Omega 3s Enrichment of Tilapia

Dr. Corilee A. Watters, MSc, RD, PhD, CNSC
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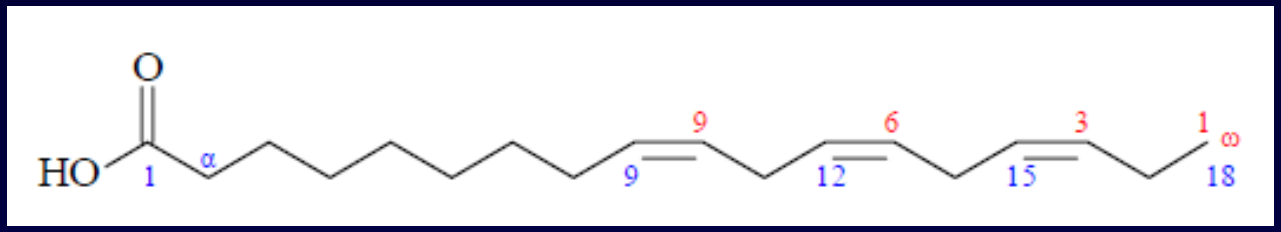
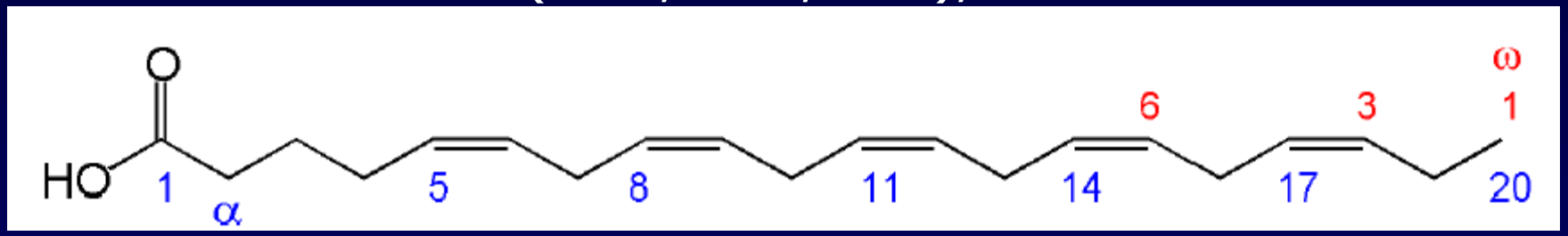
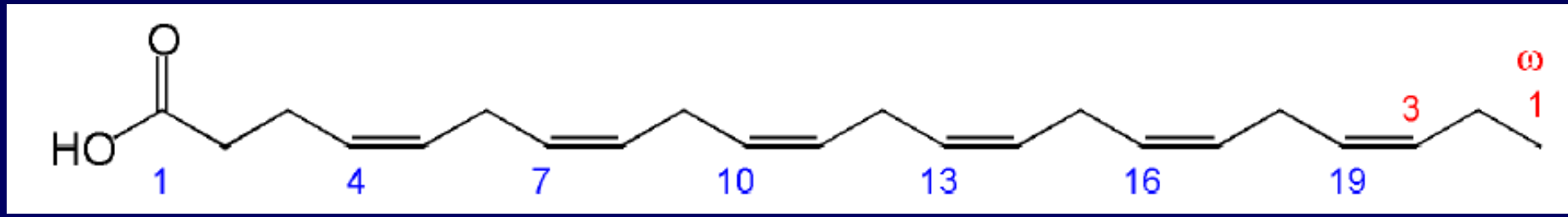
Fatty acid nomenclature



