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AS WE SEE IT

Fish ingredients in online recipes do not promote the sustainable use of vulnerable taxa

Charis Apostolidis*, Konstantinos I. Stergiou

Laboratory of Ichthyology, School of Biology, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece

ABSTRACT: Consumer preferences can be influenced by cultural factors, such as recipes. Thus, popular recipes using seafood ingredients could encourage demand for the featured marine species. We recorded the fish taxa appearing in all online Greek recipes and related the number of recipes in which a taxon is a suggested ingredient to the taxon's landings and vulnerability to fishing. For marine fish, the number of recipes per taxon (henceforth called recipe prevalence) increased significantly with the taxon's landings. When the effect of landings was removed, recipe prevalence increased significantly with vulnerability to fishing, indicating that more vulnerable taxa appear more frequently in recipes. This pattern should be reversed by eliminating the recipe abundance of taxa that are very vulnerable to fishing and counterbalance such a reduction with an increase in the representation of taxa of low vulnerability, landed in large quantities and currently underrepresented in recipes. Managing recipe composition by educating a small group of stakeholders (i.e. chefs and recipe authors) may be a cost-effective way of promoting fisheries sustainability when compared to directly educating consumers.

KEY WORDS: Consumer influence · Conservation · Landings · Recipes · Vulnerability to fishing

INTRODUCTION

Most fisheries are depleted and/or are being continually overfished (Garcia & Rosenberg 2010). Irrespective of the magnitude of fisheries mismanagement (Myers & Worm 2003, Pauly et al. 2003, Hilborn 2007, Worm et al. 2009), excessive fishing impairs ecosystem health (e.g. Jennings & Kaiser 1998, Pauly et al. 1998, Stergiou 2002) and has important socioeconomic implications (e.g. Failler & Pan 2007, Srinivasan et al. 2012). Thus, there is a growing concern for the future of fisheries, which, among other actions, has resulted in the launch of various consumer and market-based actions, such as public information campaigns and sustainability certification schemes (Halweil 2006, Jacquet & Pauly 2007, Roheim 2009). These campaigns complement traditional fisheries management and aim to influence consumer preferences towards sustainability (Halweil 2006, Jacquet & Pauly 2007, Roheim 2009). However, the effect of cultural factors, such as recipes, on consumer choices regarding fish consumption has been largely ignored (Levin & Dufault 2010).

Nowadays, chefs have started taking an energetic role in the conservation of fish stocks by recommending the consumption of sustainably exploited fish, with positive results in most cases. For example, after the launch of the BBC Channel 4 show 'Fish season', fish demand considerably increased, especially for species that were proposed to replace the overfished Atlantic cod *Gadus morhua* (e.g. demand for pollock *Pollachius virens* was reported to increase by 167%) (Tyler 2011). However, such actions have not yet been broadly applied to recipe websites. The impor-

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*Email: chapost@bio.auth.gr

tance of online recipes in influencing the public can be illustrated by the fact that the most-visited cooking website, allrecipes.com, attains about 24 million unique visitors monthly. Online recipes are not only a source of public influence but, to a certain extent, could also reflect consumer preferences, since users can post their own recipes.

Recipes have not been evaluated on a large scale from a sustainability point of view. Testing the relation between the prevalence of different fish taxa in recipes and their availability (landings) and vulnerability can reveal whether recipes could act as a driver for unsustainable use of marine resources. In addition, the form of the relation could provide directions for the conservation of fish stocks. Here, we tested this relation using the marine fish taxa in all online Greek recipes.

MATERIALS AND METHODS

We analyzed the prevalence of different fish taxa in Greek recipes and related the number of recipes in which each taxon appears (henceforth called recipe prevalence) with the taxon's landings and intrinsic vulnerability to fishing. We examined all online recipes that were available on every website listed in the catalogs of 2 Greek cooking recipe search engines (www.sintagoulis.gr and www.cookle.gr, accessed December 2011).

