (0)
	Sedberry and Cuellar 1993	4 (255)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
(39) Mutton snapper		7 (419)
Mutton snapper	Clark *et al.* 2009	1 (3)
	Duarte and Garcia 1999	1 (110)
	Freitas *et al.* 2011	1 (85)
	Gomez *et al.* 2004	1 (128)
	Heck and Weinstein 1989	1 (NA)
	Pimentel and Joyeux 2010	1 (40)
	Randall 1967	1 (53)
(40) Other snapper		31 (1,859)
Cubera snapper	Randall 1967	1 (11)
Dog snapper	Austin and Austin 1971	1 (2)
	Clark *et al.* 2009	1 (5)
	Gomez *et al.* 2004	1 (11)
	Monteiro *et al.* 2009	1 (88)
	Pimentel and Joyeux 2010	1 (45)
	Randall 1967	1 (56)
Gray snapper	Austin and Austin 1971	1 (1)
	Clamark *et al.* 2009	1 (8)
	Franks and VanderKooy 2000	1 (12)
	Gomez *et al.* 2004	1 (374)
	Guevara *et al.* 2007	1 (672)
	Hammerschlag *et al.* 2010	1 (58)
	Harrigan *et al.* 1989	2 (152)
	Layman and Silliman 2002	1 (13)
	Moriniere *et al.* 2003	2 (22)
	Nagelkerken *et al.* 2000	1 (14)
	Odom and Heald 1972	1 (96)
	Patterson *et al.* 2012	2 (0)
	Randall 1967	1 (28)
	Samano Zapata *et al.* 1998	1 (162)
	Yeager and Layman 2011	2 (0)
Mahogany snapper	Gomez *et al.* 2004	1 (5)
	Randall 1967	1 (8)
Queen snapper	Gobert *et al.* 2003	1 (3)
Silk snapper	Gomez *et al.* 2004	1 (7)
Wenchman	Gomez *et al.* 2004	1 (6)
(41) Coastal piscivores		44 (4,882)
Bonefish	Colton and Alevizon 1983	1 (365)
	Crabtree *et al.* 1998	1 (385)
	Gomez *et al.* 2004	1 (385)
	Layman and Silliman 2002	1 (10)
	Snodgrass *et al.* 2008	1 (139)
	Warmke and Erdman 1963	1 (272)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Bonefish	Weinberger and Posada 2005	1 (136)
Common snook	Adams *et al.* 2009	4 (86)
	Austin and Austin 1971	1 (8)
	Blewett *et al.* 2006	1 (432)
	Diener *et al.* 1974	1 (NA)
	Fore and Schmidt 1973	2 (269)
	Gomez *et al.* 2004	1 (23)
	Harrington and Harrington 1961	1 (167)
	Odum and Heald 1972	1 (NA)
	Rock 2009	4 (353)
	Stevens *et al.* 2010	1 (238)
	Teixeira 1997	1 (379)
Ladyfish	Austin and Austin 1971	1 (7)
	Darnell 1958	1 (5)
	Gomez *et al.* 2004	1 (1)
	Harrington and Harrington 1961	1 (33)
	Knapp 1949	1 (156)
	Odum 1971	1 (9)
	Odum and Heald 1972	1 (9)
	Sekavec 1974	3 (229)
Tarpon	Austin and Austin 1971	1 (7)
	Gomez *et al.* 2004	1 (8)
	Harrington and Harrington 1960	1 (442)
	Jud *et al.* 2011	1 (71)
	Knapp 1949	1 (37)
	Odum and Heald 1972	1 (NA)
	Randall 1967	1 (2)
	Rickards 1964	1 (213)
	Vega Cendejas and Hernandez 2002	1 (6)
(42) Seatrout		61 (7,483)
Sand seatrout	Darnell 1958	3 (47)
	Divita *et al.* 1983	1 (25)
	Kasprzak and Guillory 1984	1 (431)
	Minello *et al.* 1989	2 (21)
	Moffett 1979	1 (220)
	Overstreet and Heard 1982	1 (74)
	Peebles and Hopkins 1993	6 (607)
	Reid *et al.* 1954	5 (273)
	Sheridan 1979	1 (122)
	Sheridan and Trimm 1983	2 (130)
	Wrast 2008	1 (11)
Silver seatrout	Divita *et al.* 1983	4 (269)
Spotted seatrout	Carr and Adams 1973	1 (174)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Spotted seatrout	Darnell 1958	4 (48)
	Day 1960	1 (32)
	Gunter 1945	1 (93)
	Hettler 1989	1 (144)
	Klima and Tabb 1959	1 (26)
	Knapp 1949	1 (2,698)
	Minello *et al.* 1989	2 (20)
	Odum and Heald 1972	1 (8)
	Overstreet and Heard 1982	1 (340)
	Peebles and Hopkins 1993	7 (668)
	Rogillio 1975	1 (108)
	Russell 2002	1 (175)
	Rutherford *et al.* 1982	1 (238)
	Seagle 1969	4 (217)
	Simonsen and Cowan 2013	2 (83)
	Tabb 1961	2 (170)
	Wrast 2008	1 (11)
(43) Oceanic piscivores		45 (6,950)
Cutlassfish	Bakhoum 2007	1 (297)
	Bittar and Di Beneditto 2009	1 (350)
	Bittar *et al.* 2012	1 (0)
	Bowman *et al.* 2000	1 (11)
	Chiou *et al.* 2006	1 (836)
	Divita *et al.* 1983	1 (5)
	Martins *et al.* 2005	4 (932)
	Mericas 1981	1 (0)
	Pelaez Rodriguez *et al.* 2005	1 (149)
	Pethiyagoda 2006	1 (82)
	Portsev 1980	6 (1,576)
	Sheridan and Trimm 1983	2 (23)
	Yan *et al.* 2011	3 (738)
Escolar	Choy *et al.* 2013	1 (4)
Lancetfish	Bowman *et al.* 2000	1 (2)
	Choy *et al.* 2013	1 (120)
	Kubota and Uyeno 1970	1 (34)
	Moteki *et al.* 2001	1 (19)
	Potier *et al.* 2007	2 (278)
	Satoh *et al.* 2004	1 (168)
	Young *et al.* 2010	2 (114)
Offshore hake	Bowman *et al.* 2000	1 (13)
	Garrison and Link 2000	1 (NA)
	Langton and Bowman 1980	3 (31)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Offshore hake	Rohr and Gutherz 1977	1 (649)
Oilfish	Vasilakopoulos *et al.* 2011	1 (30)
	Viana *et al.* 2012	1 (135)
Pomfret	Blaber and Bulman 1987	1 (122)
	Vaske *et al.* 2008	1 (185)
Snake mackerel	Choy *et al.* 2013	1 (47)
(44) Benthic piscivores		77 (4,571)
Angel shark	Baremore *et al.* 2010	3 (179)
	Bowman *et al.* 2000	1 (52)
	Sommerville *et al.* 2011	1 (259)
Brazilian lizardfish	Divita 1983	1 (13)
	Pelaez Rodriguez *et al.* 2005	1 (86)
Diamond lizardfish	Randall 1967	1 (2)
Gulf flounder	Francis 2002	6 (0)
	Luczkovich *et al.* 2002	2 (31)
	Peebles and Hopkins 1993	7 (285)
	Reid 1954	1 (27)
	Topp and Hoff 1972	1 (3)
Inshore lizardfish	Carr and Adams 1973	1 (30)
	Cruz Escalona *et al.* 2005	1 (246)
	Divita 1983	2 (296)
	Gomez *et al.* 2004	1 (9)
	Grabrowski 2002	1 (27)
	Jeffers 2002	4 (742)
	Kagiwara and Abilhoa 2000	1 (73)
	Minello *et al.* 1989	2 (8)
	Pelaez Rodriguez *et al.* 2005	1 (124)
	Randall 1967	1 (3)
	Reid 1954	1 (11)
	Sheridan 2008	1 (376)
	Springer and Woodburn 1960	1 (13)
Lizardfish	Darnell 1991	2 (49)
Mexican flounder	Divita *et al.* 1983	1 (8)
Offshore lizardfish	Bowman *et al.* 2000	1 (6)
Oscellated flounder	Divita *et al.* 1983	1 (1)
Sand diver	Gomez *et al.* 2004	1 (38)
	Randall 1967	1 (18)
Shortjaw lizardfish	Gomez *et al.* 2004	1 (9)
Snake eel	Randall 1967	1 (4)
Snakefish	Divita *et al.* 1983	1 (2)
Southern flounder	Darnell 1958	1 (14)
	Day 1960	1 (44)
	Divita *et al.* 1983	1 (9)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Southern flounder	Ellis 2007	4 (268)
	Fitzhugh *et al.* 1996	7 (816)
	Gunter 1945	1 (8)
	Knapp 1949	1 (24)
	Minello *et al.* 1989	2 (19)
	Overstreet and Heard 1982	1 (97)
	Powell and Schwartz 1979	4 (234)
Spotfin flounder	Divita *et al.* 1983	1 (8)
(45) Reef/rubble-associated piscivores		35 (818)
Chain moray	Randall 1967	1 (8)
Dusky	Gladfelter and Johnson 1983	1 (55)
Dusky squirrelfish	Randall 1967	1 (42)
Great barracuda	Austin and Austin 1971	1 (21)
	DeTroch *et al.* 1998	1 (18)
	Gomez *et al.* 2004	1 (39)
	Hammerschlag *et al.* 2010	1 (39)
	Kulbicki *et al.* 2005	1 (39)
	Lugendo *et al.* 2006	3 (16)
	Randall 1967	1 (58)
	Schmidt 1989	1 (50)
Green moray	Gomez *et al.* 2004	1 (0)
Guaguanche barracuda	Divita *et al.* 1983	1 (2)
	Gomez *et al.* 2004	1 (9)
Longjaw squirrelfish	Gladfelter and Johnson 1983	1 (62)
	Randall 1967	1 (9)
Longspine squirrelfish	Gladfelter and Johnson 1983	1 (73)
	Randall 1967	1 (42)
Moray	Divita *et al.* 1983	1 (2)
Purplemouth moray	Randall 1967	1 (6)
	Young and Winn 2003	1 (18)
Reef	Gladfelter and Johnson 1983	1 (45)
Reef squirrelfish	Randall 1967	1 (19)
Sailors choice	Randall 1967	1 (21)
Soapfish	Divita *et al.* 1983	1 (1)
	Felder and Cheney 1979	1 (7)
	Randall 1967	1 (12)
Southern sennet	Randall 1967	1 (7)
Spotted moray	Randall 1967	1 (6)
	Young and Winn 2003	1 (43)
Squirrelfish	Gladfelter and Johnson 1983	1 (18)
	Gomez *et al.* 2004	1 (11)
	Randall 1967	1 (20)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
(46) Reef/rubble-associated invert feeders		157 (8,320)
Atlantic seabream	Gomez *et al.* 2004	1 (54)
	Vega Dendejas *et al.* 1994	1 (257)
Banded butterflyfish	Pitt 1991	1 (31)
	Randall 1967	1 (16)
Bank sea bass	Bullock and Smith 1991	1 (27)
	Divita *et al.* 1983	1 (16)
	Sheridan 2008	1 (56)
Barred hamlet	Randall 1967	1 (19)
Belted sandfish	Bullock and Smith 1991	1 (12)
Bigeye	Bowman *et al.* 2000	1 (2)
	Divita *et al.* 1983	1 (9)
	Gomez *et al.* 2004	1 (21)
	Randall 1967	1 (18)
Black grunt	Gomez *et al.* 2004	1 (204)
Black margate	Gomez *et al.* 2004	1 (0)
	Randall 1967	1 (40)
Black sea bass	Bowman *et al.* 2000	9 (485)
	Sedberry 1988	1 (313)
Blackear bass	Divita *et al.* 1983	1 (11)
Blackear wrasse	Randall 1967	1 (31)
Bluehead wrasse	Clifton and Motta 1998	1 (10)
	Randall 1967	1 (52)
Bluestriped grunt	Layman and Silliman 2002	1 (47)
	Randall 1967	1 (34)
Caesar grunt	Gomez *et al.* 2004	1 (21)
	Randall 1967	1 (21)
Chalk bass	Randall 1967	1 (2)
Clown wrasse	Clifton and Motta 1998	1 (15)
	Randall 1967	1 (23)
Cottonwick grunt	Gomez *et al.* 2004	1 (19)
Creole wrasse	Randall 1967	1 (15)
Creolefish	Bullock and Smith 1991	1 (2)
	Nelson 1988	1 (252)
Cubbyu	Divita *et al.* 1983	1 (8)
Dusky hamlet	Randall 1967	1 (17)
Foureye butterflyfish	Pitts 1991	1 (33)
	Randall 1967	1 (28)
Foureye butterlyfish	Birkeland and Neudecker 1981	1 (10)
French grunt	Gomez *et al.* 2004	1 (30)
	Layman and Silliman 2002	1 (3)
	Randall 1967	1 (30)
Glasseye	Randall 1967	1 (25)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Harlequin bass	Randall 1967	1 (19)
Hawkfish	Randall 1967	1 (12)
Hogfish	Bowman *et al.* 2000	1 (1)
	Clifton and Motta 1998	1 (15)
	Gomez etal 2004	1 (0)
	Randall 1967	1 (80)
	Wainwright 1987	1 (67)
Jackknife fish	Gomez *et al.* 2004	1 (1)
	Randall 1967	1 (4)
Jolthead porgy	Randall 1967	1 (9)
Knobbed porgy	Divita *et al.* 1983	1 (2)
	Horvath *et al.* 1990	1 (70)
Lane snapper	Divita *et al.* 1983	1 (22)
	Doncel and Paramo 2010	1 (148)
	Franks and VanderKooy 2000	1 (53)
	Gomez *et al.* 2004	1 (162)
	Patterson *et al.* 2012	1 (0)
	Pimentel and Joyeux 2010	1 (81)
	Randall 1967	1 (2)
	Reid 1954	1 (9)
	Rivera Arriaga *et al.* 1995	1 (444)
	Rodriquez Pino 1962	1 (0)
	Samano Zapata *et al.* 1998	1 (70)
Longsnout butterflyfish	Birkeland and Neudecker 1981	1 (12)
	Randall 1967	1 (7)
Longspine scorpionfish	Darnell 1991	3 (192)
Margate	Cummings *et al.* 1961	1 (55)
	Randall 1967	1 (39)
Mushroom scorpionfish	Randall 1967	1 (16)
Mutton hamlet	Randall 1967	1 (30)
Pearly razor	Castriota *et al.* 2005	1 (177)
	Randall 1967	1 (8)
Pluma porgy	Gomez *et al.* 2004	1 (6)
	Randall 1967	1 (10)
Porkfish	Gomez e tal 2004	1 (1)
	Randall 1967	1 (13)
Puddingwife	Randall 1967	1 (27)
Pygmy sea bass	Bullock and Smith 1991	1 (2)
Reef butterflyfish	Randall 1967	1 (3)
Reef croaker	Divita *et al.* 1983	1 (5)
	Randall 1967	1 (25)
Reef scorpionfish	Randall 1967	1 (11)
Rock sea bass	Divita *et al.* 1983	2 (256)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Rock sea bass	Ross *et al.* 1989	1 (865)
	Sheridan 2008	1 (386)
Sailors choice	Gomez *et al.* 2004	1 (4)
	Layman and Silliman 2002	1 (15)
Sand sea bass	Gomez *et al.* 2004	1 (0)
Saucereye porgy	Randall 1967	1 (12)
Schoolmaster	Austin and Austin 1971	1 (24)
	Hammerschlag Peyer and Layman 2012	2 (261)
	Layman and Silliman 2002	1 (51)
	Moriniere *et al.* 2003	2 (79)
	Nagelkerken *et al.* 2000	3 (53)
	Randall 1967	1 (58)
Sheepshead porgy	Castillo Rivera *et al.* 2007	1 (52)
	Divita *et al.* 1983	1 (1)
	Gomez *et al.* 2004	1 (0)
	Odum 1971	1 (114)
	Odum and Heald 1972	1 (114)
	Overstreet and Heard 1982	2 (125)
	Randall 1967	1 (1)
	Wrast 2008	1 (7)
Slippery dick	Clifton and Motta 1998	1 (15)
	Randall 1967	1 (46)
Smallmouth grunt	Gomez *et al.* 2004	1 (213)
	Randall 1967	1 (17)
Spanish grunt	Randall 1967	1 (19)
Spanish hogfish	Randall 1967	1 (30)
Spotfin butterflyfish	Gomez *et al.* 2004	1 (31)
	Pitts 1991	1 (31)
Spotted scorpionfish	Gomez etal 2004	1 (0)
	Randall 1967	1 (16)
Tobaccofish	Randall 1967	1 (1)
	Robins and Starck 1961	1 (3)
Tomtate	Bowman *et al.* 2000	1 (14)
	Darnell 1991	1 (16)
	Gomez *et al.* 2004	1 (32)
	Randall 1967	1 (16)
White grunt	Bowman *et al.* 2000	1 (11)
	Gomez *et al.* 2004	1 (5)
	Randall 1967	1 (15)
Whitebone porgy	Bowman *et al.* 2000	1 (2)
	Sedberry 1989	5 (318)
Yellowbelly hamlet	Randall 1967	1 (16)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Yellowhead wrasse	Clifton and Motta 1998	1 (15)
	Randall 1967	1 (10)
Yellowtail hamlet	Randall 1967	1 (60)
Yellowtail snapper	Gomez *et al.* 2004	1 (0)
	Moriniere *et al.* 2003	2 (76)
	Nagelkerken *et al.* 2000	2 (38)
	Randall 1967	1 (42)
	Rincon Sandoval *et al.* 2009	1 (505)
(47) Demersal coastal invert feeders		240 (23,132)
African pompano	Gomez *et al.* 2004	1 (2)
Atlantic bumper	Bowman *et al.* 2000	1 (4)
	Divita *et al.* 1983	1 (7)
	Gomez *et al.* 2004	1 (56)
Atlantic croaker	Bowman *et al.* 2000	7 (306)
	Darnell 1961	1 (0)
	Darnell 1991	2 (70)
	Divita *et al.* 1983	2 (1,853)
	Hansen *et al.* 1969	2 (2,470)
	Minello *et al.* 1989	2 (147)
	Overstreet and Heard 1978	1 (225)
	Reid *et al.* 1954	1 (73)
	Sheridan 1979	1 (2,217)
	Sheridan 1983	2 (152)
	Weaver and Holloway 1974	1 (0)
Banded drum	Bowman *et al.* 2000	1 (8)
	Divita *et al.* 1983	1 (45)
Barred grunt	Gomez *et al.* 2004	1 (125)
Black drum	Overstreet and Heard 1982	1 (15)
	Peters and McMichael 1990	9 (288)
	Simmons and Breuer 1962	1 (189)
	Wrast 2008	1 (6)
Caitipa mojarra	Aguirre Leion and Diaz Ruiz 2006	1 (188)
Corocoro grunt	Gomez etal 2004	1 (250)
Dwarf goatfish	Gomez *et al.* 2004	1 (3)
Florida pompano	Gomez *et al.* 2004	1 (1)
Gafftopsail catfish	Gomez *et al.* 2004	1 (4)
	Knapp 1949	1 (225)
	Kobelkowsky and Castillo Rivera 1995	1 (0)
	Mendoz Carranza 2003	1 (430)
	Ruderhausen and Locascio 2001	3 (320)
	Wrast 2008	1 (79)
	Yanez Arancibia and Lara Dominguez 1988	1 (37)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Goatfish	Divita *et al.* 1983	1 (9)
Hardhead catfish	Divita *et al.* 1983	2 (29)
	Knapp 1949	1 (468)
	Kobelkowsky and Castillo Rivera 1995	1 (0)
	Motta *et al.* 1995	1 (30)
	Odum and Heald 1972	1 (62)
	Sheridan 1983	2 (45)
	Vega Dendejas *et al.* 1994	1 (256)
	Wrast 2008	1 (72)
	Yanez Arancibia and Lara Dominguez 1988	2 (80)
Irish mojarra	Gomez *et al.* 2004	1 (1)
Jamaican weakfish	Gomez *et al.* 2004	1 (1)
Jenny mojarra	Gomez *et al.* 2004	1 (132)
Leatherjacket	Carr and Adams 1973	6 (80)
	Gomez *et al.* 2004	1 (282)
	Randall 1967	1 (7)
Longspine porgy	Bowman *et al.* 2000	3 (39)
	Divita *et al.* 1983	1 (23)
	Sheridan 1983	2 (88)
Lookdown	Gomez *et al.* 2004	1 (51)
Midshipman	Divita *et al.* 1983	1 (8)