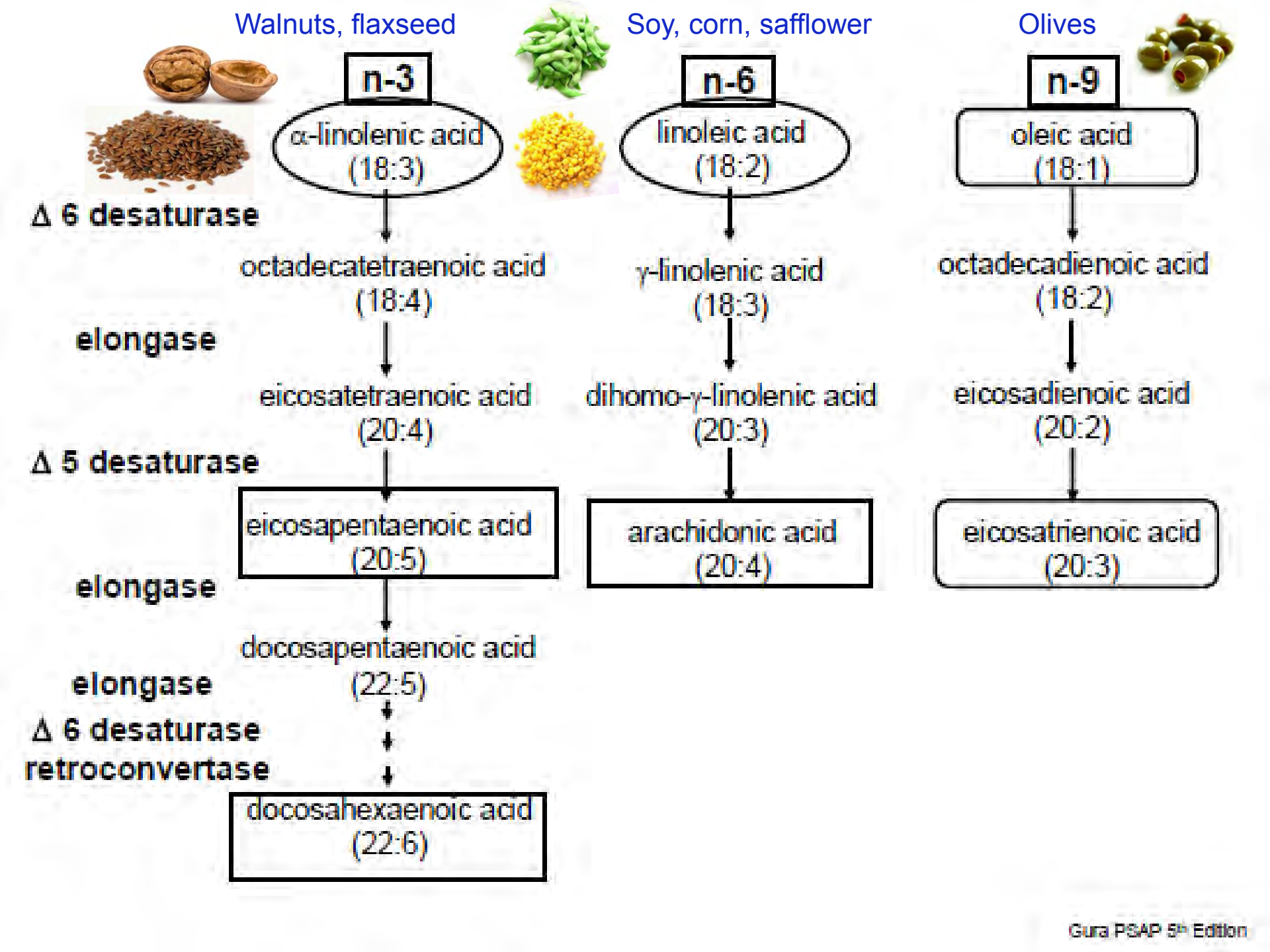
- α-linolenic acid (18:3, *n*–3; ALA),



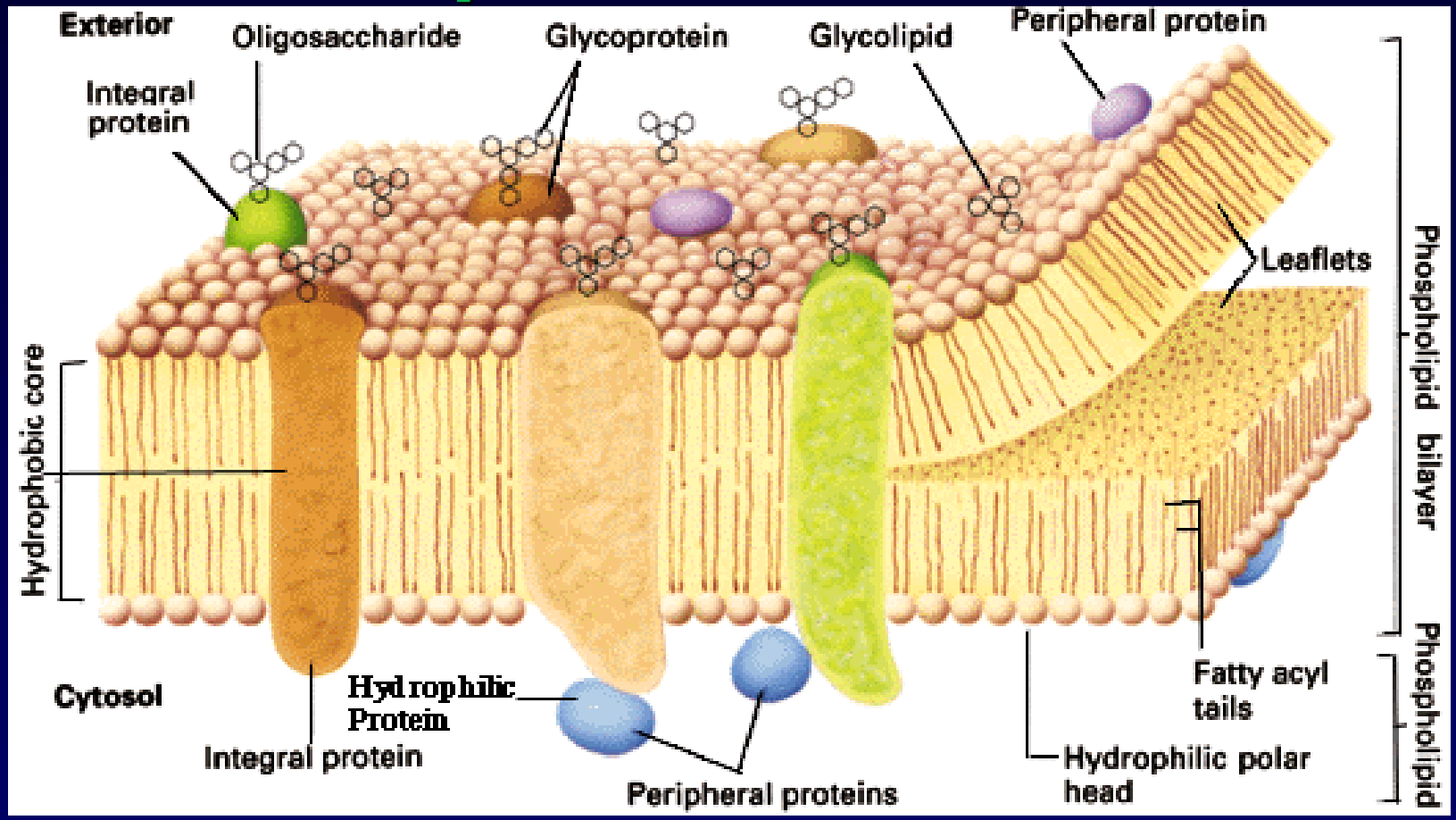
- EicosaPentaenoic Acid (20:5, *n*–3; EPA)



- DocosaHexaenoic Acid (22:6, *n*–3; DHA)