Overall, we collected 3858 recipes using fish as a primary or secondary ingredient. These recipes were derived from 129 websites, covering a wide variety of sources (i.e. recipe web sites, cooking blogs, newspapers, online magazines and television cooking programs). In the vast majority of cases, no information was provided regarding the date of recipes or whether recipes posted on the web were actually taken from other sources (e.g. from a published recipe book). All fish common names were assigned to the lowest possible taxon. European hake *Merluccius merluccius* and *Gadus morhua* have the same Greek common name ('bakaliaros'). The former is only sold fresh, while the latter is sold as salted fillets or frozen. Thus, ingredients referring to fresh 'bakaliaros' were assigned to *M. merluccius* and the remaining ones to *G. morhua*.

Intrinsic vulnerability to fishing, henceforth called vulnerability, was taken from FishBase (www.fishbase.org; Froese & Pauly 2012), as estimated by a fuzzy logic expert system (see Cheung et al. 2005 for a detailed description). The estimation of vulnerability is based on the species' life history (i.e. maximum length, age at first maturity, longevity, von Bertalanffy growth parameter *K*, natural mortality rate and fecundity) and ecology (i.e. strength of spatial behavior and geographic range). Vulnerability is a metric of extinction risk and ranges from 0 (lowest) to 100 (highest). Mean landings per taxon for 1990 to 2007 were estimated from the landings reported by Moutopoulos & Stergiou (2012). All scientific names were obtained from FishBase (Froese & Pauly 2012). The relation between recipe prevalence, landings and vulnerability was described using stepwise multiple regression, and the reported p-values are 2-tailed.

RESULTS

Of the 3858 recipes found, 179 (4.6%) referred to fish without specifying a taxon and thus were excluded from our analysis. In the remaining 3679 recipes, there were 4265 occurrences of identified taxa (i.e. 1.1 fish per recipe, as some recipes suggested >1 taxon) corresponding to 80 Greek common names, 2 of which (perch and tilapia) could not be assigned to a specific taxon. This is because these 2 taxa, both derived from aquaculture, are sold without any information on scientific names. The remaining 78 common names were assigned to 71 taxa, of which 60 (84.5%) were at the species level, 8 (11.3%) at the genus level and 3 (4.2%) at the family level (Table A1). Overall, 15 taxa (20.55%) accounted for 3234 (75.8%) of the occurrences (Fig. 1).

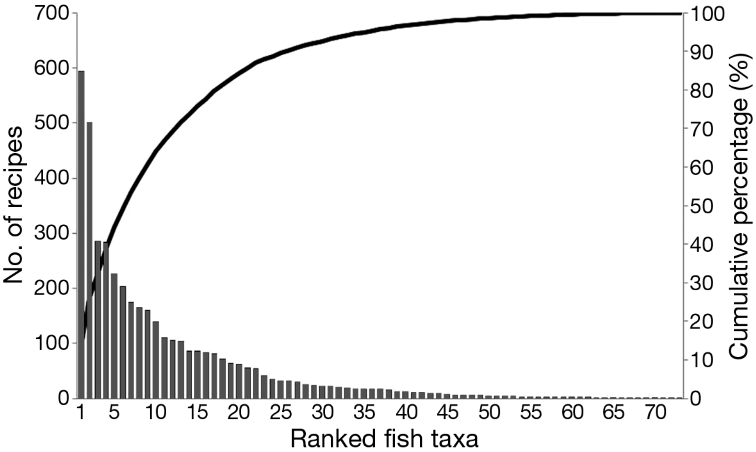

Fig. 1. Number of recipes (bars) and cumulative percentage (line, right *y*-axis) by rank for all fish taxa (n = 71) cited as ingredients in Greek online recipes