Palometa	Randall 1967	1 (23)
Palometa pompano	Gomez *et al.* 2004	1 (23)
Permit	Carr and Adams 1973	9 (134)
	Gomez *et al.* 2004	1 (2)
	Randall 1967	1 (7)
Pigfish	Adams 1976	2 (105)
	Bowman *et al.* 2000	1 (10)
	Carr and Adams 1973	10 (445)
	Divita *et al.* 1983	1 (10)
	Schmidt 1993	1 (125)
	Vega Dendejas *et al.* 1994	1 (578)
Pompano	ArmitageAlvevizon 1980	2 (105)
	Wheeler *et al.* 2002	5 (78)
Red porgy	Gomez *et al.* 2004	1 (408)
	Labropoulou *et al.* 1999	3 (408)
	Papaconstantinous and Caragitsou 1989	1 (122)
Sand drum	Gomez *et al.* 2004	1 (100)
Sandflat mojarra	Austin and Austin 1971	1 (24)
	Randall 1967	1 (19)
Silver jenny	Carr and Adams 1973	8 (306)
	Motta *et al.* 1995	1 (30)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Silver jenny	Odum and Heald 1972	1 (112)
	Peebles and Hopkins 1993	7 (429)
	Vega Dendejas *et al.* 1994	1 (107)
Silver perch	Adams 1976	1 (77)
	Bowman *et al.* 2000	1 (1)
	Carr and Adams 1973	19 (797)
	Chavance *et al.* 1984	1 (34)
	Divita *et al.* 1983	1 (1)
	Minello *et al.* 1989	2 (52)
	Peebles and Hopkins 1993 1993	9 (604)
	Schmidt 1993	1 (51)
	Vega Dendejas *et al.* 1994	1 (168)
	Waggy *et al.* 2007	1 (NA)
	Wrast 2008	1 (8)
Slender mojarra	Layman and Sills 2002	1 (70)
Southern kincroaker	Gomez *et al.* 2004	1 (4)
	Knapp 1949	1 (259)
Southern kingcroaker	Divita *et al.* 1983	2 (80)
Spot croaker	Adams 1976	1 (112)
	Alexander 1983	1 (75)
	Bowman *et al.* 2000	5 (373)
	Divita *et al.* 1983	1 (239)
	Hodson *et al.* 1981	1 (1,026)
	Kobylinksi and Sheridan 1979 1979	1 (903)
	Minello *et al.* 1989	2 (299)
	Peebles and Hopkins 1993	6 (280)
	Sheridan 1979	1 (903)
	Sheridan 1983	2 (58)
	Weaver and Holloway 1974	1 (0)
	Wrast 2008	1 (23)
Spotfin mojarra	Gomez *et al.* 2004	1 (129)
	Odum and Heald 1972	1 (95)
	Vega Dendejas *et al.* 1994	1 (113)
Spotted goatfish	Gomez *et al.* 2004	1 (16)
	Randall 1967	1 (26)
Star drum	Divita *et al.* 1983	1 (20)
Striped mojarra	Aguirre Leion and Diaz Ruiz 2006	1 (280)
	Austin and Austin 1971	1 (7)
	Gomez *et al.* 2004	1 (53)
	Odum and Heald 1972	1 (14)
Tidewater mojarra	Ley *et al.* 1994	1 (181)
	Peebles and Hopkins 1993	7 (299)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Whitemouth croaker	Austin and Austin 1971	1 (3)
	Gomez *et al.* 2004	1 (55)
Yellow goatfish	Gomez *et al.* 2004	1 (4)
	Randall 1967	1 (14)
Yellowfin mojarra	Austin and Austin 1971	1 (25)
	Gomez *et al.* 2004	1 (1)
	Layman and Sills 2002	1 (5)
	Randall 1967	1 (27)
(48) Red drum		23 (3,419)
Red drum	BassAvault 1975	18 (541)
	Boothby and Avault 1971	1 (286)
	Knapp 1949	1 (754)
	Overstreet and Heard 1978	1 (43)
	Scharf and Schlicht 2000	1 (598)
	Simmons and Breuer 1962	1 (1,197)
(49) Benthic coastal invert feeders		89 (6,596)
Band cusk eel	Divita 1983	1 (5)
Bandtail goby	Kramer *et al.* 2009	1 (18)
Bandtail searobin	Ross 1977	1 (27)
Barbfish	Randall 1967	1 (7)
Barred searobin	Ross 1977	1 (28)
Batfish	Randall 1967	1 (9)
Bay whiff	Castillo Rivera *et al.* 2000	1 (146)
	Divita 1983	1 (10)
	Guedes and Araujo 2008	1 (205)
	Toepfer and Fleeger 1995	1 (0)
Bighead searobin	Divita 1983	1 (9)
	Ross 1977	1 (69)
	Sheridan 2008	1 (154)
Blackedge cusk eel	Divita *et al.* 1983	2 (147)
Blackwing searobin	Divita *et al.* 1983	1 (9)
	Sheridan 2008	1 (474)
Bluespotted searobin	Bowman *et al.* 2000	1 (1)
	Divita 1983	1 (7)
	Ross 1977	1 (141)
Bridled goby	Randall 1967	1 (4)
Brotula	Divita 1983	1 (5)
Cleaning goby	Randall 1967	1 (1)
Conger eel	Bowman 2000	1 (7)
	Divita *et al.* 1983	1 (1)
	Morato *et al.* 1999	1 (95)
Crested cusk eel	Divita 1983	1 (11)
Crested goby	Bouchereau *et al.* 2012	1 (200)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Crested goby	Darcy 1981	1 (90)
Cusk eel	Bowman *et al.* 2000	1 (2)
	Gomez *et al.* 2004	1 (1)
Dusky flounder	Bowman *et al.* 2000	1 (1)
	Divita 1983	1 (1)
	Topp and Hoff 1972	4 (168)
Dwarf sand perch	Darnell 1991	3 (166)
Fawn cusk eel	Bowman *et al.* 2000	4 (109)
Flounder	Grabrowski 2002	1 (75)
Frillfin goby	Emmanuel and Ajibola 2010	1 (300)
Fringed flounder	Guedes and Araujo 2008	1 (940)
	Reichert 2003	1 (82)
Goby	Toepfer and Fleeger 1995	1 (0)
Goldspot goby	Randall 1967	1 (10)
Gulf hake	Divita 1983	1 (5)
Leopard searobin	Darnell 1991	2 (51)
	Divita 1983	1 (2)
	Ross 1977	2 (544)
Pallid goby	Kramer *et al.* 2009	1 (36)
Pancake batfish	Darnell 1991	3 (354)
Sand perch	Bortone 1971	1 (127)
	Bowman *et al.* 2000	1 (2)
	Bullock and Smith 1991	1 (17)
	Divita *et al.* 1983	1 (27)
	Gilbran 2007	1 (16)
	Sheridan 2008	1 (258)
Searobin	Divita *et al.* 1983	1 (9)
	Gomez *et al.* 2004	1 (1)
Shortnose batfish	Darnell 1991	1 (15)
Shortwing searobin	Darnell 1991	1 (51)
Smoothhead scorpionfish	Darnell 1991	2 (48)
	Divita *et al.* 1983	1 (5)
Southern hake	Divita *et al.* 1983	2 (94)
Spotted hake	Bowman *et al.* 2000	5 (41)
	Steimle *et al.* 2000	1 (196)
Threadfin	Divita 1983	1 (29)
	Rivera Arriagag UNK	2 (354)
Tonguefish	Austin and Austin 1971	1 (1)
	Peebles and Hopkins 1993	1 (36)
	Stickney 1976	2 (542)
	Toepfer and Fleeger 1995	1 (0)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
(50) Tilefish		9 (658)
Blueline tilefish	Bielsa and Labisky 1987	4 (92)
	Gomez *et al.* 2004	1 (311)
	Ross 1982	1 (92)
Golden tilefish	Bowman *et al.* 2000	1 (6)
	Freeman and Turner 1977	1 (150)
Sand tilefish	Randall 1967	1 (7)
(51) Gray triggerfish		14 (391)
Gray triggerfish	Aggrey Fynn 2007	4 (65)
	Casazza 2008	2 (33)
	Durie and Turingan 2001	2 (53)
	Felder and Chaney 1979	1 (1)
	Gomez *et al.* 2004	1 (197)
	Patterson *et al.* 2012	2 (0)
	Vose and Nelson 1994	2 (42)
(52) Coastal omnivores		91 (7,289)
Ocean triggerfish	Randall 1967	1 (4)
Atlantic spadefish	Gomez 2004	1 (1)
	Hayse 1989	3 (155)
	Randall 1967	1 (22)
Bandtail puffer	Randall 1967	1 (29)
	Targett 1978	1 (453)
Checkered puffer	Austin and Austin 1971	1 (2)
	Chi Espinola and Vega Cendejas 2013	1 (382)
	Dubiaski silva and Masunari 2008	1 (14)
	Santos and Rodriquez 2012	1 (51)
	Targett 1978	1 (339)
	Turingan 1994	1 (10)
Fringed filefish	Casazza 2008	1 (32)
	Clements and Livingston 1983	6 (0)
	Randall 1967	1 (13)
Orange filefish	Gomez *et al.* 2004	1 (5)
	Randall 1967	2 (31)
Pinfish	Alexander 1983	1 (102)
	Bowman *et al.* 2000	1 (5)
	Brook 1977	1 (38)
	Canto Maza and Vega Cendejas 2008	1 (90)
	Darnell 1958	5 (99)
	Divita 1983	1 (4)
	Grabowski 2002	2 (135)
	Gunter 1945	1 (8)
	Hansen 1969	2 (3,627)
	Luczkovich *et al.* 2002	1 (45)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Pinfish	Minello *et al.* 1989	2 (196)
	Motta *et al.* 1995	1 (30)
	Prado and Heck 2011	1 (13)
	Russell 2005	1 (137)
	Schmidt 1993	1 (197)
	Stoner and Livingston 1984	14 (0)
	Vega Cendejas *et al.* 1994	1 (375)
	Winemiller *et al.* 2007	1 (0)
Planehead filefish	Adams 1976	1 (87)
	Bowman *et al.* 2000	1 (4)
	Casazza 2008	2 (115)
	Clements and Livingston 1983	6 (0)
	Dubiaski silva and Masunari 2008	1 (32)
	Prado and Heck 2011	1 (23)
Scrawled filefish	Randall 1967	1 (8)
Sharpnose puffer	Randall 1967	1 (26)
Smooth puffer	Denadai *et al.* 2011	1 (123)
Southern puffer	Carr and Adams 1973	4 (35)
Spadefish	Divita *et al.* 1983	1 (2)
Spottail pinfish	Bowman *et al.* 2000	1 (5)
	Carr and Adams 1972	1 (18)
	Pike and Lindquist 1994	1 (96)
Unicorn filefish	Gomez *et al.* 2004	1 (29)
	Lopez *et al.* 2002	1 (16)
Whitespotted filefish	Randall 1967	1 (10)
	Turingan 1994	1 (10)
Yellow chub	Randall 1967	1 (6)
(53) Reef omnivores		58 (1,174)
Beaugregory	Nagelkerken *et al.* 2006	1 (8)
	Randall 1967	1 (41)
Bermuda chub	Randall 1967	1 (19)
Blue angelfish	Feddern 1968	1 (71)
	Patterson 2012	1 (0)
	Weaver and Sulak 2000	1 (NA)
Blue tang	Ferreira *et al.* 2006	1 (20)
	Randall 1967	1 (25)
Bucktooth parrotfish	Randall 1967	1 (5)
Cherubfish	Randall 1967	1 (4)
Chub	Ferreira *et al.* 2006	1 (20)
	Silvano and Guth 2006	1 (20)
Cocoa damselfish	Feitosa *et al.* 2012	2 (60)
	Randall 1967	1 (7)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Doctorfish	Ferreira *et al.* 2006	1 (20)
	Nagelkerken *et al.* 2006	1 (11)
	Randall 1967	1 (20)
Dusky damselfish	Dromard *et al.* 2013	2 (36)
	Feitosa *et al.* 2012	2 (60)
	Randall 1967	1 (43)
Emerald parrotfish	Prado and Heck 2011	1 (14)
French angelfish	Batista *et al.* 2012	3 (15)
	Feddern 1968	1 (41)
	Gomez *et al.* 2004	1 (1)
	Randall 1967	1 (23)
Gray angelfish	Feddern 1968	1 (66)
	Gomez *et al.* 2004	1 (34)
	Randall 1967	1 (34)
Green razor	Randall 1967	1 (12)
Midnight parrotfish	Randall 1967	1 (12)
Ocean surgeonfish	Ferreira *et al.* 2006	1 (20)
	Nagelkerken *et al.* 2006	1 (10)
	Randall 1967	1 (23)
Parrotfish parrotfish	Gomez *et al.* 2004	1 (18)
Princess parrotfish	Randall 1967	1 (8)
Queen angelfish	Feddern 1968	1 (36)
	Randall 1967	1 (26)
Queen parrotfish	Randall 1967	1 (14)
Rainbow parrotfish	Randall 1967	1 (15)
Redband parrotfish	Randall 1967	1 (11)
Redfin parrotfish	Randall 1967	1 (18)
Redtail parrotfish	Nagelkerken *et al.* 2006	1 (7)
	Randall 1967	1 (6)
Rock beauty	Feddern 1968	1 (42)
	Neudecker 1979	1 (6)
	Randall 1967	1 (24)
Stoplight parrotfish	Randall 1967	1 (20)
Striped parrotfish	Nagelkerken *et al.* 2006	1 (26)
	Randall 1967	1 (9)
Threespot damselfish	Dromard *et al.* 2013	2 (33)
	Randall 1967	1 (18)
Yellowtail damselfish	Randall 1967	1 (42)
(54) Surface pelagics		23 (1,642)
Agulon	Randall 1967	1 (7)
Balao	Randall 1967	1 (9)
Ballyhoo	Berkeley and Houde 1978	1 (261)
	Randall 1965	1 (11)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Ballyhoo	Randall 1967	1 (39)
Flyingfish	Casazza 2008	10 (212)
	Lewis *et al.* 1962	1 (258)
	Lipskaya 1980	2 (414)
	Lipskaya 1980	1 (234)
	Van Noord *et al.* 2013	1 (11)
Halfbeak	Berkeley and Houde 1978	1 (98)
	Carr and Adams 1973	1 (77)
Houndfish	Randall 1967	1 (11)
(56) Oceanic planktivores		31 (1,565)
Argentine	Bowman *et al.* 2000	6 (76)
Armorhead	Seki and Somerton 1994	1 (221)
Hatchetfish	Hopkins and Baird 1985	4 (741)
	Merret and Roe 1974	6 (170)
Lanternfish	Alwis and Gjosaeter 1988	11 (331)
	Bowman *et al.* 2000	2 (19)
Luminous hake	Darnell 1991	1 (7)
(57) Sardine-herring-scad		51 (2,797)
Alabama shad	Mickle *et al.* 2013	1 (NA)
American shad	Bowman e tal 2000	1 (21)
Atlantic herring	Bowman e tal 2000	1 (108)
Atlantic thread herring	Gomez *et al.* 2004	1 (66)
Bigeye scad	Bowman *et al.* 2000	1 (10)
	Gomez *et al.* 2004	1 (93)
	Randall 1967	1 (12)
Blueback herring	Bowman e tal 2000	1 (9)
	Creed 1985	1 (103)
Dwarf round herring	Randall 1967	1 (18)
False pilchard	Randall 1967	1 (12)
Gizzard shad	Winemiller *et al.* 2007	1 (0)
Herring	McMichael Unknown	1 (447)
Mackerel scad	Gomez *et al.* 2004	1 (2)
	Randall 1967	1 (2)
Redear sardine	Nagelkerken *et al.* 2006	1 (6)
	Randall 1967	1 (24)
Rough scad	Bowman *et al.* 2000	1 (11)
	Darnell 1991	1 (23)
	Divita *et al.* 1983	1 (2)
Round herring	Bowman e tal 2000	1 (84)
Round sardinella	Gomez *et al.* 2004	1 (143)
Round scad	Bowman *et al.* 2000	1 (3)
	Divita *et al.* 1983	1 (3)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Round scad	DonaldsonClavijo 1994	1 (180)
	Hales 1986	3 (416)
	Randall 1967	1 (10)
Sardine	Carr and Adams 1973	2 (28)
	McMichael UNK	1 (220)
Sardinella	Divita *et al.* 1983	1 (1)
	Tsikliras *et al.* 2005	7 (87)
Scaled herring	Gomez *et al.* 2004	1 (30)
Scaled sardine	Motta 1995	1 (30)
	Odom and Heald 1972	1 (32)
	Vega Cendejas *et al.* 1994	1 (326)
Spanish sardine	Bowman e tal 2000	1 (8)
Thread herring	Carr and Adams 1973	3 (56)
	Randall 1967	1 (17)
	Vega Cendejas *et al.* 1994	1 (74)
	Vega Cendejas *et al.* 1997	1 (80)
(58-62) Menhaden		8 (723)
Finescale menhaden	Castillo Rivera *et al.* 1996	1 (100)
	Divita *et al.* 1983	1 (1)
Gulf menhaden	Castillo Rivera *et al.* 1996	1 (100)
	Deegan *et al.* 1990	1 (0)
	Matlock and Garcia 1983	1 (5)
	Weaver and Holloway 1974	1 (0)
	Winemiller *et al.* 2007	1 (0)
Menhaden	Govoni *et al.* 1983 1983	1 (517)
(63) Anchovy-silverside-killifish		62 (7,726)
Anchovy	Darnell 1958	5 (81)
	Odum and Heald 1972	1 (27)
Bay anchovy	Carr and Adams 1973	2 (73)
	Peebles and Hopkins 1993	7 (409)
	Sheridan 1978	1 (3,399)
	Weaver and Holloway 1974	1 (0)
Diamond killifish	Odum and Heald 1972	1 (28)
Goldspotted killifish	Ley *et al.* 1994	1 (334)
	Motta 1995	1 (30)
	Odum and Heald 1972	1 (81)
Gulf killifish	Alexander 1983	1 (73)
	Harrington and Harrington 1961	1 (90)
	Ley *et al.* 1994	1 (248)
	Minello *et al.* 1989	2 (44)
	Perschbacher and Strawn 1986 1986	1 (43)
	Rozas and LaSalle 1990	1 (104)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
Least killifish	Odum and Heald 1972	1 (22)
Longnose killifish	Bennett 1973	1 (318)
	Motta 1995	1 (30)
Marsh killifish	Harrington and Harrington 1961	1 (88)
Mosquitofish	Harrington and Harrington 1961	1 (400)
	Odum and Heald 1972	1 (87)
Rainwater killifish	Harrington and Harrington 1961	1 (400)
	Odum and Heald 1972	1 (74)
	Weaver and Holloway 1974	1 (0)
Reef silverside	Randall 1967	1 (14)
Sailfin molly	Weaver and Holloway 1974	1 (0)
Sheepshead minnow	Alexander 1983	1 (114)
	Harrington and Harrington 1961	1 (400)
	Odum and Heald 1972	1 (44)
Silverside	Bowman *et al.* 2000	1 (6)
	Carr and Adams 1973	7 (278)
	Darnell 1958	3 (55)
	Odum and Heald 1972	1 (108)
	Randall 1967	1 (9)
Striped anchovy	Bowman *et al.* 2000	1 (14)
	Carr and Adams 1973	4 (121)
	Motta 1995	1 (30)
Tidewater silverside	Alexander 1983	1 (50)
(64) Mullet		29 (2,972)
Grey mullet	Alexander 1983	1 (37)
	Blanco *et al.* 2003	2 (3)
	Collins 1981	2 (221)
	Eggold and Motta 1992	8 (200)
	Hadwen *et al.* 2007	1 (23)
	Harrington and Harrington 1961	1 (399)
	Kanou *et al.* 2004	2 (53)
	Larson and Shanks 1996	2 (20)
	Modou *et al.* 2014	1 (1,478)
	Odum 1970	1 (0)
	Platell *et al.* 2006	1 (46)
	Ramirez Luna *et al.* 2014	1 (43)
	Winemiller *et al.* 2007	1 (0)
White mullet	Austin and Austin 1971	1 (45)
	Gomez *et al.* 2004	1 (286)
	Larson and Shanks 1996	1 (9)
	Randall 1967	1 (13)
	Sanchez 2002	1 (96)