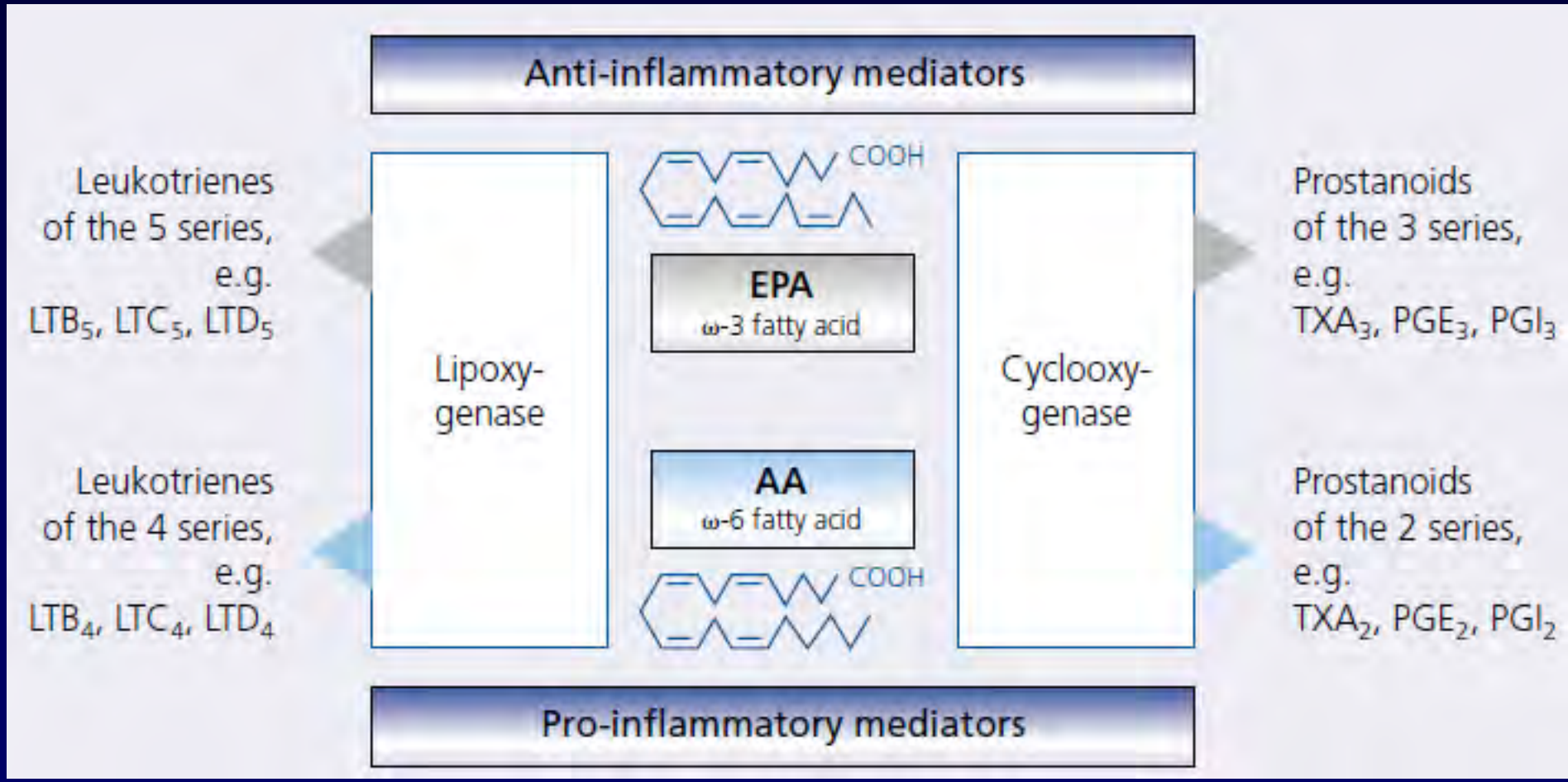

Walnuts, flaxseed
Soy, corn, safflower
Olives
n-3
α-linolenic acid
(18:3)
n-6
linoleic acid
(18:2)
n-9
oleic acid
(18:1)
Δ 6 desaturase
octadecatetraenoic acid
(18:4)
γ-linolenic acid
(18:3)
octadecadienoic acid
(18:2)
elongase
eicosatetraenoic acid
(20:4)
dihomo-γ-linolenic acid
(20:3)
eicosadienoic acid
(20:2)
Δ 5 desaturase
eicosapentaenoic acid
(20:5)
arachidonic acid
(20:4)
eicosatrienoic acid
(20:3)
elongase
docosapentaenoic acid
(22:5)
elongase
Δ 6 desaturase
retroconvertase
docosahexaenoic acid
(22:6)