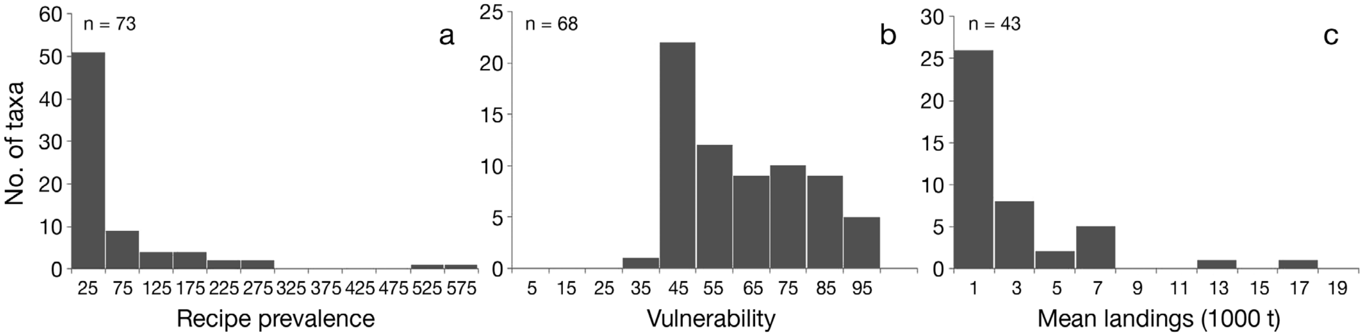

Fig. 2. Distribution of (a) recipe prevalence (number of recipes in which each taxon appears), (b) vulnerability and (c) mean landings for the fish taxa cited in Greek online recipes. *x*-axis labels denote midpoints of bins

The distributions of recipe prevalence, vulnerability and mean landings for the different taxa are shown in Fig. 2. Recipe prevalence ranged from 1 (0.02%) to 595 (14.0%) recipes (Fig. 2a, Table A1), with a mean value (±SD) of 58 ± 105.33. Vulnerability ranged from 25, for European anchovy *Engraulis encrasicolus*, to 88, for sturgeon *Acipenser sturio* and Atlantic halibut *Hippoglossus hippoglossus*, with a mean value of 52.8 ± 16.52 and a main mode at 40 to 45 (Fig. 2b). Mean landings (Fig. 2c) ranged from 84.3 t, for shi drum *Umbrina cirrosa*, to 17798 t, for European sardine *Sardina pilchardus*.

We confined our analysis to marine wild stocks native to Greece (57.8% of recipe citations), excluding cultured (25.6%), imported (15.4%) and freshwater species (1.2%). The most prevalent of the 55 marine taxa cited in 2467 recipes were *Engraulis encrasicolus*, followed by *Thunnus* spp. and common sole *Solea solea*, with 286 (11.6%), 284 (11.5%) and 226 (9.2%) occurrences respectively (Table A1).

For the 41 Greek native marine taxa for which landings were available, the following multiple regression was found ($R^2 = 0.216$, $p = 0.039$, df = 2,38, $F = 5.230$): log(recipe prevalence) = −2.852 + 0.471 log (mean landings) + 1.645 log(vulnerability). The 2 predictors were not intercorrelated ($n = 41$, $r = 0.176$, $p = 0.271$). Thus, after correcting for the effect of landings (partial $r = 0.409$, $p = 0.009$), recipe prevalence was significantly correlated (partial $r = 0.322$, $n = 41$, $p = 0.040$) with vulnerability, indicating that more vulnerable species appear more frequently in recipes (Fig. 3). The relation between recipe prevalence, vulnerability and mean landings was stronger ($R^2 = 0.405$, $p < 0.001$, df = 2,31, $F = 10.529$): log(recipe prevalence) = −3.223 + 0.444 log(mean landings) + 1.940 log(vulnerability) after excluding 3 apparent outlier taxa (*Engraulis encrasicolus*, *Solea solea* and white grouper *Epinephelus aeneus*) above the regression line and 4 taxa (blotched picarel *Spicara maena*, annular seabream *Diplodus annularis*, blue whiting *Micromesistius poutassou* and round sardinella *Sardinella aurita*) below the regression line.