Table S1.1-Continued. Summary of diet studies used to develop the diet matrix.

Functional group/species	Reference	Observations (Stomachs)
(65) Butterfish		12 (873)
Butterfish	Bowman *et al.* 2000	6 (680)
	Darnell 1991	2 (86)
	Divita *et al.* 1983	1 (6)
	Horn 1970	1 (20)
	Mansueti 1963	1 (36)
	Oviatt and Kramer 1977	1 (45)

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Appendix 2 – menhaden plausible predators' analyses and data

Table S2.1. Summary of menhaden bycatch studies. At-sea studies report both releasable and landed bycatch. - indicates no data.

Study	Area	Sampled	Year	Months	Effort	Total Bycatch %W	%N	Notes
de Silva and Condrey (1998)	TX-MS	At-sea	1995	Apr - Oct	257 sets	-	0.17	
de Silva *et al.* (1996)	TX-MS	At-sea	1994	Jun - Oct	455 sets	0.66	1.51	Also discussed in de Silva (1998) dissertation
Condrey (1994)	LA-AL	At-sea	1992	Apr - Oct	49 sets	1.20	1.00	
Guillory and Hutton (1982)	LA	Plant	1980	Apr - Oct	24 trips	1.60	2.39	Large specimens (e.g., shark, crevalle jacks, etc.) were either removed from the catch during harvesting or unloading to prevent damage to the suction pumps or retained for personal consumption
	LA	Plant	1981	Apr - Oct	18 trips	3.10	2.96	
	LA	Plant	1980-81	Apr - Oct	42 trips	2.35	2.68	
Dunham (1972)	LA	Dock	1971	Jun – Oct	NA	-	0.05	Large species of fish usually removed from the catch during harvesting or unloading, since they caused damage to nets and/or unloading pumps or retained for personal consumption
	LA	Dock	1972	May - Jun	NA	2.00	-	

Table S2.1-Continued. Summary of menhaden bycatch studies. At-sea studies report both releasable and landed bycatch. - indicates no data.