Dietary Fat influences membrane composition & function



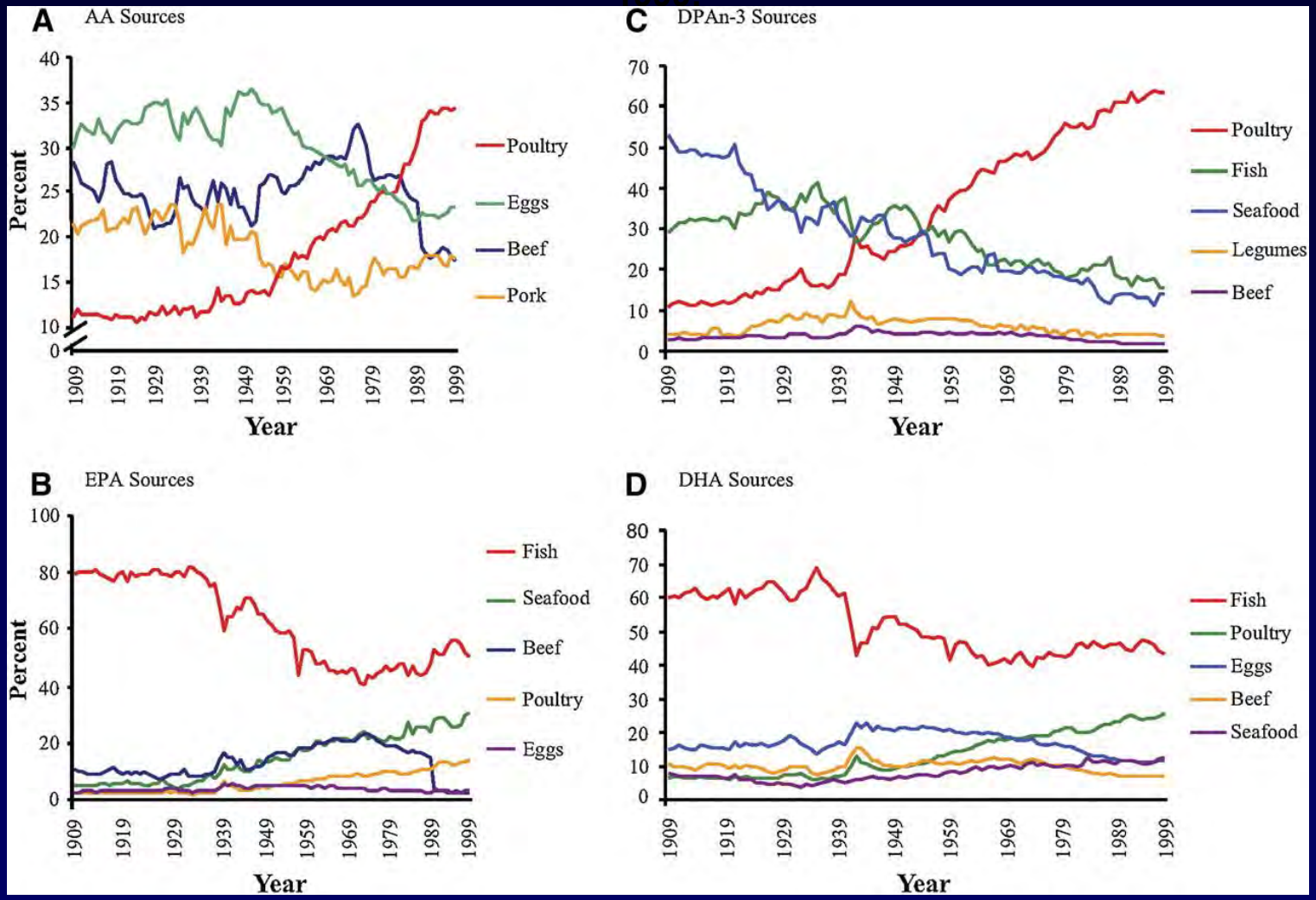
Membrane fluidity, cell signalling, affect PPARs –bind to DNA change cytokines

Eicosanoids derived from eicosapentaenoic acid (EPA) and arachidonic acid (AA)



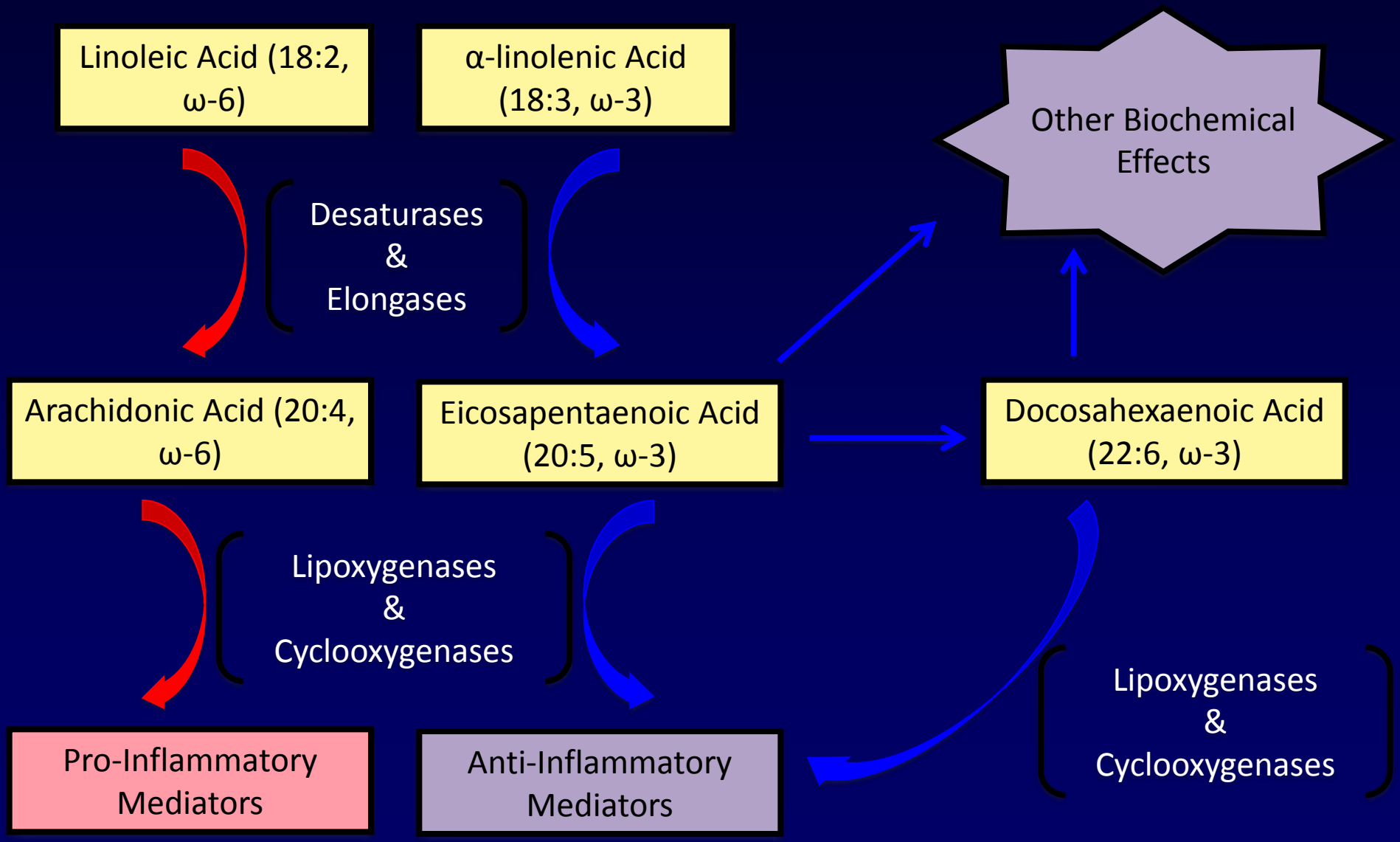
Sources of arachidonic acid (AA) (A), eicosapentaenoic acid (EPA) (B), docosapentaenoic acid (DPAn−3) (C), and docosahexaenoic acid (DHA) (D) from current foods between 1909 and 1999