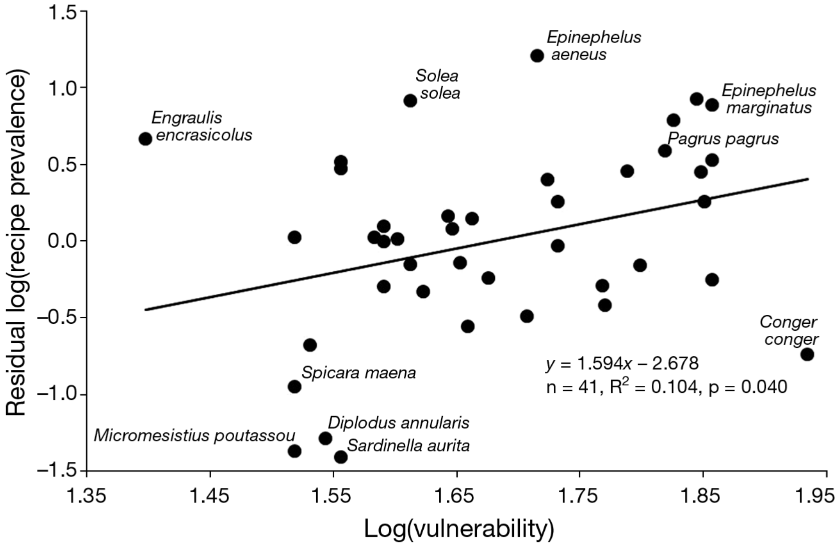

Fig. 3. Plot of recipe prevalence (number of recipes in which each taxon appears), after removing the effect of landings (residual recipe prevalence), versus vulnerability to fishing for 41 Greek native marine fish taxa cited in online recipes

DISCUSSION

The fact that recipe prevalence increased with landings indicates that the regional cooking culture is developed based on the more abundant species in the area. Yet, recipe composition applies a greater pressure on more vulnerable fish species as unmasked after correcting for landings. This can be explained by the fact that fish taxa with very high landings are not proportionally represented in recipes. However, the direction of causation for the above relation is not easy to identify, and in any case, our aim was to highlight the trend and its implications for the conservation of fish stocks. This trend should be changed by decreasing the recipe abundance of taxa that are very vulnerable to fishing and counterbalance such a reduction with an increase in the representation of taxa of low vulnerability, which are landed in large quantities and currently under-represented in recipes.

Various ways exist for reversing the above mentioned trend. For example, editors of recipe websites could ban publication of recipes that have as ingredients very vulnerable species, and also remove such recipes that are already posted. At the same time, editors in close cooperation with chefs, could promote recipes with less vulnerable species, providing at the same time necessary information (e.g. vulnerability and exploitation patterns) on such environmentally responsible choices. For the Greek online cuisine, in particular, recipes with taxa such as dusky grouper *Epinephelus marginatus* and red porgy *Pagrus pagrus* (both assessed as endangered by the International Union for Conservation of Nature) should be removed and replaced by less vulnerable taxa such as *Spicara maena*, *Sardinella aurita*, *Diplodus annularis* and *Micromesistius poutassou* (see Fig. 3).

The realization of a change in consumer preferences through recipes would require first that recipes can adjust with time and second the education and active participation of chefs and recipe authors in order to exploit their skills to strongly influence consumers. Levin & Dufault (2010), by analyzing seafood recipes published in cookbooks from 1885 to 2007, showed that the mean trophic level of seafood represented in recipes increased with time (eating up the food web). This finding shows that recipe composition can change with time. Suggestions made by cultural icons in the cooking industry (e.g. television cooking show presenters) can influence and shape consumer preferences, possibly much more than scientists and other stakeholders can. A good example is the late celebrity chef Julia Child, who promoted consumption of American angler *Lophius americanus* in the USA through her popular television cooking show (Weber 2002).

