Supplementary Materials for Aquaculture Over-Optimism

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Fig. S1

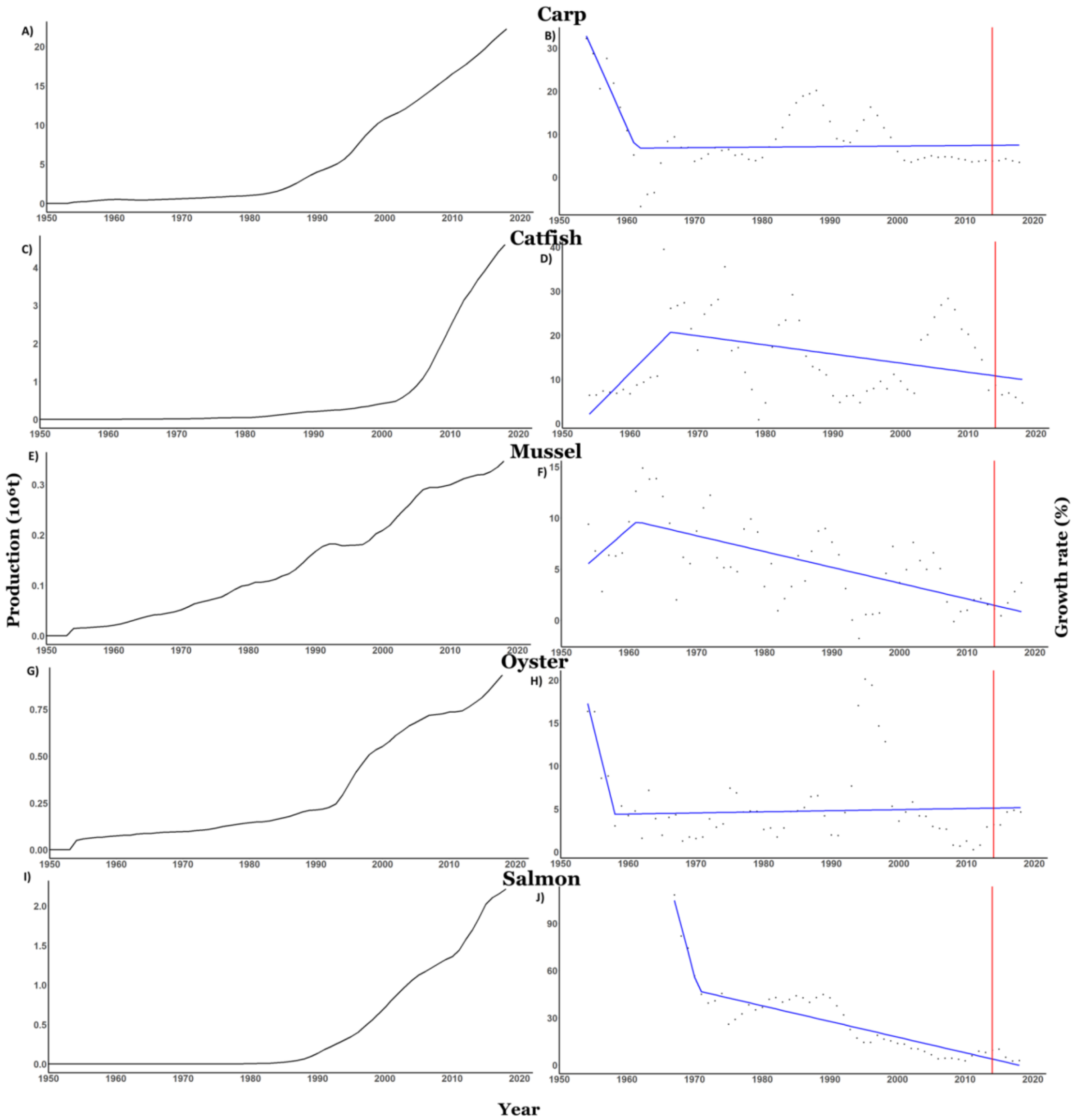
Carp
Catfish
Mussel
Oyster
Salmon
A)
B)
C)
D)
E)
F)
G)
H)
I)
J)
Production (10⁶t)
Growth rate (%)
Year