Study	Area	Sampled	Year	Months	Effort	Total Bycatch		Notes
Christmas *et al.* (1960)	MS	At-sea	1958	Jun - Aug, Oct	62 sets	2.80	3.90	Larger species often excluded from samples (e.g., mackerel only in 5 samples but observed in 26 sets). Imperfect identification of the releasable bycatch (i.e., hard to ID fish in the net from the deck)
	MS	At-sea	1959	May	27 sets	2.80	3.90	
Stevens (1960)	TX-LA	Plant	1959-60	NA	NA	0.00	0.00	When game fish are taken in nets, they are often retained for personal consumption
Knapp (1950)	LA	At-sea	1948	Jun - Aug	17 hauls	-	0.06	Observer placed on single steamer (H. C. Dashiell)
Miles and Simmons (1950)	TX	At-sea	1949	Jun - Sep	143 sets	-	0.14	Observer placed on single steamer (Alfred E. Davies, Jr)
Simmons (1949)	LA	At-sea	1948	Jun - Aug	59 hauls	-	0.03	Observer placed on single steamer (H. C. Dashiell); discussed in Miles and Simmons (1950)

Table S2.2. Comparison of species composition and abundance (number or percentage where denoted with %N) across studies quantifying bycatch in the menhaden fishery. - indicates no data. Bycatch species have been organized according to the functional group in the Gulf-wide ecosystem model. Note that * under Christmas (1960) reference means that the species was observed in the nets but not in the samples.

Species	Scientific name	Simmons (1949)	Knapp (1950)	Breuer (1950)	Christ-mas (1960)	Condrey (1994) Release	de Silva and Condrey (1998)	Dun-ham (1972)	Condrey (1994) Retained (%N)	Guillory and Hutton (1982) (%N)
Dolphins										
Porpoise	Phocoenidae	-	-	-	-	5	-	-	-	-
Large coastal sharks										
Blacktip	*Carcharhinus limbatus*	-	-	-	*	-	184	-	-	-
Bull	*Carcharhinus leucas*	-	-	-	*	-	39	-	-	-
Requiem	*Carcharhinus* sp.	-	-	-	-	-	57	-	-	-
Sand	*Carcharias littoralis*	-	-	163	-	-	-	-	-	-
Hammerhead	*Sphyrna* sp.	-	-	13	-	-	-	-	-	-
Shark	*Elasmobranch*	63	63	-	-	201	-	7	-	0.4
Small coastal sharks										
Bonnethead	*Sphyrna tiburo*	-	-	26	*	-	-	-	-	-
Pelagic coastal piscivores										
Blue runner	*Caranx crysos*	-	-	8	-	-	-	-	-	-
Crevalle jack	*Caranx hippos*	-	-	91	*	246	349	2	-	0.2
Bluefish	*Pomatomus saltatrix*	42	42	304	3	3	-	7	0.3	0.4
Atlantic needlefish	*Strongylura marina*	-	-	3	-	2	-	-	-	-
King mackerel	*Scomberomorus cavalla*	-	-	1	-	4	-	-	-	0.1
Spanish mackerel	*Scomberomorus maculatus*	107	47	205	5	101	241	10	0.9	1
Coastal piscivores										
Ladyfish	*Elops saurus*	-	-	-	-	5	-	-	-	0.3
Atlantic tarpon	*Megalops Atlanticus*	5	5	13	*	-	-	-	-	-
Sea trout										
Sand seatrout	*Cynoscion arenarius*	-	-	-	83	69	-	-	3.1	-

Table S2.2-Continued. Comparison of species composition and abundance (number or percentage where denoted with %N) across studies quantifying bycatch in the menhaden fishery. - indicates no data. Bycatch species have been organized according to the functional group in the Gulf-wide ecosystem model. Note that * under Christmas (1960) reference means that the species was observed in the nets but not in the samples.

Species	Scientific name	Simmons (1949)	Knapp (1950)	Breuer (1950)	Christ-mas (1960)	Condrey (1994) Release	de Silva and Condrey (1998)	Dun-ham (1972)	Condrey (1994) Retained (%N)	Guillory and Hutton (1982) (%N)
Spotted seatrout	*Cynoscion nebulosus*	2	2	3	7	19	-	5	-	2.2
Silver trout	*Cynoscion nothus*	-	-	242	70	29	-	-	6	-
Seatrout	*Cynoscion* sp.	77	77	-	-	-	3,507	11	-	19.7
Oceanic piscivores										
Largehead hairtail	*Trichiurus lepturus*	72	-	247	13	86	470	7	0.9	1.3
Benthic piscivores										
Southern flounder	*Paralichthys lethostigma*	-	3	-	*	-	-	-	-	-
Fourspotted flounder	*Paralichthys oblongus*	-	-	2	-	-	-	-	-	-
Flounder	*Paralichthys* sp.	7	-	5	-	-	-	7	-	-
Inshore lizardfish	*Synodus foetens*	-	-	1	-	-	-	-	-	-
Skates and Rays										
Spotted eagle ray	*Aetobatus narinari*	-	1	1	-	-	-	-	-	-
Atlantic stingray	*Dasyatis sabina*	-	12	9	2	-	-	-	-	0.1
Stingrays	*Dasyatis* sp.	13	-	-	-	-	-	-	-	-
Smooth butterfly ray	*Gymnura micrura*	-	-	9	0	-	-	-	-	-
Skate	*Raja* sp.	-	-	-	-	-	-	4	-	-
Texas clearnose skate	*Raja texana*	-	-	-	1	-	-	-	-	-
Cownose ray	*Rhinoptera bonasus*	-	-	24	*	25	70	37	-	0.1
Grouper										
Atlantic goliath grouper	*Epinephelus itajara*	-	-	-	*	-	-	-	-	-
Demersal coastal invertebrate feeders										
Red drum	*Sciaenops ocellatus*	1	1	-	-	15	245	-	-	-
Catfish	*Ariidae*	-	-	-	-	-	1,002	-	-	-
Gafftopsail catfish	*Bagre marina*	3	3	36	85	825	-	33	5.3	1.1

Table S2.2-Continued. Comparison of species composition and abundance (number or percentage where denoted with %N) across studies quantifying bycatch in the menhaden fishery. - indicates no data. Bycatch species have been organized according to the functional group in the Gulf-wide ecosystem model. Note that * under Christmas (1960) reference means that the species was observed in the nets but not in the samples.

Species	Scientific name	Simmons (1949)	Knapp (1950)	Breuer (1950)	Christ-mas (1960)	Condrey (1994) Release	de Silva and Condrey (1998)	Dun-ham (1972)	Condrey (1994) Retained (%N)	Guillory and Hutton (1982) (%N)
Hardhead catfish	*Galeichthys felis*	3	-	18	83	95	-	118	4.7	8.3
Southern kingcroaker	*Menticirrhus americanus*	-	-	-	18	-	-	6	-	0.2
Northern kingfish	*Menticirrhus focaliger*	-	-	-	1	-	-	-	-	-
Gulf kingcroaker	*Menticirrhus littoralis*	-	-	-	10	-	-	-	-	-
Kingcroaker	*Menticirrhus* sp.	7	7	8	-	-	-	-	-	-
Black drum	*Pogonias cromis*	3	3	-	-	19	-	3	-	-
Benthic coastal invertebrate feeders										
Polka-dot batfish	*Ogcocephalus radiatus*	-	-	8	-	-	-	-	-	-
Crested cusk-eel	*Ophidion welshi*	-	-	-	-	-	-	1	-	-
Southern hake	*Urophycis floridana*	-	-	-	*	-	-	-	-	-

Table S2.3. Potential predators of menhaden in the Gulf of Mexico and justifications (e.g., percent contribution of fish to total predator diet, taxonomic resolution at which potential menhaden consumption has been reported, and co-occurrence in menhaden bycatch). Atl refers to observations of predation on *Brevoortia tyrannus* and Gulf refers to *Brevoortia patronus*. Species groups are defined in Table 1. References by species and prey item are provided in Table S2.4.

Predator	Fish (% diet)	Reported Predation on… Atl	Gulf	*Brevoortia* sp	Clupeid	PS Bycatch	Plausible predator of menhaden?
Coastal dolphins	79	X	X	X	X		Yes - *B. patronus* predation
Sea birds	67	X	X	X	X		Yes - *B. patronus* predation
Sea turtles	23	X					Yes? - *Brevoortia* sp. predation in Atlantic (assumed interaction could occur in GOM)
Blacktip shark	88	X	X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Dusky shark	77			X	X	X?	Yes - *Brevoortia* sp. predation and possibly present in purse seine bycatch ("Carcharhinidae")
Sandbar shark	63	X		X	X	X?	Yes - *Brevoortia* sp. predation and possibly present in purse seine bycatch ("Carcharhinidae")
Large coastal sharks	78	X	X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Large oceanic sharks	80	X			X		Yes? - *Brevoortia* sp. predation in Atlantic (assumed interaction could occur in GOM)
Atlantic sharpnose shark	64		X	X	X		Yes - *B. patronus* predation
Small coastal sharks	44	X	X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Yellowfin tuna	76	X			X		Yes? - *Brevoortia* sp. predation in Atlantic (assumed interaction could occur in GOM)
Bluefin tuna	77	X			X		Yes? - *Brevoortia* sp. predation in Atlantic (assumed interaction could occur in GOM)
Other tunas	78				X		No? - clupeids probably refer to offshore species?
Billfish	76			X	X		Yes? - *Brevoortia* sp. predation
Swordfish	59	X					Yes? - *Brevoortia* sp. predation in Atlantic (assumed interaction could occur in GOM)

Table S2.3-Continued. Potential predators of menhaden in the Gulf of Mexico and justifications (e.g., percent contribution of fish to total predator diet, taxonomic resolution at which potential menhaden consumption has been reported, and co-occurrence in menhaden bycatch). Atl refers to observations of predation on *Brevoortia tyrannus* and Gulf refers to *Brevoortia patronus*. Species groups are defined in Table 1. References by species and prey item are provided in Table S2.4.

Predator	Fish (% diet)	Predation		*Brevoortia* sp	Clupeid	PS Bycatch	Plausible predator of menhaden?
		Atl	Gulf				
Amberjacks	75				X		No? - clupeids probably refer to offshore species?
Cobia	60	X	X	X	X		Yes - *B. patronus* predation
King mackerel (0-1 yr)	80				X	X	Yes - present inshore, with feeding habits assumed similar to adults
King mackerel (1+ yr)	74	X	X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Spanish mackerel (0-1yr)	79		X		X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Spanish mackerel (1+ yr)	82	X	X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Pelagic coastal piscivores	68	X	X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Coastal piscivores	51		X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Sea trout	43		X	X	X	X	Yes - *B. patronus* predation and present in purse seine bycatch
Oceanic piscivores	61				X	X	Yes? - consumes "clupeids" and present in purse seine bycatch (multiple studies)
Benthic piscivores	62			X	X	X	Yes? - *Brevoortia* sp. predation and present in purse seine bycatch
Reef piscivores	48				X		No? – clupeid likely refers to reef species
Skates-Rays	38					X	No? – bycatch likely incidental (no evidence of predation)
Gag grouper (0-3 yr)	67		X		X		Yes - *B. patronus* predation
Gag grouper (3+ yr)	70		X		X		Yes - *B. patronus* predation
Red grouper	58				X		No - clupeid likely refers to reef fish

Table S2.3-Continued. Potential predators of menhaden in the Gulf of Mexico and justifications (e.g., percent contribution of fish to total predator diet, taxonomic resolution at which potential menhaden consumption has been reported, and co-occurrence in menhaden bycatch). Atl refers to observations of predation on *Brevoortia tyrannus* and Gulf refers to *Brevoortia patronus*. Species groups are defined in Table 1. References by species and prey item are provided in Table S2.4.

Predator	Fish (% diet)	Predation		*Brevoortia* sp	Clupeid	PS Bycatch	Plausible predator of menhaden?
		Atl	Gulf				
Goliath grouper	50					X	No? - bycatch likely incidental
Shallow-water grouper	56				X		No - clupeid likely refers to reef fish
Deep-water grouper	44				X		No - clupeid likely refers to reef fish
Tilefish	17	X			X		No? - *Brevoortia* sp. predation in Atlantic, but assumed deeper in GOM
Red snapper (0-1 yr)	55				X		No? - no evidence of consumption of *Brevoortia* sp.
Red snapper (1-2 yr)	55				X		No? - clupeid likely refers to non-*Brevoortia* sp.
Red snapper (3+ yr)	51						No? - clupeid likely refers to non-*Brevoortia* sp.
Vermilion snapper	18				X		No? - clupeid likely refers to reef species
Other snapper	41			X			Yes? - *Brevoortia* sp. predation by gray snapper
Red drum	45		X	X		X	Yes - *B. patronus* predation and present in purse seine bycatch
Demersal coastal invertebrate feeders	1		X	X	X	X	Yes? - *B. patronus* predation and present in purse seine bycatch
Benthic coastal invertebrate feeders	1		X			X	Yes? - *B. patronus* predation, but is this a rare event?
Reef invertebrate feeders	2					X	No - predation unlikely
Coastal omnivores	1					X	No - predation unlikely
Anchovy-silversides-killifish	<1		X			X	No - predation unlikely (consumption of menhaden likely detritus)

Table S2.4. Associated references documenting predation of Menhaden or unidentified clupeids. References can be found in the Appendix 1 reference list. Regions shown in parentheses when outside the Gulf of Mexico (Atl = Atlantic, Pac = Pacific).