The American Journal of Clinical Nutrition



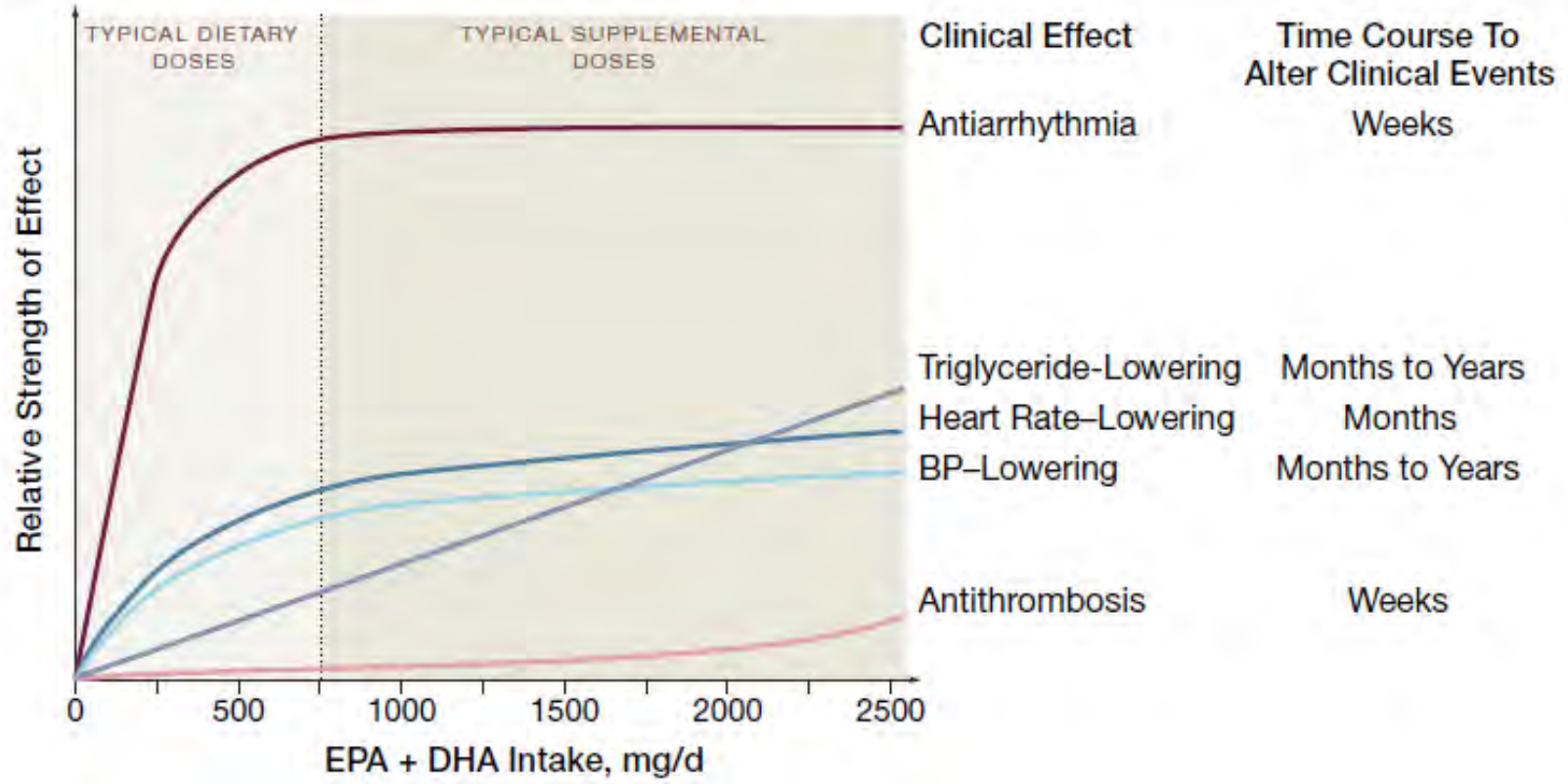
Blasbalg T L et al. Am J Clin Nutr 2011;93:950-962