Fig. S1 (continued)

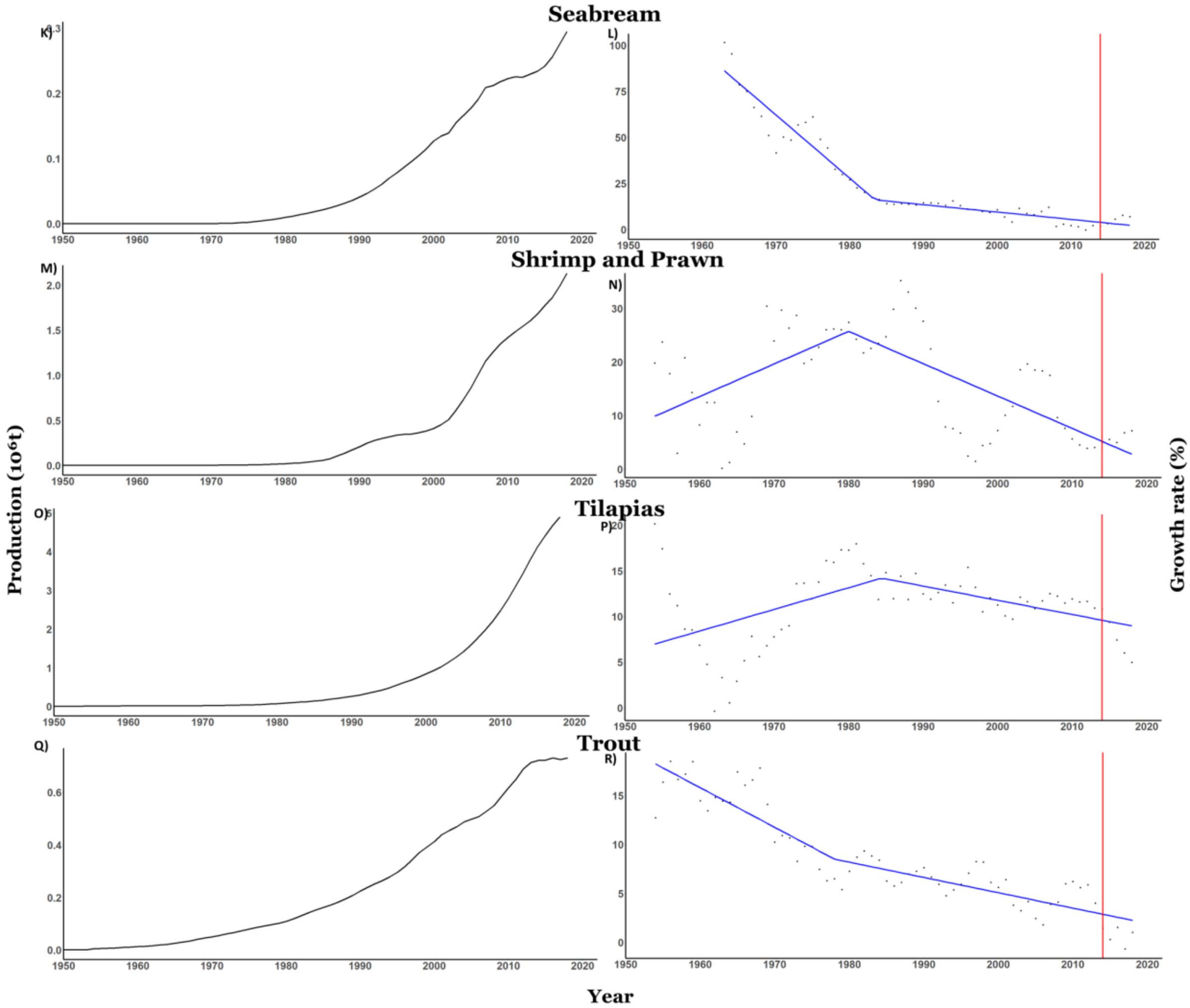

Fig. S1. Aquaculture production and growth rates for top ten species. Figure A-R illustrate total production from 1950 to 2018 and the five-year moving average growth rate from 1950 to 2018. The five-year moving average growth rate trends are: B) slope1= -3.55, slope2=0.01, R^2 = 0.5; D) slope1= 1.55, slope2=-0.21, R^2 = 0.21; F) slope1=0.57, slope=-0.15, R^2 = 0.43; H) slope1=-3.43, slope=0.01, R^2 = 0.21; J) slope=-16.2, slope=-0.99, R^2 = 0.90; L) slope=-3.43, slope=-0.4, R^2 = 0.94; N) slope1=0.61,slope=-0.60, R^2 = 0.42; P) slope1=0.23, slope2=-0.16, R^2 = 0.22; rR slope1=-0.4, slope2=-0.16, R^2 = 0.85.

Table S1. Species group based on a common name included in this study.

Carp	Catfish	Mussel	Oyster	Salmon	Shrimp & Prawn	Seabream	Tilapias	Trout
Bighed carp	Africa-bighead catfish, hybrid	Australian mussel	American cupped oyster	Atlantic salmon	Baltic prawn	Blackhed seabream	Blackchin tilapia	Brook trout
Black carp	African catfish	Blue mussel	Blacklip pearl oyster	Chinook (Spring King) salmon	Banana prawn	Blackspot (red) seabream	Blue tilapia	Golden trout
Carassus spp	Amazon sailfin catfish	Chilean mussel	Chilean flat oyster	Chum (Keta Dog) salmon	Brown tiger prawn	Bluespotd seabream	Blue-Nile tilapia, hybrid	Rainbow trout