Predator	*Brevoortia* sp. references	Clupeid references
Coastal dolphins		
Bottlenose dolphin (*Tursiops truncatus*)	Leatherwood *et al.* 1975; Barros and Odell 1990; Barros 1992; Barros and Wells 1998; Leatherwood *et al.* 1978 (Atl); Mead and Potter 1990 (Atl); Barros 1993 (Atl); Gannon and Waples 2004 (Atl); Bowen 2011 (Atl); Pate and McFee 2012 (Atl)	Barros 1992; Barros and Wells 1998; Mead and Potter 1990 (Atl); Barros 1993 (Atl); Santos *et al.* 2007 (Atl)
Seabirds		
Osprey (*Pandion haliaetus*)	McLean and Byrd 1991 (Atl); Glass and Watts 2009 (Atl)	Glass and Watts 2009 (Atl)
Black skimmer (*Rynchops niger*)	Mariano *et al.* 2007 (Atl); King 1989b	-
Brown pelican (*Pelecanus occidentalis*)	Fogarty *et al.* 1981	-
Double-crested cormorant (*Phalacrocorax auritus*)	Withers and Brooks 2004	Anderson *et al.* 2004 (Pac)
Neotropical cormorant (*Phalacrocorax olivaceous*)	King 1989a	-
Common tern (*Sterna hirundo*)	Bugoni and Vooren 2004 (Atl)	-
Common loon *Gavia immer*	GSMFC 2015	
Sea turtles		
Loggerhead (*Caretta caretta)*	Seney and Musick 2007 (Atl)	-
Kemp's ridley (*Lepidochelys kempi*)	Seney 2003 (Atl)	-
Blacktip shark (*Carcharhinus limbatus*)	Hueter 1994; de Silva 2001; Hoffmayer and Parsons 2003; Bethea *et al.* 2004; Barry *et al.* 2008; Wrast 2008; Castro 1996 (Atl); Gurshin 2005 (Atl)	Heupel and Heuter 2002
Dusky shark (*Carcharhinus obscurus*)	Clark and von Schmidt 1965; de Silva 2001	Smale 1991 (Atl); Bowman *et al.* 2000 (Atl); Hussey *et al.* 2011 (Atl); FWRI FIM diet database
Sandbar shark (*Carcharhinus plumbeus*)	Clark and von Schmidt 1965; de Silva 2001; Medved *et al.* 1985 (Atl); McElroy 2009 (Atl); Ellis and Musick 2007 (Atl)	Stillwell and Kohler 1993 (Atl); McElroy 2009 (Atl); Ellis and Musick 2007 (Atl)
Other large coastal sharks		
Bull shark (*Carcharhinus leucas*)	Darnell 1958; de Silva 2001; Snelson *et al.* 1984 (Atl)	-

Table S2.4-Continued. Associated references documenting predation of Menhaden or unidentified clupeids. References can be found in the Appendix 1 reference list. Regions shown in parentheses when outside the Gulf of Mexico (Atl = Atlantic, Pac = Pacific).

Predator	*Brevoortia* sp. references	Clupeid references
Spinner shark (*Carcharhinus brevipinna*)	de Silva 2001; Bethea *et al.* 2004; Avendano-Alvares *et al.* 2013	Stevens and McLoughlin 1991 (Pac)
Silky shark (*Carcharhinus falciformis*)	de Silva 2001; Bowman *et al.* 2000 (Atl)	-
Requiem shark (*Carcharhinus* sp.)	Knapp 1950	-
Sand tiger shark (*Carcharias taurus*)	Clark and von Schmidt 1965; Gelsleichter *et al.* 1999 (Atl)	-
Scalloped hammerhead (*Sphyrna lewini*)	Bethea *et al.* 2011	Stevens and Lyle 1989 (Pac); Hussey *et al.* 2011 (Atl)
Great hammerhead (*Sphyrna mokarran*)	Hueter 1994	-
Large oceanic sharks		
Shortfin mako (*Isurus oxyrinchus)*	Stillwell and Kohler 1982 (Atl); Bowman *et al.* 2000 (Atl); Wood *et al.* 2009 (Atl)	Maia *et al.* 2006 (Atl)
Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)	Clark and von Schmidt 1965; Barry 2002; Hoffmayer and Parsons 2003; Bethea *et al.* 2004, 2006; McCallister 2012 (Atl)	Clark and von Schmidt 1965; Davis 2010; Gelsleichter *et al.* 1999 (Atl); Bowman *et al.* 2000 (Atl)
Other small coastal sharks		
Blacknose shark (*Carcharhinus acronotus*)	Ford 2012 (Atl)	-
Finetooth shark (*Carcharhinus isodon*)	de Silva 2001; Hoffmayer and Parsons 2003; Bethea *et al.* 2004; Castro 1993 (Atl); Gurshin 2005 (Atl)	-
Smooth dogfish (*Mustelus canis*)	McElroy 2009 (Atl)	Bowman *et al.* 2000 (Atl)
Dogfish (Squalidae)	Baughman and Springer 1950	-
Yellowfin tuna (*Thunnus albacares*)	Rudershausen *et al.* 2010 (Atl)	Manooch and Mason 1983; Olson *et al.* 2014 (Pac)
Bluefin tuna (*Thunnus thynnus*)	Chase 2002 (Atl); Butler 2007 (Atl)	Orsi Relini *et al.* 1995 (Atl); Sinopoli *et al.* 2004 (Atl); Karakulak *et al.* 2009 (Atl)
Other tunas		
Blackfin tuna (*Thunnus Atlanticus*)	-	Manooch and Mason 1983
Skipjack tuna (*Katsuwonus pelamis*)	-	Dragovich and Potthoff 1972 (Atl)

Table S2.4-Continued. Associated references documenting predation of Menhaden or unidentified clupeids. References can be found in the Appendix 1 reference list. Regions shown in parentheses when outside the Gulf of Mexico (Atl = Atlantic, Pac = Pacific).

Predator	*Brevoortia* sp. references	Clupeid references
Billfish		
Sailfish (*Istiophorus nigricans*)	Knapp 1950	
Blue marlin (*Makaira nigricans*)		Abitia-Cardenas *et al.* 1999 (Pac)
Swordfish (*Xiphias gladius*)	Stillwell and Kohler 1985 (Atl); Bowman *et al.* 2000 (Atl)	-
Greater amberjack (*Seriola dumerili*)	-	Manooch and Haimovici 1983 (Atl); Badalamenti *et al.* 1995 (Atl); Matallanas *et al.* 1995 (Atl)
Cobia (*Rachycentron canadum*)	Meyer and Franks 1996; Arendt *et al.* 2001 (Atl)	Meyer and Franks 1996; Arendt *et al.* 2001 (Atl); FWRI FIM diet database
King mackerel (*Scomberomorus cavalla*)	Knapp 1950; Miles 1949; Kemp 1950; DeVane 1978; Saloman and Naughton 1983a	Beaumariage 1973; McMichael 1981; Finucane *et al.* 1990; Menezes 1969 (Atl); Naughton and Saloman 1981 (Atl); Blanton *et al.* 1972; Florida Fish and Wildlife Conservation Commission 2012; FWRI FIM diet database
Spanish mackerel (*Scomberomorus maculatus*)	Knapp 1950; Kemp 1950; Naughton and Saloman 1981; Saloman and Naughton 1983b	Naughton and Saloman 1981; Finucane *et al.* 1990; Klima 1959 (Atl); FWRI FIM diet database
Pelagic coastal piscivores		
Little tunny (*Euthynnus alletteratus*)	Manooch *et al.* 1985	Manooch *et al.* 1985
Crevalle jack (*Caranx hippos*)	Saloman and Naughton 1984	Saloman and Naughton 1984; FWRI FIM diet database
Bluefish (*Pomatomus saltatrix*)	Naughton and Saloman 1984; Bowman *et al.* 2000 (Atl); Gartland *et al.* 2006 (Atl)	Buckel *et al.* 1999 (Atl); FWRI FIM diet database
Coastal piscivores		
Ladyfish (*Elops saurus*)	Sekavec 1974	Reid 1955
Common Snook (*Centropomus undecimalis*)	Blewett *et al.* 2006; FWRI FIM diet database	Blewett *et al.* 2006; Adams *et al.* 2009; Rock 2009; FWRI FIM diet database

Table S2.4-Continued. Associated references documenting predation of Menhaden or unidentified clupeids. References can be found in the Appendix 1 reference list. Regions shown in parentheses when outside the Gulf of Mexico (Atl = Atlantic, Pac = Pacific).

Predator	*Brevoortia* sp. references	Clupeid references
Tarpon (*Megalops Atlanticus*)	Knapp 1950	-
Seatrouts		
Sand seatrout (*Cynoscion arenarius*)	Reid *et al.* 1954; Moffett *et al.* 1979; Kasprzak and Guillory 1984; Wrast 2008	Darnell 1958; FWRI FIM diet database
Spotted seatrout (*Cynoscion nebulosus*)	Gunter 1945; Knapp 1950; Day 1960; Seagle 1969; Rogillio 1975; Overstreet and Heard 1982; Russell 2005; Wrast 2008; Simonsen and Cowan 2013; Tabb 1961 (Atl)	Miles 1949; FWRI FIM diet database
Oceanic piscivores		
Cutlassfish (*Trichiurus lepturus*)	-	Portsev 1980 (Indian)
Offshore hake (*Merluccius albidus*)	-	Rohr and Gutherz 1977
Benthic piscivores		
Southern flounder (*Paralichthys lethostigma*)	Knapp 1950	Diener *et al.* 1974
Gulf flounder (*Paralichthys albigutta*)	-	FWRI FIM diet database
Inshore lizardfish (*Synodus foetens*)	-	Sheridan 2008; Hildebrand 1954; FWRI FIM diet database
Sand diver (*Synodus intermedius*)	-	FWRI FIM diet database
Snakefish (*Trachinocephalus myops*)	-	FWRI FIM diet database
Reef piscivores		
Great barracuda (*Sphyraena barracuda*)	-	Randall 1967 (Caribbean); FWRI FIM diet database
Northern sennet (*Sphyraena borealis*)	-	FWRI FIM diet database
Gag grouper (*Mycteroperca microlepis*)	Naughton and Saloman 1985; Bullock and Smith 1991; Weaver 1996	Naughton and Saloman 1985; Weaver 1996
Red grouper (*Epinephelus morio*)	-	Weaver 1996; FWRI FIM diet database
Goliath grouper (*Epinephelus itajara*)	-	Koenig and Coleman 2009

Table S2.4-Continued. Associated references documenting predation of Menhaden or unidentified clupeids. References can be found in the Appendix 1 reference list. Regions shown in parentheses when outside the Gulf of Mexico (Atl = Atlantic, Pac = Pacific).

Predator	*Brevoortia* sp. references	Clupeid references
Other shallow-water grouper		FWRI FIM diet database
Scamp (*Mycteroperca phenax*)		
Deep-water grouper		
Snowy grouper (*Hyporthodus niveatus*)	-	Bielsa and Labinsky 1987 (Atl)
Tilefish		
Northern tilefish (*Lopholatilus chamaeleonticeps*)	Freeman and Turner 1977 (Atl)	-
Blueline tilefish (*Caulolatilus microps*)	-	Bielsa and Labinsky 1987 (Atl)
Red snapper (*Lutjanus campechanus*)	-	Futch and Bruger 1976; Sheridan 2008; FWRI FIM diet database
Vermilion snapper (*Rhomboplites aurorubens*)	-	FWRI FIM diet database
Other snapper		
Gray snapper (*Lutjanus griseus*)	FWRI FIM diet database	FWRI FIM diet database
Red drum (*Sciaenops ocellatus*)	Knapp 1950; Simmons and Breuer 1962; Boothby and Avault 1971; Scharf and Schlicht 2000	-
Demersal coastal invertebrate feeders		
Black drum (*Pogonias cromis*)	Diener *et al.* 1974	-
Silver perch (*Bairdiella chrysoura*)	Wrast 2008	-
King croaker (*Menticirrhus* sp.)	Knapp 1950	-
Atlantic croaker (*Micropogonias undulatus*)	Reid 1955	Diener *et al.* 1974; Fontenot and Rogillio 1970
Spot croaker (*Leiostomus xanthurus*)	Matlock and Garcia 1983	-
Gafftopsail catfish (*Bagre marinus*)	Knapp 1950; Wrast 2008	Ruderhausen and Locascio 2001
Hardhead catfish (*Ariopsis felis*)	Knapp 1950; Wrast 2008	-
Benthic coastal invertebrate feeders		
Southern codling (*Urophycis floridana*)	Diener *et al.* 1974	

Table S2.4-Continued. Associated references documenting predation of Menhaden or unidentified clupeids. References can be found in the Appendix 1 reference list. Regions shown in parentheses when outside the Gulf of Mexico (Atl = Atlantic, Pac = Pacific).

Predator	*Brevoortia* sp. references	Clupeid references
Atlantic threadfin (*Polydactylus octonemus*)	Diener *et al.* 1974	-
Reef invertebrate feeders		
Bank sea bass (*Centropristis ocyurus*)	-	FWRI FIM diet database
Black sea bass (*Centropristis striata*)	-	FWRI FIM diet database
Knobbed porgy (*Calamus nodusus*)	-	Nelson 1988
Cottonwick grunt (*Haemulon melanurum*)	-	Nelson 1988
Gulf toadfish (*Opsanus beta*)	-	Diener *et al.* 1974
Yellowtail snapper (*Ocyurus chrysurus*)	-	Rincon-Sandoval *et al.* 2009
Lane snapper (*Lutjanus synagris*)	-	FWRI FIM diet database
Coastal omnivores		
Least puffer (*Sphoeroides parvus*)	-	Diener *et al.* 1974
Anchovies-silversides-killifish		
Gulf killifish (*Fundulus grandis*)	Rozas and LaSalle 1990	-
Inland silverside (*Menidia beryllina*)	Levine 1980	-

Appendix 3 – Ecosim calibration parameters

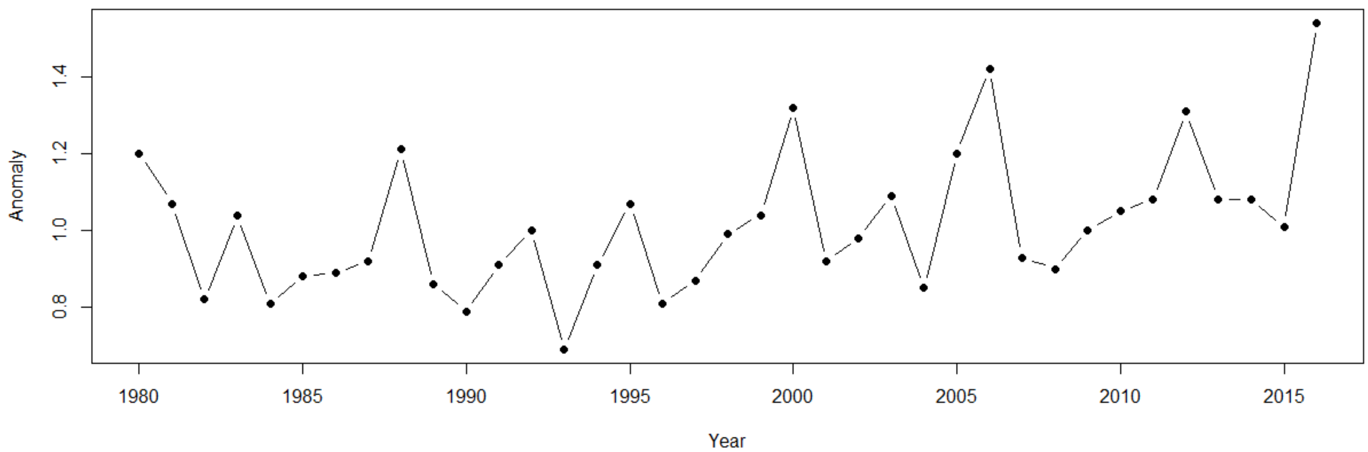

Figure S3.1. Primary Production (PP) anomaly time series. PP anomaly represents the temporal variation in the system's primary productivity. PP anomaly is produced by the Ecosim's automatic fitting routine based on minimizing the SSE using an iterative search algorithm (Christensen *et al.*, 2005).