Consumer preferences are presumably more malleable when the marketplace has a diversity of choices. The large number of native fish species represented in our sample of recipes (compared to that of Levin & Dufault 2010) is clearly attributed to the multispecies nature of the Mediterranean fisheries (Stergiou et al. 1997). In areas supporting multispecies fisheries, it could be relatively easier to re-orient the public toward consuming less vulnerable species. In contrast, in northern areas supporting fisheries made up of relatively few species, consumers have fewer options for such a reorientation, unless they are directed to imported species. The latter, however, might drive imported species to depletion in their native ecosystems (Pelletier & Tyedmers 2008).

The interaction between online recipes and consumer preferences can be masked by various issues. For example, many individuals purchase ingredients without consulting recipes, and others enjoy reading recipes that they might never prepare or might replace certain ingredients with more easily available or affordable substitutes. In addition, online recipes might be a biased sample of available recipes. Yet, there is no doubt that in the digital era, more and more people will rely on online recipes within the 'internet life style' framework as is true for e.g. scientific literature, books, newspapers and other consumer goods. This is especially true of recipes for which a quick search online is preferable for day-to-day cooking. Thus, the influence of recipes on consumer consumption is expected to drastically increase in the near future.

The strong enforcement of fisheries management measures at various levels is the only certain way to reduce overfishing (Worm et al. 2009). However, since consumer demand for fish will continue to increase, and fisheries management cannot always be effective, alternative management actions may also be necessary. Managing aspects of culture that strongly influence the public, such as recipes, by educating a small group of stakeholders (i.e. chefs and recipe authors) may be a cost-effective way of promoting fisheries sustainability.

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LITERATURE CITED

➤ Cheung WWL, Pitcher TJ, Pauly D (2005) A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine fishes to fishing. Biol Conserv 124:97–111

➤ Failler P, Pan H (2007) Global value, full value and societal costs: capturing the true cost of destroying marine ecosystems. Soc Sci Inf (Paris) 46:109–134

Froese R, Pauly D (2012) Fishbase. www.fishbase.org Accessed 20 January 2012

Garcia SM, Rosenberg AA (2010) Food security and marine capture fisheries: characteristics, trends, drivers and future perspectives. Philos Trans R Soc Lond B 365: 2869–2880

Halweil B (2006) Catch of the day: choosing seafood for healthier oceans. Worldwatch Paper 172. Worldwatch Institute, Washington, DC

Hilborn R (2007) Reinterpreting the state of fisheries and their management. Ecosystems 10:1362–1369

Jacquet JL, Pauly D (2007) The rise of seafood awareness campaigns in an era of collapsing fisheries. Mar Policy 31:308–313

Jennings S, Kaiser MJ (1998) The effects of fishing on marine ecosystems. Adv Mar Biol 34:201–352

Levin PS, Dufault A (2010) Eating up the food web. Fish Fish 11:307–312

Moutopoulos DK, Stergiou KI (2012) Spatial disentangling of Greek fisheries landings by gear between 1928–2007. J Biol Res 18:265–279

Myers RA, Worm B (2003) Rapid worldwide depletion of predatory fish communities. Nature 423:280–283

Pauly D, Christensen V, Dalsgaard J, Froese R, Torres FJ (1998) Fishing down marine food webs. Science 279: 860–863

Pauly D, Alder J, Bennett E, Christensen V, Tyedmers P, Watson R (2003) The future for fisheries. Science 302: 1359–1361

Pelletier N, Tyedmers P (2008) Life cycle considerations for improving sustainability assessments in seafood awareness campaigns. Environ Manag 42:918–931

Roheim CA (2009) An evaluation of sustainable seafood guides: implications for environmental groups and the seafood industry. Mar Resour Econ 24:301–310

Srinivasan UT, Watson R, Sumaila UR (2012) Global fisheries losses at the exclusive economic zone level, 1950 to present. Mar Policy 36:544–549

Stergiou KI (2002) Overfishing, tropicalization of fish stocks, uncertainty and ecosystem management: resharpening Ocham's razor. Fish Res 55:1–9