Catla	Amur catfish	Chinese pond mussel	Cortez oyster	Coho (Silver) salmon	Caramote prawn	Common two-banded seabream	Longfin tilapia	Sea trout
Common carp	Asian redtail catfish	Cholga mussel	Cupped oysters nei	Masu (Cherry) salmon	Common prawn	Crimson seabream	Mango tilapia	Sevan trout
Crucian carp	Bagrid catfish	Choro mussel	European flat oyster	Pacific salmons nei	Eastern king prawn	Gilthead seabream	Mozambique tilapia	Trouts nei
Grass carp (White amur)	Black catfishes nei	Freshwater mussel shells	Flat and cupped oysters nei	Pink (Humpback) salmon	Fleshy prawn	Goldlined seabream	Nile tilapia	
Hoven's carp	Catfishes nei	Green mussel	Flat oysters nei	Salmonids nei	Giant river prawn	Goldsilk seabream	Redbelly tilapia	
Mrigal carp	Channel catfish	Horse mussels nei	Gasar cupped oyster	Salmonoids nei	Giant tiger prawn	Japanese seabream	Redbreast tilapia	
Mud carp	Chinese longsnout catfish	Korean mussel	Hooded oyster	Sockeye (Red) salmon	Green tiger prawn	Porgies, seabreams nei	Sabaki tilapia	
Nilem carp	Duckbill catfish	Mediterranean mussel	Indian backwater oyster		Indian white prawn	Redbanded seabream	Three spotted tilapia	
Roho labeo	Hetero-Clarias catfish, hybrid	New Zealand mussel	Mangrove cupped oyster		Kuruma prawn	Sharpsnout seabream	Tilapia shiranus	