Table S3.1. Predation Vulnerability matrix from the base Ecosim run. Columns and rows represent predators and prey, respectively.

Prey \ predator	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Coastal dolphins	-	-	-	-	-	2	2	2	2	-	-	-	-
2 Offshore dolphins	-	-	-	-	-	2	2	-	-	2	-	-	-
3 Baleen whales	-	-	-	-	-	-	-	-	-	2	-	-	-
4 Seabird	-	-	-	2	-	-	2	-	2	2	-	-	-
5 Sea turtle	-	-	-	-	-	-	2	-	2	2	-	-	-
6 Blacktip shark	-	-	-	-	-	2	2	2	2	2	-	-	-
7 Dusky shark	-	-	-	-	-	2	2	2	2	2	-	-	-
8 Sandbar shark	-	-	-	-	-	2	2	2	2	2.67	-	-	-
9 Large coastal sharks	-	-	-	-	-	2	2	2	2	2	-	-	2
10 Large oceanic sharks	-	-	-	-	-	-	2	2	6.14	1.05	-	-	-
11 Atlantic sharpnose shark	2	-	-	-	2	2	2	2	2	2	5.6	2	-
12 Small coastal sharks	2	-	-	-	2	2	2	2	2	2	2	2	-
13 Yellowfin tuna	-	-	-	-	-	10.01	1.05	2	1.1	2	-	-	1.05
14 Bluefin tuna	-	-	-	-	-	2	2	2	2	2	-	-	1.05
15 Other tunas	-	-	-	-	-	2	2	2	1.1	2	-	-	1.05
16 Billfish	-	-	-	-	-	-	2	-	2	2	-	-	5.68
17 Swordfish	-	-	-	-	-	-	1.05	-	1.1	5.65	-	-	15.96
18 Pelagic coastal piscivores	2	2	2	2	2	2	2	2	2	2	2	2	22.7
19 Amberjack	2	2	-	2	2	2	2	2	2	2	2	2	2
20 Cobia	2	2	-	-	-	2	2	2	2	2	2	2	2
21 King mackerel (0-1yr)	2	-	-	2	-	2	2	2	2	2	2	2	2
22 King mackerel (1+yr)	2	2	-	-	-	2	2	2	2	2	2	2	2
23 Spanish mackerel (0-1yr)	2	-	-	2	-	2	2	2	2	2	2	2	2
24 Spanish mackerel (1+yr)	2	2	-	-	-	5.17	2	2	2	2	2	2	57.52
25 Skates-rays	2	2	-	-	2	2	2	2	2	2	2	2	-
26 Gag grouper (0-3yr)	-	-	-	2	-	2	2	-	2	-	-	-	2
27 Gag grouper (3+yr)	-	-	-	-	-	2	2	-	2	-	-	-	2
28 Red grouper (0-3yr)	-	-	-	2	-	2	2	-	12.41	-	-	-	2
29 Red grouper (3+yr)	-	-	-	-	-	2	2	-	2	-	-	-	2
30 Yellowedge grouper (0-3yr)	-	-	-	-	-	-	2	-	2	-	-	-	-
31 Yellowedge grouper (3+yr)	-	-	-	-	-	-	2	-	2	-	-	-	2
32 Goliath grouper	-	-	-	2	-	2	2	-	2	-	-	-	2
33 Deep-water grouper	-	-	-	-	-	-	2	-	2	-	-	-	2
34 Shallow-water grouper	-	-	-	2	-	2	2	-	2	-	-	2	2
35 Red snapper (0yr)	-	-	-	-	-	2	-	2	2	-	2	-	2
36 Red snapper (1-2yr)	-	-	-	-	-	2	-	2	2	-	2	-	2
37 Red snapper (3+yr)	-	-	-	-	-	2	-	2	2	2	2	-	2
38 Vermilion snapper	-	-	-	-	-	2	-	2	2	2	2	-	2
39 Mutton snapper	-	-	-	-	-	2	-	2	2	2	2	-	2
40 Other snapper	-	-	-	-	-	2	-	2	2	2	2	-	2
41 Coastal piscivores	1.05	-	-	1.05	2	2	2	2	2	2	2	2	-
42 Sea trout	2	-	-	2	2	6.36	2	2	2	-	2	2	-
43 Oceanic piscivores	2	2	-	2	-	1.05	2	2	2	31.44	1.05	2	1.05
44 Benthic piscivores	2	-	-	2	2	2	2	2	2	2	2	2	2
45 Reef piscivores	-	-	-	-	-	2	2	2	2	2	1.05	2	2
46 Reef invertebrate feeders	2	-	-	2	2	2	2	2	2	2	2	2	2
47 Demersal coastal invertebrate feeders	2	-	-	2	2	2	2	2	2	2	2	2	2
48 Red drum	2	-	-	-	-	2	-	-	2	-	2	-	-
49 Benthic coastal invertebrate feeders	2	-	-	2	2	2	2	2	2	2	2	2	2
50 Tilefish	-	-	-	-	-	-	-	-	-	2	-	-	1.05
51 Gray triggerfish	2	-	-	-	-	2	2	2	2	2	-	-	2
52 Coastal omnivores	2	-	-	2	-	2	2	2	2	2	2	2	252.55
53 Reef omnivores	2	-	-	2	-	2	2	2	2	2	-	2	158.05
54 Surface pelagics	2	2	-	2	-	2	2	2	2	147.88	-	-	1.05
55 Large oceanic planktivores	-	-	-	-	-	-	-	-	2	2	-	-	2
56 Oceanic planktivores	2	2	2	2	2	2	2	2	2	2	-	-	16.89
57 Sardine-herring-scad	25.02	32.4	2	16.27	2	33.7	2	2	2	376.34	1.05	2	1357.8
58 Menhaden (0yr)	-	-	-	2	-	-	-	-	-	-	-	-	-
59 Menhaden (1yr)	2	-	-	2	2	2	2	2	2	-	2	2	-
60 Menhaden (2yr)	2	-	-	2	2	2	2	2	2	2	2	2	2
61 Menhaden (3yr)	2	-	-	2	2	2	2	2	2	2	2	2	2
62 Menhaden (4+yr)	2	-	-	2	2	2	2	2	2	2	2	2	2
63 Anchovy-silverside-killifish	2	2	2	2	2	1.05	2	1.1	2	1.05	2	2	2
64 Mullet	2	-	-	2	2	2	2	2	2	2	2	2	2
65 Butterfish	2	2	2	2	2	2	2	2	2	2	2	2	2
66 Cephalopod	2	1.05	1.05	48.59	2	2	2	2	2	318.73	1.05	2	2997.78
67 Pink shrimp	2	-	-	2	2	2	2	2	2	2	2	2	2
68 Brown shrimp	2	-	-	2	2	2	2	2	2	2	2	2	2
69 White shrimp	2	-	-	2	2	2	2	2	2	2	2	2	2
70 Crab	2	-	-	2	2	2	2	2	2	2	2	2	2
71 Sessile epifauna	-	-	-	2	2	-	2	2	2	2	2	2	2
72 Mobile epifauna	2	-	2	2	2	2	2	1.1	2	2	1.05	2	2
73 Zooplankton	2	2	2	2	2	2	2	2	2	2	2	2	2
74 Infauna	2	-	-	2	2	2	2	2	2	2	1.05	2	2
75 Algae	2	-	-	-	2	2	-	2	2	2	2	2	2
76 Seagrass	-	-	-	2	2	2	2	2	2	2	2	2	2
77 Phytoplankton	-	-	-	-	-	-	-	-	-	-	-	-	-
78 Detritus	2	2	-	2	-	1.05	2	2	2	1E+10	1.05	2	1.1

Table S3.1-Continued. Predation Vulnerability matrix from the base Ecosim run. Columns and rows represent predators and prey, respectively.

Prey \ predator	14	15	16	17	18	19	20	21	22	23	24	25	26
1 Coastal dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-
2 Offshore dolphins	-	2	-	-	-	-	-	-	-	-	-	-	-
3 Baleen whales	-	-	-	-	-	-	-	-	-	-	-	-	-
4 Seabird	-	-	-	-	-	-	-	-	-	-	-	-	-
5 Sea turtle	-	-	2	-	-	-	-	-	-	-	-	-	-
6 Blacktip shark	-	-	-	-	-	-	-	-	-	-	-	-	-
7 Dusky shark	-	-	-	-	-	-	-	-	-	-	-	-	-
8 Sandbar shark	-	-	-	-	-	-	-	-	-	-	-	-	-
9 Large coastal sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
10 Large oceanic sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
11 Atlantic sharpnose shark	-	-	-	-	-	-	-	-	-	-	-	-	-
12 Small coastal sharks	2	-	-	2	-	-	2	-	-	-	-	-	-
13 Yellowfin tuna	2	1.05	2	19.86	20.21	-	1.05	-	10.66	-	-	-	-
14 Bluefin tuna	2	2	2	1.05	-	-	2	-	2	-	-	-	-
15 Other tunas	2	2	1.05	1.05	2	-	2	-	2	-	-	-	-
16 Billfish	-	2	2	-	2	-	-	-	-	-	-	-	-
17 Swordfish	-	2	2	-	-	-	-	-	-	-	-	-	-
18 Pelagic coastal piscivores	2	2	1.05	1.05	2	2	2	-	2	-	2	2	-
19 Amberjack	2	2	2	2	2	2	2	-	2	-	2	2	-
20 Cobia	2	2	2	2	2	2	2	-	2	-	2	2	-
21 King mackerel (0-1yr)	2	2	2	2	2	2	2	-	2	-	2	2	-
22 King mackerel (1+yr)	2	2	2	2	1.05	2	2	-	-	-	1.05	-	-
23 Spanish mackerel (0-1yr)	2	2	2	2	2	1.01	2	-	2	-	2	2	-
24 Spanish mackerel (1+yr)	2	2	2	2	2	2	2	-	2	-	-	-	-
25 Skates-rays	2	-	-	2	-	1.01	2	-	-	-	-	2	-
26 Gag grouper (0-3yr)	2	2	2	-	2	2	2	-	2	-	-	-	2
27 Gag grouper (3+yr)	2	2	2	-	2	1.59	2	-	2	-	-	-	-
28 Red grouper (0-3yr)	2	2	2	-	2	1.1	2	-	2	-	-	-	2
29 Red grouper (3+yr)	2	2	2	-	4.05	1.36	2	-	2	-	-	-	-
30 Yellowedge grouper (0-3yr)	2	2	2	-	-	2	-	-	-	-	-	-	2
31 Yellowedge grouper (3+yr)	2	2	2	-	1.05	1.91	2	-	-	-	-	-	-
32 Goliath grouper	2	2	2	-	2	2	2	-	2	-	-	-	2
33 Deep-water grouper	2	2	2	-	2	2	2	-	-	-	-	-	-
34 Shallow-water grouper	2	2	2	-	2	1.08	1.05	-	2	-	-	-	2
35 Red snapper (0yr)	-	2	2	-	2	2	2	-	2	-	-	2	-
36 Red snapper (1-2yr)	-	2	2	-	2	2	2	-	2	-	-	2	-
37 Red snapper (3+yr)	-	2	2	-	2	2	2	-	2	-	-	2	-
38 Vermilion snapper	-	2	2	-	2	2	-	-	2	-	-	2	2
39 Mutton snapper	-	2	2	-	2	2	-	-	2	-	-	2	2
40 Other snapper	-	2	2	-	2	1.09	-	-	2	-	-	2	2
41 Coastal piscivores	2	2	2	-	1.05	-	2	-	2	2	2	2	2
42 Sea trout	2	2	2	-	2	-	2	-	2	2	2	2	-
43 Oceanic piscivores	2	80.66	176.99	1.05	8.58	-	2	-	2	-	2	-	-
44 Benthic piscivores	2	2	2	-	2	1.01	2	2	2	-	2	2	2
45 Reef piscivores	2	40.18	2	10.35	2	-	-	-	2	-	-	-	-
46 Reef invertebrate feeders	2	201.75	497.67	1.05	2	2.77	2	2	2	2	2	2	2
47 Demersal coastal invertebrate feeders	2	216.11	2	1.05	2	3.35	2	2	2	2	2	2	2
48 Red drum	-	-	-	-	2	-	-	-	-	-	-	-	-
49 Benthic coastal invertebrate feeders	1.05	403.35	2	1.05	2	2	2	2	2	2	1.05	2	2
50 Tilefish	-	-	-	-	-	-	-	-	2	-	-	-	-
51 Gray triggerfish	2	52.91	2	2	2	2	2	-	2	-	-	-	-
52 Coastal omnivores	2	138.01	2	1.05	2	2	2	2	2	2	2	2	2
53 Reef omnivores	2	58.44	2	44.01	2	2	2	-	2	-	2	2	2
54 Surface pelagics	2	86.66	2	1.05	9.32	2	-	-	2	-	9.48	2	-
55 Large oceanic planktivores	-	1.05	2	-	2	-	-	-	-	-	-	-	-
56 Oceanic planktivores	2	33.58	2	1.05	2	1.62	-	2	-	-	-	2	-
57 Sardine-herring-scad	1.05	187.38	2101.69	1.05	1.05	2.32	1.05	2	12.4	2	14.7	2	2
58 Menhaden (0yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
59 Menhaden (1yr)	-	2	-	-	2	2	2	2	1.1	2	1.05	-	2
60 Menhaden (2yr)	2	2	9755.84	1.05	2	2	2	2	1.1	2	2	-	2
61 Menhaden (3yr)	2	2	2	2	2	2	2	2	1.1	2	1.05	-	2
62 Menhaden (4+yr)	2	2	2	2	2	2	2	2	1.1	2	1.05	-	2
63 Anchovy-silverside-killifish	2	1.05	3910.58	1.05	1.05	1.01	1.05	958.61	1.1	255.71	1.05	2	2
64 Mullet	2	410.74	2	-	2	3.45	2	2	2	2	2	2	-
65 Butterfish	2	127.63	2	1.05	2	2	2	2	2	2	2	2	-
66 Cephalopod	2	2355.92	1.05	1.05	1.05	38.46	2	2	2	2	2	2	2
67 Pink shrimp	2	2	2	2	2	2	2	2	2	2	2	2	2
68 Brown shrimp	2	2	2	2	2	2	2	2	2	2	2	2	2
69 White shrimp	2	3691.67	2	2	2	2	2	2	2	2	2	2	2
70 Crab	2	795.44	2	2	2	2	1.05	-	2	2	2	2	2
71 Sessile epifauna	2	37018.11	2	-	2	2	2	-	-	-	-	2	2
72 Mobile epifauna	2	49473.78	194191.7	1.05	2	54.67	2	2	1.1	2	2	1.1	2
73 Zooplankton	2	86045.32	2	1.05	2	1678.29	2	2	2	2	2	2	2
74 Infauna	2	113089.4	2	2	2	1733.55	2	-	2	2	2	2	2
75 Algae	2	2128495	2	-	2	-	-	-	-	-	-	2	2
76 Seagrass	2	-	2	2	2	2	-	-	2	-	-	2	2
77 Phytoplankton	-	-	-	-	2	-	-	-	-	-	-	-	-
78 Detritus	2	1E+10	5.24	1.05	1.05	2	2	2	2	2	2	1.1	2

Table S3.1-Continued. Predation Vulnerability matrix from the base Ecosim run. Columns and rows represent predators and prey, respectively.