Quality Assessment - Placebo



Cardiovascular Health

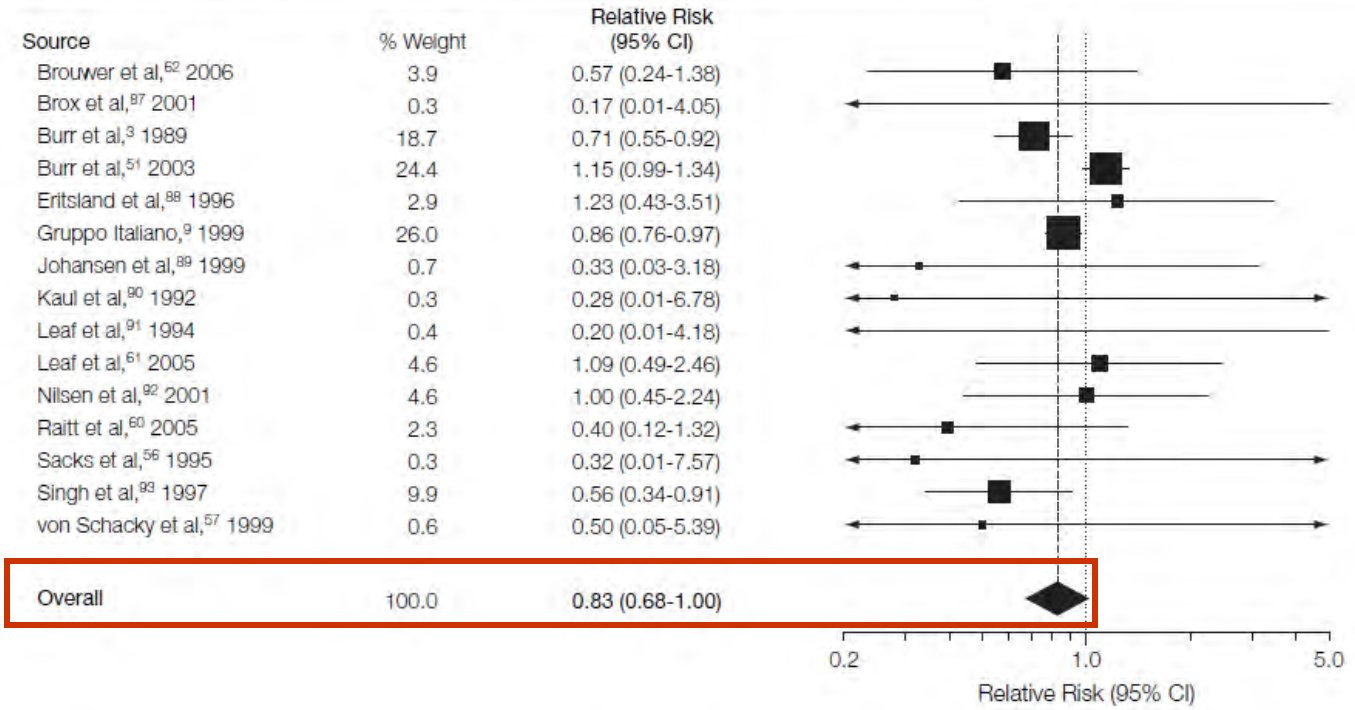
Figure 3. Schema of Potential Dose Responses and Time Courses for Altering Clinical Events of Physiologic Effects of Fish or Fish Oil Intake



Mozaffarian D, Rimm EB. Fish intake, contaminants, and human health: evaluating the risks and the benefits. JAMA 2006 296(15):1885-1899

Inverse relationship between fish oil and total mortality

Figure 4. Risk of Total Mortality Due to Intake of Fish or Fish Oil in Randomized Clinical Trials



↓ 17%

Mozaffarian D, Rimm EB. Fish intake, contaminants, and human health: evaluating the risks and the benefits. JAMA 2006 296(15):1885-1899

Fish oil supplement are not enough

Association Between Omega-3 Fatty Acid Supplementation and Risk of Major Cardiovascular Disease Events

A Systematic Review and Meta-analysis

Evangelos C. Rizos, MD, PhD
Evangelia E. Ntzani, MD, PhD
Eftychia Bika, MD
Michael S. Kostapanos, MD
Moses S. Elisaf, MD, PhD, FASA, FRSH

Context Considerable controversy exists regarding the association of omega-3 polyunsaturated fatty acids (PUFAs) and major cardiovascular end points.

Objective To assess the role of omega-3 supplementation on major cardiovascular outcomes.

Data Sources MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Trials through August 2012.

Conclusion Overall, omega-3 PUFA supplementation was not associated with a lower risk of all-cause mortality, cardiac death, sudden death, myocardial infarction, or stroke based on relative and absolute measures of association.

JAMA. 2012;308(10):1024-1033 www.jama.com

Public Health Nutrition: 15(4), 725–737 doi:10.1017/S1368980011002254

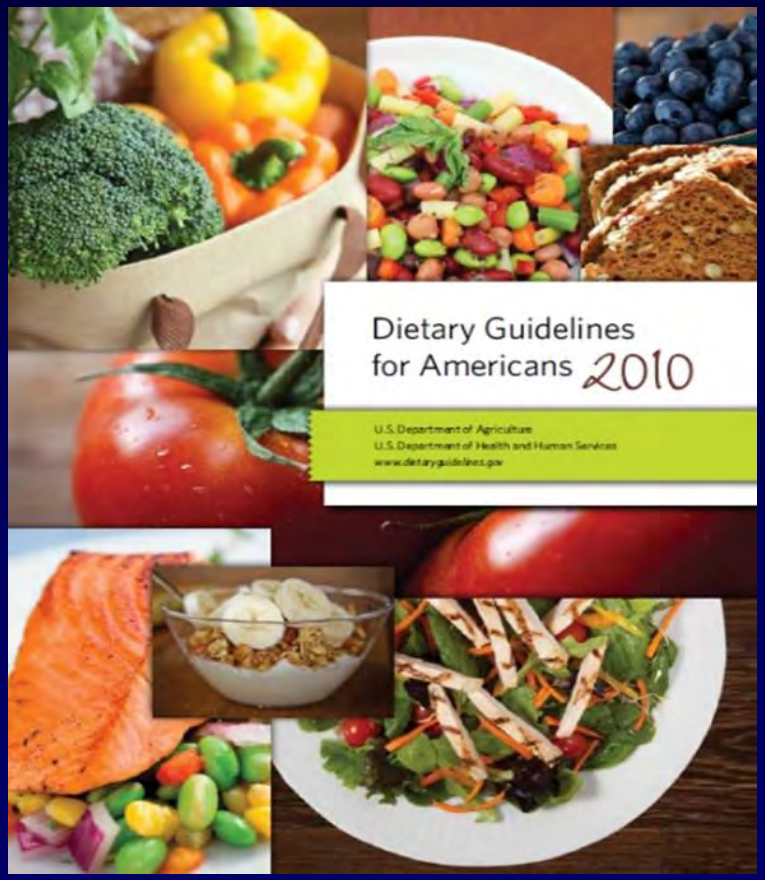
Fish consumption and CHD mortality: an updated meta-analysis of seventeen cohort studies