Silver, bighead carps nei	Hong Kong catfish	River Plata mussel	Olympia oyster	Monkey river prawn	Silver seabream	Tilapias nei
Silver carp	Naked catfishes	Sea mussels nei	Pacific cupped oyster	Monsoon river prawn	Sobaity seabream	
Small scale mud carp	North African catfish	South American rock mussel	Pearl oyster shells nei	Oriental river prawn	Twobar seabream	
	Pangas catfish		Penguin wing oyster	Redtail prawn	White seabream	
	Pangas catfishes nei		Slipper cupped oyster	River prawns nei	Yellowback seabream	
	Philippine catfish		Sydney cupped oyster	Akiami paste shrimp	Yellowfin seabream	
	South American catfish			Atlantic ditch shrimp		
	Stinging catfish			Blue shrimp		
	Striped catfish			Brine shrimp		
	Suckermouth catfish			Eastern school shrimp		
	Torpedo-shaped catfishes nei			Freshwater prawns, shrimps nei		
	Upsidedown catfishes			Greasyback shrimp		
	Wels(Som) catfish			Metapenaeus shrimps nei		
	Yellow catfish			Northern white shrimp		
				Palaemonid shrimps nei		

	Penaeus shrimps nei	
	Southern white shrimp	
	Speckled shrimp	
	Whiteleg shrimp	

Global fish consumption projections

The paper begins with a discussion on the global status and trends of fish production and consumption, with special focus on the impressive growth of aquaculture which has enabled what we denote here as aquaculture over-optimism. The study reviews previous studies that have forecast the direction of per capita fish consumption and aquaculture production. First, baseline scenario, which represents an outcome based on zero growth rate in both aquaculture production and consumption. Under the baseline scenario, aquaculture production is constant 60 Mt (in edible form) between 2018 and 2030, while per capita consumption in edible form is expected to increase by 1 percent per year at a global level, largely driven by population growth. Thus, the baseline model provides an important benchmark against which to measure these changes.

For the second scenario, we obtained historical consumption data from the "Food" category in the FAO Food Balance Sheets in live weight equivalent (http://www.fao.org/faostat/en/#data/FBS) from 1950 to 2018, and the medium-variant global population estimates for 2030 from United Nations, Department of Economic and Social Affairs, Population Division (2019). We used the recent 5-year average annual fish consumption growth rate to predict global consumption out 2030.
Under the third scenario, we reviewed global consumption growth rate out 2030 based on recent literature (i.e., World Bank 2014; FAO 2020; OECD/FAO 2021) and present the per capita predictions for 2030. Aggregate fish in edible weight with conversion from live-to-edible based on conversion factor reported in Naylor et al. 2021. Since we are interested in linearly predicting per capita fish consumption, our model is specified as follows:

$$Dt = Ct * (1 + r)^{n}$$

Where Dt is future consumption value at year (2030), Ct, is the current consumption value in the base year (2018), r is the compound annual growth rates, and n denotes the number of years between 2018 to 2030.

Table 1 Previous assessments of projected global per capita fish consumption growth rate (%).

Organization	Report	Time period	Projection 2030 (kg/cap/year)	Growth Rate (2019-2030) (%/year)
FAO	SOFIA 2018	2019-2030	21.5	0.4
World Bank	Fish to 2030	2010-2030	18.2	0.3
OECD-FAO	Agricultural Outlook	2021-2030	21.2	0.4

Projected global aquaculture production, 2030 (million tonnes)

To be consistent with our demand model, we predict aquaculture production by 2030 using the recent 5-year average aquaculture production growth rate and predicted aquaculture production growth rate up to 2030 based on the literature (i.e., World Bank 2014; FAO 2020; OECD/FAO 2021). Annual global aquaculture production (in million tonnes) data were extracted from FAOSTAT from 1980 to 2018 and the recent 5-year average annual global aquaculture production was calculated and used for our analysis.

Table 2 Previous assessments of global aquaculture growth rates (%)

Organization	Report	Time period	Projected Aquaculture production (million tonnes)	Growth Rate (2010-2030) (%/year)
FAO	SOFIA 2018	2017-2030	109	2.1
World Bank	Fish to 2030	2010-2030	93	2.4
OECD-FAO	Agricultural Outlook	2021-2030	103	2.0