Prey \ predator	27	28	29	30	31	32	33	34	35	36	37	38	39
1 Coastal dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-
2 Offshore dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-
3 Baleen whales	-	-	-	-	-	-	-	-	-	-	-	-	-
4 Seabird	-	-	-	-	-	-	-	-	-	-	-	-	-
5 Sea turtle	-	-	-	-	-	2	-	-	-	-	-	-	-
6 Blacktip shark	-	-	-	-	-	-	-	-	-	-	-	-	-
7 Dusky shark	-	-	-	-	-	-	-	-	-	-	-	-	-
8 Sandbar shark	-	-	-	-	-	-	-	-	-	-	-	-	-
9 Large coastal sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
10 Large oceanic sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
11 Atlantic sharpnose shark	2	-	6.93	-	2	2	-	-	-	-	-	-	-
12 Small coastal sharks	2	-	2	-	2	2	-	-	-	-	-	-	-
13 Yellowfin tuna	1.1	-	5.05	-	2	2	-	-	-	-	-	-	-
14 Bluefin tuna	1.1	-	1.05	-	2	2	-	-	-	-	-	-	-
15 Other tunas	22.69	-	1.05	-	2	2	-	-	-	-	-	-	-
16 Billfish	-	-	-	-	-	-	-	-	-	-	-	-	-
17 Swordfish	-	-	-	-	-	-	-	-	-	-	-	-	-
18 Pelagic coastal piscivores	2	-	2	-	2	2	2	2	2	2	-	2	-
19 Amberjack	2	-	2	-	2	2	2	2	2	2	-	2	-
20 Cobia	2	-	2	-	2	2	2	2	-	-	-	2	-
21 King mackerel (0-1yr)	2	-	2	-	-	2	-	-	-	-	-	-	-
22 King mackerel (1+yr)	2	-	2	-	-	2	-	-	-	-	-	-	-
23 Spanish mackerel (0-1yr)	2	-	2	-	-	2	-	-	-	-	-	-	-
24 Spanish mackerel (1+yr)	2	-	2	-	-	2	-	-	-	-	-	-	-
25 Skates-rays	2	-	2	-	2	2	-	-	-	-	-	-	-
26 Gag grouper (0-3yr)	2	2	2	2	2	2	2	2	2	2	2	-	2
27 Gag grouper (3+yr)	2	-	1.05	-	2	2	-	-	-	-	-	-	-
28 Red grouper (0-3yr)	2	2	2	2	2	2	2	2	14.13	2	2	-	9.88
29 Red grouper (3+yr)	1.1	-	1.05	-	2	2	-	-	-	-	-	-	-
30 Yellowedge grouper (0-3yr)	2	2	2	2	2	-	-	2	2	-	-	-	2
31 Yellowedge grouper (3+yr)	-	-	-	-	2	-	2	-	-	-	-	-	-
32 Goliath grouper	2	1.05	2	2	-	2	-	2	2	2	2	-	2
33 Deep-water grouper	-	-	-	-	2	-	2	-	-	-	2	-	-
34 Shallow-water grouper	2	58.12	17.83	2	2	2	2	35.24	2	2	2	-	1.99
35 Red snapper (0yr)	-	-	2	-	2	-	-	2	2	2	-	-	2
36 Red snapper (1-2yr)	-	-	2	-	2	-	-	2	2	2	-	-	2
37 Red snapper (3+yr)	-	-	2	-	2	2	-	1.05	-	-	2	-	-
38 Vermilion snapper	1.1	2	12.42	2	2	2	2	2	2	2	2	2	2
39 Mutton snapper	2	2	2	2	-	2	2	2	2	2	2	-	2
40 Other snapper	2	2	2	2	2	2	2	2	2	2	2	-	2
41 Coastal piscivores	-	2	-	2	-	-	-	-	-	-	-	-	-
42 Sea trout	-	-	-	-	-	-	-	-	-	-	-	-	-
43 Oceanic piscivores	-	-	-	-	2	-	-	-	1.05	9.09	2	2	-
44 Benthic piscivores	2	2	2.86	2	2	-	2	2	2	2	2	-	2
45 Reef piscivores	-	-	9.8	-	2	2	2	1.05	1.05	2	2	-	-
46 Reef invertebrate feeders	2	1.05	1.05	2	2	563	2	20.13	2	12.22	2	-	1.99
47 Demersal coastal invertebrate feeders	2	2	6.15	2	2	2	2	1.05	2	2	2	2	2
48 Red drum	-	-	-	-	-	-	-	-	-	-	-	-	-
49 Benthic coastal invertebrate feeders	2	113	10.55	2	2	2	2	30.21	2	15.87	13.81	2	2
50 Tilefish	-	-	-	-	-	-	-	-	-	-	-	-	-
51 Gray triggerfish	-	-	-	-	-	-	-	-	-	-	-	-	-
52 Coastal omnivores	2	2	2	2	2	2	-	1.05	2	2	2	-	2
53 Reef omnivores	2	39.17	9.28	2	2	2	-	2	2	2	2	-	2
54 Surface pelagics	-	-	-	-	-	-	-	-	-	-	-	-	-
55 Large oceanic planktivores	-	-	-	-	-	-	-	-	-	-	-	-	-
56 Oceanic planktivores	-	-	-	-	-	-	-	-	2	2	2	-	-
57 Sardine-herring-scad	1.1	115	1.05	2	61.16	2	2	101	2	2	2	2	2
58 Menhaden (0yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
59 Menhaden (1yr)	2	-	-	-	-	-	-	-	-	-	-	-	-
60 Menhaden (2yr)	2	-	-	-	-	-	-	-	-	-	-	-	-
61 Menhaden (3yr)	2	-	-	-	-	-	-	-	-	-	-	-	-
62 Menhaden (4+yr)	2	-	-	-	-	-	-	-	-	-	-	-	-
63 Anchovy-silverside-killifish	-	2	-	2	-	1.05	4.24	1.05	1.05	134	176	-	1.99
64 Mullet	2	-	-	-	-	2	-	-	-	-	-	-	2
65 Butterfish	-	-	-	-	-	-	1.05	-	2	2	2	-	2
66 Cephalopod	2	2	1.05	2	2	2	476	2	2	2	2	1.1	2
67 Pink shrimp	2	2	2	2	2	2	2	2	2	2	2	2	2
68 Brown shrimp	2	2	2	2	2	2	2	2	2	2	2	2	2
69 White shrimp	2	2	2	2	2	6308	2	2	2	2	2	2	2
70 Crab	2	112	17.16	2	2	1.05	1.05	1.05	2	2	2	2	1.99
71 Sessile epifauna	2	2	2	2	732	-	2	4024	1.05	2	2	1.1	2
72 Mobile epifauna	2	7.24	1.05	1.99	596	23.22	17558	8552	1.05	1.05	3689	1.1	1.99
73 Zooplankton	2	2	2	2	-	2	2	1.05	1.05	2	2	1553	24542
74 Infauna	2	6735	2	2	2497	368135	2	1.05	1.05	2	9782	1970	1.99
75 Algae	-	-	-	-	-	-	-	-	2	2	2	2	2
76 Seagrass	-	2	-	-	-	-	-	-	-	-	-	-	1.99
77 Phytoplankton	-	-	-	-	-	-	-	1.05	-	-	-	-	2
78 Detritus	2	934	2	2	2	2	2	1E+10	1.05	2	1E+10	1.89E+09	1.99

Table S3.1-Continued. Predation Vulnerability matrix from the base Ecosim run. Columns and rows represent predators and prey, respectively.

Prey \ predator	40	41	42	43	44	45	46	47	48	49	50	51	52
1 Coastal dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-
2 Offshore dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-
3 Baleen whales	-	-	-	-	-	-	-	-	-	-	-	-	-
4 Seabird	-	-	-	-	-	-	-	-	-	-	-	-	-
5 Sea turtle	-	-	-	-	-	-	-	-	-	-	-	-	-
6 Blacktip shark	-	-	-	-	-	-	-	-	-	-	-	-	-
7 Dusky shark	-	-	-	-	-	-	-	-	-	-	-	-	-
8 Sandbar shark	-	-	-	-	-	-	-	-	-	-	-	-	-
9 Large coastal sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
10 Large oceanic sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
11 Atlantic sharpnose shark	-	-	-	-	-	-	-	-	-	-	-	-	-
12 Small coastal sharks	-	-	-	2	-	-	-	-	-	-	2	-	-
13 Yellowfin tuna	-	-	-	25.11	-	-	-	-	-	-	-	-	-
14 Bluefin tuna	-	-	-	2	-	-	-	-	-	-	-	-	-
15 Other tunas	-	-	-	2	-	-	-	-	-	-	-	-	-
16 Billfish	-	-	-	-	-	-	-	-	-	-	-	-	-
17 Swordfish	-	-	-	-	-	-	-	-	-	-	-	-	-
18 Pelagic coastal piscivores	-	2	2	2	2	2	2	2	-	-	2	-	-
19 Amberjack	-	2	2	2	2	2	2	1.67	-	-	2	-	-
20 Cobia	-	-	-	2	-	2	-	-	-	-	2	-	-
21 King mackerel (0-1yr)	-	-	-	2	-	2	-	-	-	-	-	-	-
22 King mackerel (1+yr)	-	-	-	2	-	2	-	-	-	-	-	-	-
23 Spanish mackerel (0-1yr)	-	2	2	2	-	2	-	-	-	-	-	-	-
24 Spanish mackerel (1+yr)	-	-	-	2	-	2	-	-	-	-	-	-	-
25 Skates-rays	-	-	-	-	-	-	-	-	-	-	-	-	-
26 Gag grouper (0-3yr)	2	-	-	-	-	-	-	-	-	-	2	-	-
27 Gag grouper (3+yr)	-	-	-	-	-	-	-	-	-	-	2	-	-
28 Red grouper (0-3yr)	2	-	-	-	-	-	-	-	-	-	2	-	-
29 Red grouper (3+yr)	-	-	-	-	-	-	-	-	-	-	2	-	-
30 Yellowedge grouper (0-3yr)	-	-	-	-	-	-	-	-	-	-	2	-	-
31 Yellowedge grouper (3+yr)	-	-	-	-	-	-	-	-	-	-	2	-	-
32 Goliath grouper	2	-	-	-	-	-	-	-	-	-	2	-	-
33 Deep-water grouper	2	-	-	-	-	-	-	-	-	-	2	-	-
34 Shallow-water grouper	2	-	-	-	-	-	-	-	-	-	2	-	-
35 Red snapper (0yr)	-	-	-	-	-	-	2	-	-	-	-	-	-
36 Red snapper (1-2yr)	-	-	-	-	-	-	2	-	-	-	-	-	-
37 Red snapper (3+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
38 Vermilion snapper	-	-	-	-	2	2	2	-	-	-	-	-	-
39 Mutton snapper	-	-	-	-	2	2	2	-	-	-	-	-	-
40 Other snapper	-	2	2	2	2	2	-	-	-	-	-	-	-
41 Coastal piscivores	-	2	2	2	2	-	2	2	-	2	-	-	-
42 Sea trout	-	2	2	6.64	2	-	2	1.97	-	-	-	-	-
43 Oceanic piscivores	-	-	-	1.05	10.81	-	2	2	-	-	2	-	-
44 Benthic piscivores	2	2	2	2	2	2	2	2	1.18	2	2	-	-
45 Reef piscivores	-	-	-	2	2	2	-	-	-	-	2	-	-
46 Reef invertebrate feeders	2	2	2	2	2	2.35	2	2	1.18	2	2	-	-
47 Demersal coastal invertebrate feeders	2	2	2	2	2	2	2	2	1.18	2	2	-	2
48 Red drum	-	2	-	-	-	-	-	-	-	-	-	-	-
49 Benthic coastal invertebrate feeders	2	2	2	17.83	2	2.61	2	2	1.18	2	2	2	2
50 Tilefish	-	-	-	2	-	-	-	-	-	-	2	-	-
51 Gray triggerfish	2	-	-	44.7	-	-	-	-	-	-	-	-	-
52 Coastal omnivores	2	2	2	2	2	2	2	2	1.18	2	-	-	-
53 Reef omnivores	2	21.15	2	2	-	2	2	1.93	1.18	-	2	-	-
54 Surface pelagics	2	2	2	2	2	3.63	2	2	-	2	-	2	-
55 Large oceanic planktivores	-	-	-	2	-	-	-	-	-	-	-	-	-
56 Oceanic planktivores	-	-	-	2	2	2	2	2	-	-	2	-	-
57 Sardine-herring-scad	2	5.77	1.1	34.41	76.81	4.29	2	2	-	2	2	-	2
58 Menhaden (0yr)	2	2	10.83	-	2	-	-	2	1.18	2	-	-	-
59 Menhaden (1yr)	2	2	13.8	2	2	-	-	2	1.18	2	-	-	-
60 Menhaden (2yr)	2	2	6.25	2	2	-	-	2	1.18	2	-	-	-
61 Menhaden (3yr)	2	2	2	2	2	-	-	2	1.18	2	-	-	-
62 Menhaden (4+yr)	2	2	2	2	2	-	-	2	1.18	2	-	-	-
63 Anchovy-silverside-killifish	2	28.74	1.5	67.76	174	12.32	2	2	1.18	2	-	-	2
64 Mullet	2	2	2	2	2	1.05	-	2	1.18	-	-	-	-
65 Butterfish	2	-	-	2	2	-	-	2	-	-	2	-	-
66 Cephalopod	2	47.34	1.05	117	2	35.08	2	1.05	1.18	1.05	2	2	1.05
67 Pink shrimp	2	2	2	2	2	2	2	1.3	1.18	2	2	2	2
68 Brown shrimp	2	2	2	2	2	2	2	1.05	1.18	2	2	2	2
69 White shrimp	2	2	2	2	2	39.68	2	2	1.18	2	2	2	2
70 Crab	2	29.33	1.52	2	2	3.95	2	2	1.18	2	2	2	2
71 Sessile epifauna	2	2	2	2	2	431	2	9.66	1.18	148	1.1	1.99	1.05
72 Mobile epifauna	2	2	1.05	3038	2	428	1.05	21.57	1.18	258	1.1	1.99	319
73 Zooplankton	2	2	270	14951	2	1502	2	92.17	1.18	3.66	2	2	1.05
74 Infauna	2	2	151	10272	2	1289	1.05	30.91	1.18	670	2.1	1.99	147
75 Algae	2	2	2	2	2	-	2	1.05	1.18	1254	-	2	1.52
76 Seagrass	2	2	4448	2	2	99826	2	3016	1.18	21.05	-	2	65.06
77 Phytoplankton	2	2	1347	-	-	85440	2	1.05	-		-	2	1.05
78 Detritus	1.05	1.05	2	1E+10	1.05	1.05	1.05	1.05	1.18	4.72	2	2	1E+10