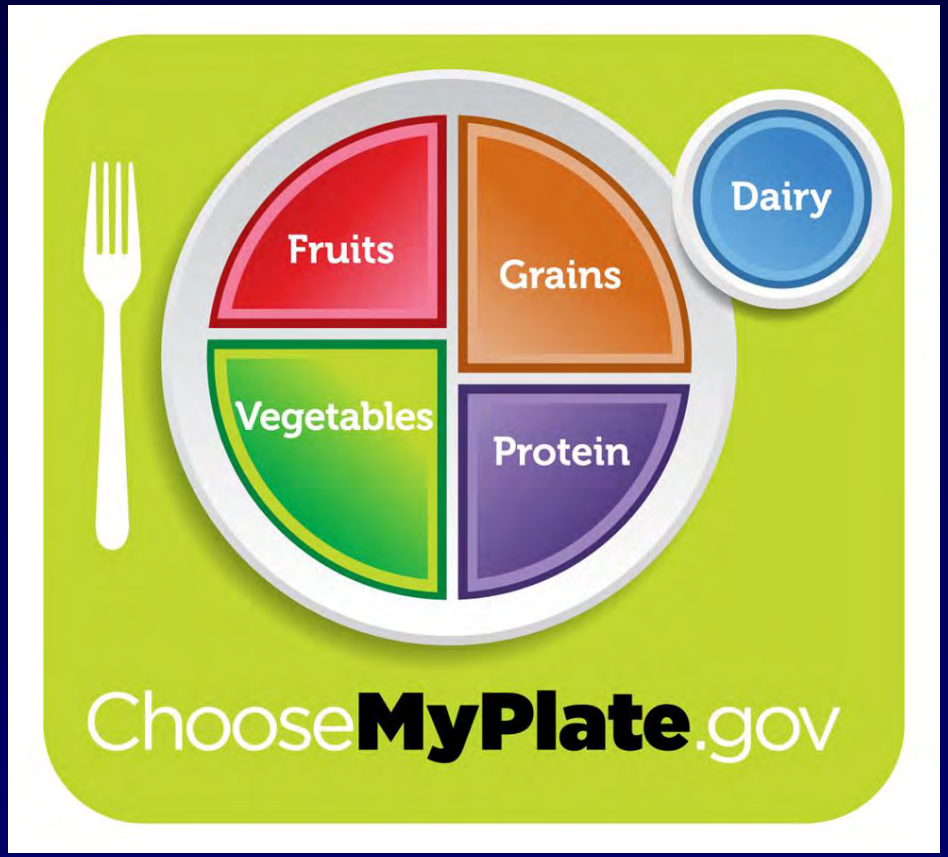
Jusheng Zheng[1], Tao Huang[1], Yinghua Yu[1,2], Xiaojie Hu[1], Bin Yang[1] and Duo Li[1,3,*]
[1]Department of Food Science and Nutrition, Zhejiang University, 268 Kaixuan Road, Hangzhou 310029, People's Republic of China: [2]School of Health Sciences, University of Wollongong, Wollongong, New South Wales, Australia: [3]APCNS Centre of Nutrition and Food Safety, Hangzhou, People's Republic of China

- Low fish intake 1 serving/wk Relative risk of fish intake on CHD mortality was 0.84
- Moderate fish intake of 2-4 servings/ wk Relative risk of fish intake on CHD mortality was 0.79

Healthy foods

Twice a week, make seafood—fish and shellfish—the main protein food on your plate.* Seafood contains a range of nutrients, including healthy omega-3 fats. According to the *2010 Dietary Guidelines for Americans*, eating about 8 ounces per week (less for young children) of a variety of seafood can help prevent heart disease.





How much fish?

- recommend intake of at least two 4 oz servings of fatty fish per week

"Large-scale epidemiologic studies suggest that people at risk for coronary heart disease benefit from consuming omega-3 fatty acids from marine and plant sources. However, more studies are needed to show a cause-and-effect beneficial relationship between ALA and heart disease.