Stergiou KI, Christou ED, Georgopoulos D, Zenetos A, Souvermezoglou C (1997) The Hellenic Seas: physics, chemistry, biology and fisheries. Oceanogr Mar Biol Annu Rev 35:415–538

Tyler R (2011) Fishmongers' sales rise on Channel 4's Fish season starring Gordon Ramsay and Jamie Oliver. The Telegraph (www.telegraph.co.uk)

Weber ML (2002) From abundance to scarcity: a history of U.S. marine fisheries policy. Island Press, Washington, DC

Worm B, Hilborn R, Baum JK, Branch TA and others (2009) Rebuilding global fisheries. Science 325:578–585

Appendix 1

Table A1. Assigned taxon, Greek and English common names, number (N) of recipes citing the taxon, vulnerability index (Vuln.) and mean landings (±SE; in t), for all fish cited in online Greek recipes. The vulnerability to fishing index (see text for definition) ranges from 0 to 100, with 100 representing the taxon most vulnerable to fishing. na: not available

Taxon	Greek name	English name	N	Vuln.	Landings (t)
Native marine					
Engraulis encrasicolus	Gavros	European anchovy	286	25.0	13 820.1 ± 550.7
Thunnus spp.	Tonoi	Tuna	284	70.0	3075.3 ± 202.7
Solea solea	Glossa	Common sole	226	41.0	1852.7 ± 136.4
Sardina pilchardus	Sardela	European pilchard	204	36.0	17 798.6 ± 953.5
Epinephelus aeneus	Sphyrida	White grouper	161	52.0	154.62 ± 7.3
Xiphias gladius	Xiphias	Swordfish	111	72.0	2937.15 ± 91.9
Dentex dentex	Sinagrida	Common dentex	106	67.0	589.41 ± 16.6
Mullus surmuletus	Barbouni	Surmullet	105	36.0	2673.52 ± 127.8
Merluccius merluccius	Bakaliaros freskos	European hake	87	71.0	7354.3 ± 218.7
Epinephelus marginatus	Rofos	Dusky grouper	84	72.0	190.5 ± 9.0
Lophius spp.	Peskandritses	Monkfish	82	70.5	2129.6 ± 103.8
Pagrus pagrus	Phagri	Red porgy	73	66.0	744.8 ± 16.8
Triakidae	Galeos/glaukos	Houndsharks	64	61.5	1139.9 ± 50.3
Scorpaena spp.	Skorpioi	Scorpionfishes	63	53.0	1472.8 ± 55.1
Scomber colias	Kolios	Atlantic chub mackerel	57	46.0	4960.4 ± 772.4
Pagellus erythrinus	Lithrini	Common pandora	54	54.0	2286.0 ± 78.0
Spicara smaris	Marida	Picarel	41	39.0	5072.4 ± 551.5
Boops boops	Gopa	Bogue	35	45.0	7475.1 ± 721.9
Sarda sarda	Palamida	Atlantic bonito	32	33.0	2350.3 ± 97.1
Scomber scombrus	Skoumbri	Atlantic mackerel	30	44.0	912.3 ± 203.0
Mugilidae	Kefalos	Mullets	26	47.4	6468.7 ± 185.0
Atherina boyeri	Atherina	Big-scale sand smelt	22	43.0	na
Mullus barbatus	Koutsomoura	Red mullet	17	42.0	3735.1 ± 95.9
Seriola dumerili	Magiatiko	Greater amberjack	17	54.0	675.5 ± 40.8
Diplodus sargus	Sargos	White seabream	17	63.0	1386.5 ± 38.2

Table A1 (continued)