Table S3.1-Continued. Predation Vulnerability matrix from the base Ecosim run. Columns and rows represent predators and prey, respectively.

Prey \ predator	53	54	55	56	57	58	59	60	61	62	63	64	65
1 Coastal dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-
2 Offshore dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-
3 Baleen whales	-	-	-	-	-	-	-	-	-	-	-	-	-
4 Seabird	-	-	-	-	-	-	-	-	-	-	-	-	-
5 Sea turtle	-	-	-	-	-	-	-	-	-	-	-	-	-
6 Blacktip shark	-	-	-	-	-	-	-	-	-	-	-	-	-
7 Dusky shark	-	-	-	-	-	-	-	-	-	-	-	-	-
8 Sandbar shark	-	-	-	-	-	-	-	-	-	-	-	-	-
9 Large coastal sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
10 Large oceanic sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
11 Atlantic sharpnose shark	-	-	-	-	-	-	-	-	-	-	-	-	-
12 Small coastal sharks	-	-	-	-	-	-	-	-	-	-	-	-	-
13 Yellowfin tuna	-	-	-	-	-	-	-	-	-	-	-	-	-
14 Bluefin tuna	-	-	-	-	-	-	-	-	-	-	-	-	-
15 Other tunas	-	-	-	-	-	-	-	-	-	-	-	-	-
16 Billfish	-	-	-	-	-	-	-	-	-	-	-	-	-
17 Swordfish	-	-	-	-	-	-	-	-	-	-	-	-	-
18 Pelagic coastal piscivores	-	-	-	-	2	-	-	-	-	-	-	-	-
19 Amberjack	-	-	-	-	-	-	-	-	-	-	-	-	-
20 Cobia	-	-	-	-	-	-	-	-	-	-	-	-	-
21 King mackerel (0-1yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
22 King mackerel (1+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
23 Spanish mackerel (0-1yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
24 Spanish mackerel (1+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
25 Skates-rays	-	-	-	-	-	-	-	-	-	-	-	-	-
26 Gag grouper (0-3yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
27 Gag grouper (3+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
28 Red grouper (0-3yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
29 Red grouper (3+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
30 Yellowedge grouper (0-3yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
31 Yellowedge grouper (3+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
32 Goliath grouper	-	-	-	-	-	-	-	-	-	-	-	-	-
33 Deep-water grouper	-	-	-	-	-	-	-	-	-	-	-	-	-
34 Shallow-water grouper	-	-	-	-	-	-	-	-	-	-	-	-	-
35 Red snapper (0yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
36 Red snapper (1-2yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
37 Red snapper (3+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
38 Vermilion snapper	-	-	-	-	-	-	-	-	-	-	-	-	-
39 Mutton snapper	-	-	-	-	-	-	-	-	-	-	-	-	-
40 Other snapper	-	-	-	-	-	-	-	-	-	-	-	-	-
41 Coastal piscivores	-	-	-	-	-	-	-	-	-	-	-	-	-
42 Sea trout	-	-	-	-	-	-	-	-	-	-	-	-	-
43 Oceanic piscivores	-	-	-	-	-	-	-	-	-	-	-	-	-
44 Benthic piscivores	-	-	-	-	2	-	-	-	-	-	-	-	-
45 Reef piscivores	-	-	-	-	-	-	-	-	-	-	-	-	-
46 Reef invertebrate feeders	-	-	-	-	2	-	-	-	-	-	-	-	-
47 Demersal coastal invertebrate feeders	-	-	-	-	2	-	-	-	-	-	-	-	-
48 Red drum	-	-	-	-	-	-	-	-	-	-	-	-	-
49 Benthic coastal invertebrate feeders	2	-	-	-	-	-	-	-	-	-	-	-	-
50 Tilefish	-	-	-	-	-	-	-	-	-	-	-	-	-
51 Gray triggerfish	-	-	-	-	-	-	-	-	-	-	-	-	-
52 Coastal omnivores	-	-	-	-	2	-	-	-	-	-	-	-	-
53 Reef omnivores	-	-	-	-	-	-	-	-	-	-	-	-	-
54 Surface pelagics	-	2	-	-	2	-	-	-	-	-	-	-	-
55 Large oceanic planktivores	-	-	-	-	-	-	-	-	-	-	-	-	-
56 Oceanic planktivores	-	-	2	2	2	-	-	-	-	-	-	-	-
57 Sardine-herring-scad	-	1.05	-	-	2	-	-	-	-	-	-	-	-
58 Menhaden (0yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
59 Menhaden (1yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
60 Menhaden (2yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
61 Menhaden (3yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
62 Menhaden (4+yr)	-	-	-	-	-	-	-	-	-	-	-	-	-
63 Anchovy-silverside-killifish	-	1.05	-	-	2	-	-	-	-	-	2	-	-
64 Mullet	-	-	-	-	-	-	-	-	-	-	-	-	-
65 Butterfish	-	-	-	-	-	-	-	-	-	-	-	-	-
66 Cephalopod	-	35.04	2	2	10.53	-	-	-	-	-	-	-	-
67 Pink shrimp	2	2	-	2	2	-	-	-	-	-	2	-	2
68 Brown shrimp	2	2	-	2	2	-	-	-	-	-	2	-	2
69 White shrimp	2	2	-	2	2	-	-	-	-	-	2	-	2
70 Crab	85.56	2	-	-	2	-	-	-	-	-	-	-	-
71 Sessile epifauna	1.05	2	-	-	25.78	-	-	-	-	-	18.31	-	2
72 Mobile epifauna	3239	1.05	2	1.05	1.05	1.05	1.05	1.05	2	2	1.05	1.05	1.05
73 Zooplankton	6669	393	2	1.05	113	9.13	1.05	23.98	118	1.05	70.35	1.05	1.05
74 Infauna	4947	2	-	1.05	1.05	2	2	2	2	2	66.2	1.05	2
75 Algae	38157	2	-	-	2	1.05	1.05	1.05	1.05	2	2	1.05	2
76 Seagrass	437657	2	2	-	2	-	-	-	-	-	5869	1.05	2
77 Phytoplankton	351432	2	-	-	2.21	97.94	82.07	1.05	1266	4980	2317	1.05	1.05
78 Detritus	1E+10	1E+10	-	-	1E+10	1.05	1.05	1.05	1.05	1.05	1E+10	1.05	2

Table S3.1-Continued. Predation Vulnerability matrix from the base Ecosim run. Columns and rows represent predators and prey, respectively.

Prey \ predator	66	67	68	69	70	71	72	73	74
1 Coastal dolphins	-	-	-	-	-	-	-	-	-
2 Offshore dolphins	-	-	-	-	-	-	-	-	-
3 Baleen whales	-	-	-	-	-	-	-	-	-
4 Seabird	-	-	-	-	-	-	-	-	-
5 Sea turtle	-	-	-	-	-	-	-	-	-
6 Blacktip shark	-	-	-	-	-	-	-	-	-
7 Dusky shark	-	-	-	-	-	-	-	-	-
8 Sandbar shark	-	-	-	-	-	-	-	-	-
9 Large coastal sharks	-	-	-	-	-	-	-	-	-
10 Large oceanic sharks	-	-	-	-	-	-	-	-	-
11 Atlantic sharpnose shark	-	-	-	-	-	-	-	-	-
12 Small coastal sharks	-	-	-	-	-	-	-	-	-
13 Yellowfin tuna	-	-	-	-	-	-	-	-	-
14 Bluefin tuna	-	-	-	-	-	-	-	-	-
15 Other tunas	-	-	-	-	-	-	-	-	-
16 Billfish	-	-	-	-	-	-	-	-	-
17 Swordfish	-	-	-	-	-	-	-	-	-
18 Pelagic coastal piscivores	-	-	-	-	-	-	-	-	-
19 Amberjack	-	-	-	-	-	-	-	-	-
20 Cobia	-	-	-	-	-	-	-	-	-
21 King mackerel (0-1yr)	-	-	-	-	-	-	-	-	-
22 King mackerel (1+yr)	-	-	-	-	-	-	-	-	-
23 Spanish mackerel (0-1yr)	-	-	-	-	-	-	-	-	-
24 Spanish mackerel (1+yr)	-	-	-	-	-	-	-	-	-
25 Skates-rays	-	-	-	-	-	-	-	-	-
26 Gag grouper (0-3yr)	-	-	-	-	-	-	-	-	-
27 Gag grouper (3+yr)	-	-	-	-	-	-	-	-	-
28 Red grouper (0-3yr)	-	-	-	-	-	-	-	-	-
29 Red grouper (3+yr)	-	-	-	-	-	-	-	-	-
30 Yellowedge grouper (0-3yr)	-	-	-	-	-	-	-	-	-
31 Yellowedge grouper (3+yr)	-	-	-	-	-	-	-	-	-
32 Goliath grouper	-	-	-	-	-	-	-	-	-
33 Deep-water grouper	-	-	-	-	-	-	-	-	-
34 Shallow-water grouper	-	-	-	-	-	-	-	-	-
35 Red snapper (0yr)	-	-	-	-	-	-	-	-	-
36 Red snapper (1-2yr)	-	-	-	-	-	-	-	-	-
37 Red snapper (3+yr)	-	-	-	-	-	-	-	-	-
38 Vermilion snapper	-	-	-	-	-	-	-	-	-
39 Mutton snapper	-	-	-	-	-	-	-	-	-
40 Other snapper	-	-	-	-	-	-	-	-	-
41 Coastal piscivores	-	-	-	-	-	-	-	-	-
42 Sea trout	-	-	-	-	-	-	-	-	-
43 Oceanic piscivores	-	-	-	-	-	-	-	-	-
44 Benthic piscivores	-	-	-	-	-	-	-	-	-
45 Reef piscivores	-	-	-	-	-	-	-	-	-
46 Reef invertebrate feeders	2	-	-	-	2	-	-	-	-
47 Demersal coastal invertebrate feeders	2	-	-	-	-	-	-	-	-
48 Red drum	-	-	-	-	-	-	-	-	-
49 Benthic coastal invertebrate feeders	-	-	-	-	-	-	-	-	-
50 Tilefish	-	-	-	-	-	-	-	-	-
51 Gray triggerfish	-	-	-	-	-	-	-	-	-
52 Coastal omnivores	2	-	-	-	2	-	4.89	-	2
53 Reef omnivores	2	-	-	-	-	-	-	-	-
54 Surface pelagics	-	-	-	-	-	-	-	-	-
55 Large oceanic planktivores	-	-	-	-	-	-	-	-	-
56 Oceanic planktivores	-	-	-	-	-	-	-	-	-
57 Sardine-herring-scad	25.66	-	-	-	2	-	-	-	-
58 Menhaden (0yr)	-	-	-	-	-	-	-	-	-
59 Menhaden (1yr)	-	-	-	-	-	-	-	-	-
60 Menhaden (2yr)	-	-	-	-	-	-	-	-	-
61 Menhaden (3yr)	-	-	-	-	-	-	-	-	-
62 Menhaden (4+yr)	-	-	-	-	-	-	-	-	-
63 Anchovy-silverside-killifish	2.82	-	-	-	2	-	-	-	-
64 Mullet	-	-	-	-	2	-	-	-	-
65 Butterfish	-	-	-	-	-	-	-	-	-
66 Cephalopod	22.37	-	-	-	2	-	1.05	-	-
67 Pink shrimp	-	-	-	-	2	-	-	-	-
68 Brown shrimp	-	-	-	-	2	-	-	-	-
69 White shrimp	-	-	-	-	2	-	-	-	-
70 Crab	-	-	-	-	2	-	-	-	-
71 Sessile epifauna	-	2	2	2	-	-	2.21	-	-
72 Mobile epifauna	19.69	2	2	2	96.4	2	13.76	-	2
73 Zooplankton	16.9	-	-	-	-	187	-	3.04	-
74 Infauna	1.05	2	2	2	1.1	2	4.44	-	6.02
75 Algae	-	2	1.99	1.05	2	-	1.05	-	-
76 Seagrass	-	-	-	-	-	-	1.05	-	-
77 Phytoplankton	-	2	1.99	3371	-	71.49	71.23	5.03	1.05
78 Detritus	1.05	2	1.99	1.5	1E+10	1E+10	1.05	149460	1.05