Taxon	Greek name	English name	N	Vuln.	Landings (t)
Serranus spp.	Mpoukanares/chanoi/perkes	Combers	17	44.3	365.6 ± 29.8
Zeus faber	Christopsaro	John dory	16	39.0	283.8 ± 22.7
Triglidae	Kaponia/chelidonopsara	Gurnards	13	38.3	259.0 ± 24.6
Trachurus spp.	Savridia	Jack mackerels	13	45.7	6967.1 ± 723.3
Sarpa salpa	Salpa	Salema	12	41.0	583.2 ± 47.0
Raja spp.	Vatoi/Rines	Rays	11	58.7	1013.8 ± 47.8
Sparisoma cretense	Skaros	Parrotfish	9	36.0	na
Polyprion americanus	Vlachos	Wreckfish	9	72.0	506.3 ± 16.3
Umbrina cirrosa	Milokopi	Shi drum	8	40.0	84.3 ± 5.9
Pomatomus saltatrix	Gofari	Bluefish	7	59.0	692.8 ± 34.9
Lithognathus mormyrus	Mourmoura	Sand steenbras	7	40.0	na
Epinephelus costae	Stira	Goldblotch grouper	6	66.0	na
Belone belone	Zargana	Garfish	6	39.0	238.8 ± 26.7
Trachinus draco	Drakaina	Greater weever	5	42.0	na
Uranoscopus scaber	Lichnos	Stargazer	5	32.0	na
Sphyraena sphyraena	Loutsos	European barracuda	5	75.0	na
Spicara maena	Tseroula/menoula	Blotched picarel	5	33.0	6166.8 ± 581.2
Oblada melanura	Melanouri	Saddled seabream	4	34.0	765.0 ± 87.1
Conger conger	Mougri	European conger	4	86.0	1067.8 ± 96.3
Labrus spp.	Chiloudes/petrochiloudes	Wrasses	3	39.0	na
Xyrichthys novacula	Rouzeti	Pearly razorfish	3	36.0	na
Muraena helena	Smerna	Mediterranean moray	3	74.0	na
Scophthalmus maximus	Kalkani	Turbot	3	51.0	127.7 ± 7.2
Coryphaena hippurus	Kinigos	Common dolphinfish	2	39.0	na
Mycteroperca rubra	Piga	Mottled grouper	2	81.0	na
Pagellus acarne	Mousmouli	Axillary seabream	1	43.0	na
Phycis spp.	Salouvardos	Forkbeards	1	54.5	na
Diplodus annularis	Sparos	Annular seabream	1	35.0	786.56 ± 52.6
Micromesistius poutassou	Prosfigaki	Blue whiting	1	33.0	1284.0 ± 116.2
Sardinella aurita	Frisa	Round sardinella	1	36.0	1558.5 ± 220.1
Native freshwater					
Cyprinus carpio	Grivadi	Common carp	23	65.0	na
Anguilla anguilla	Xeli	European eel	21	70.0	na
Esox lucius	Tournas	Northern pike	3	69.0	na
Rutilus rutilus	Tsironi	Roach	2	37.0	na
Silurus glanis	Goulianos	Wels catfish	1	87.0	na
Acipenser sturio	Mourouna	Sturgeon	1	88.0	na
Imported					
Gadus morhua	Bakaliaros kseros (gados)	Atlantic cod	595	65.0	na
Beryx decadactylus	Kokkinopsaro	Alfonsino	32	72.0	na
Clupea harengus	Rega	Atlantic herring	24	36.0	na
Hippoglossus hippoglossus	Ippoglosos	Atlantic halibut	3	88.0	na
Notothenia microlepidota	Black cod	Black cod	1	62.0	na
Aquacultured					
Salmo salar	Solomos	Atlantic salmon	502	na	na
Not specified	Perka	Perch	175	na	na
Sparus aurata	Tsipoura	Gilthead seabream	166	na	na
Dicentrarchus labrax	Lauraki	European seabass	139	na	na
Oncorhynchus mykiss	Pestrofa	Rainbow trout	87	na	na
Pangasianodon hypophthalmus	Pagasios	Striped catfish	19	na	na
Not specified	Tilapia	Tilapia	4	na	na

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