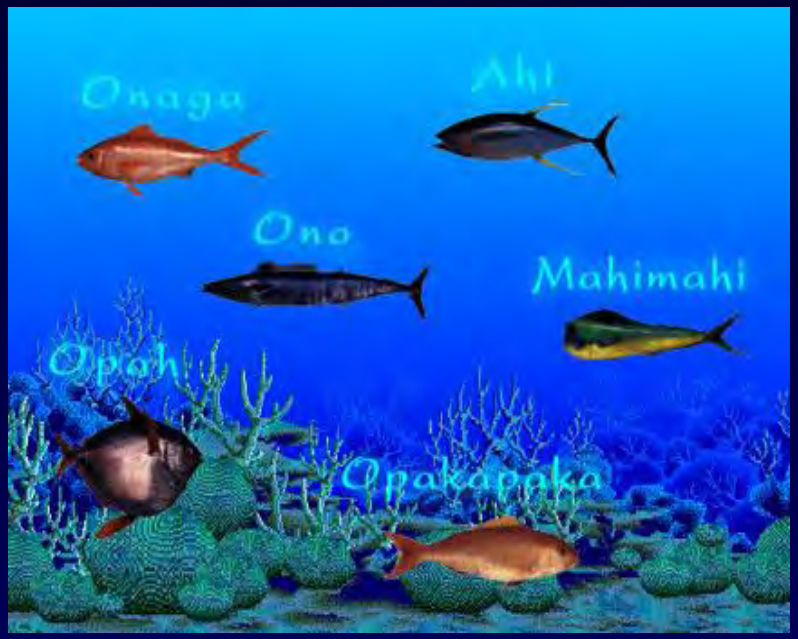
Summary – fish beneficial

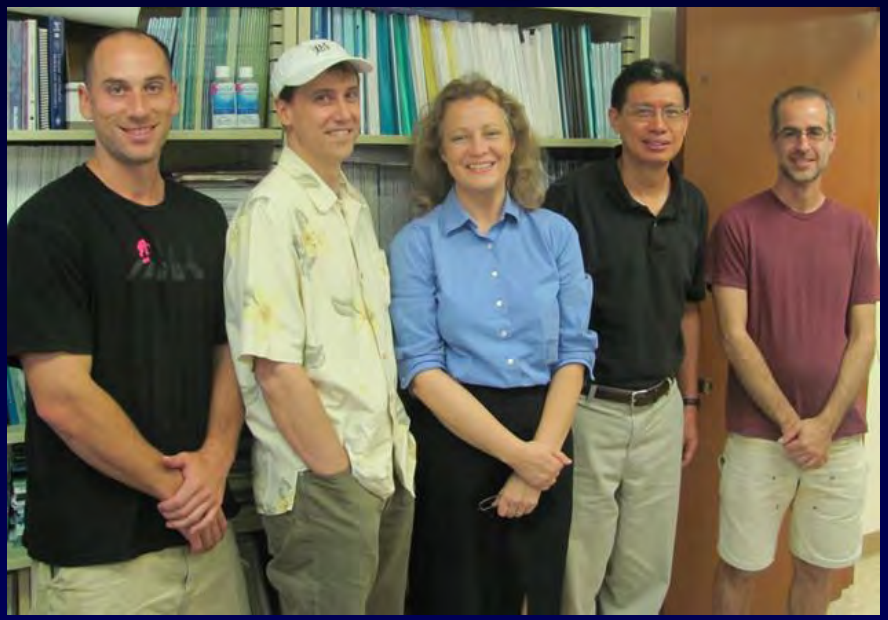
- comparing the benefits of LCn3PUFAs with the risks of methylmercury among women of childbearing age, **maternal fish consumption lowers the risk of suboptimal neurodevelopment in their offspring compared with the offspring of women not eating fish.″WHO 2011**

- **Consuming fish with low level mercury reduces risk of ADHD in children (n=400) in Mass.** *(Archieves of Pediatrics and Adolescent Medicine, 2012)*

- **Consuming high omega 3 fish in obese adolescents is associated with lower fatty liver disease** *(St. Jules, Watters, 2013 in press)*

Review sources and LC omega3





Data on FA composition

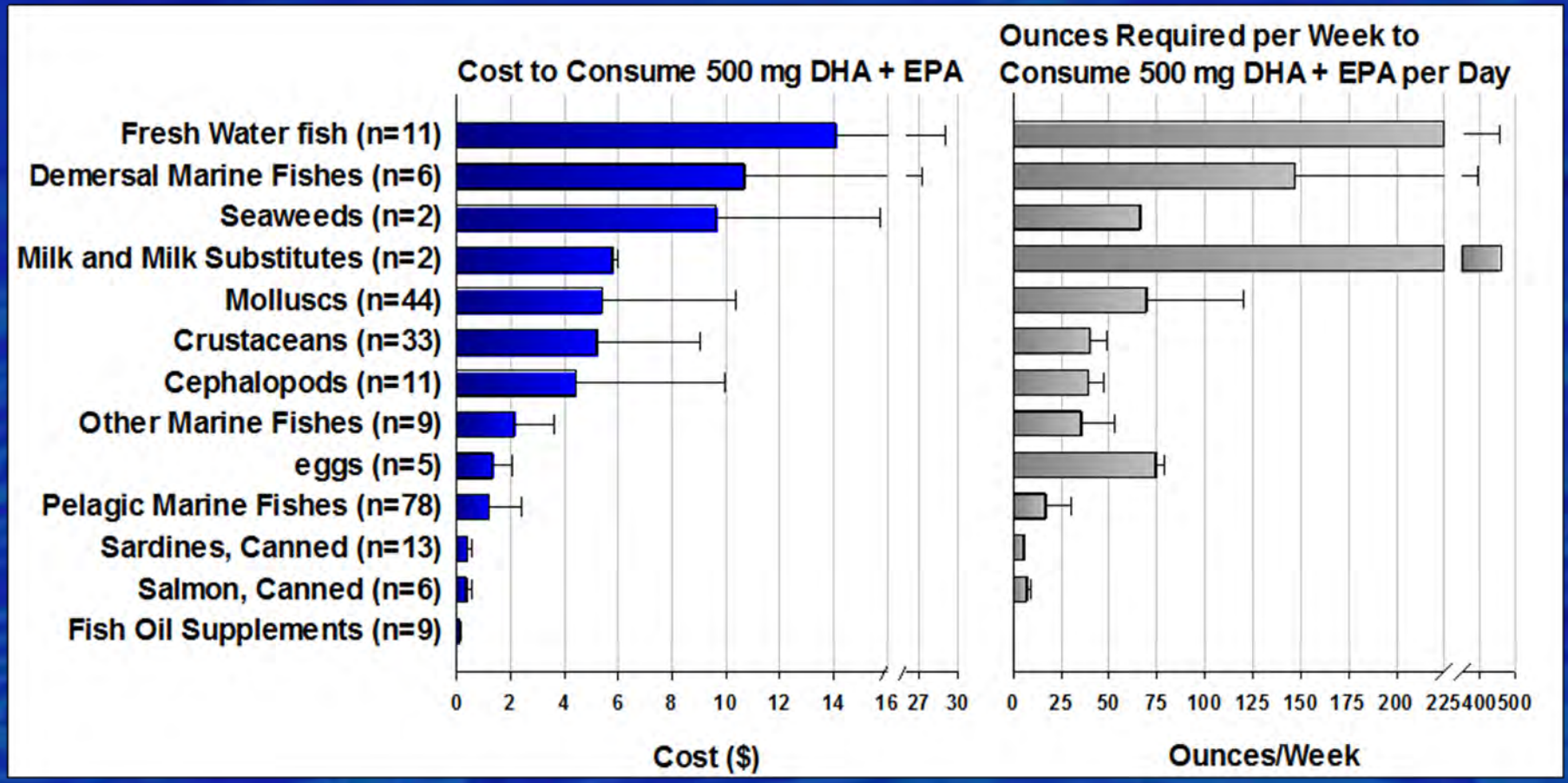
Comparison of the nutritional–toxicological conflict related to seafood consumption in different regions worldwide

Isabelle Sioen [a,b,*], Stefaan De Henauw [a], John Van Camp [b], Jean-Luc Volatier [c], Jean-Charles Leblanc [c]

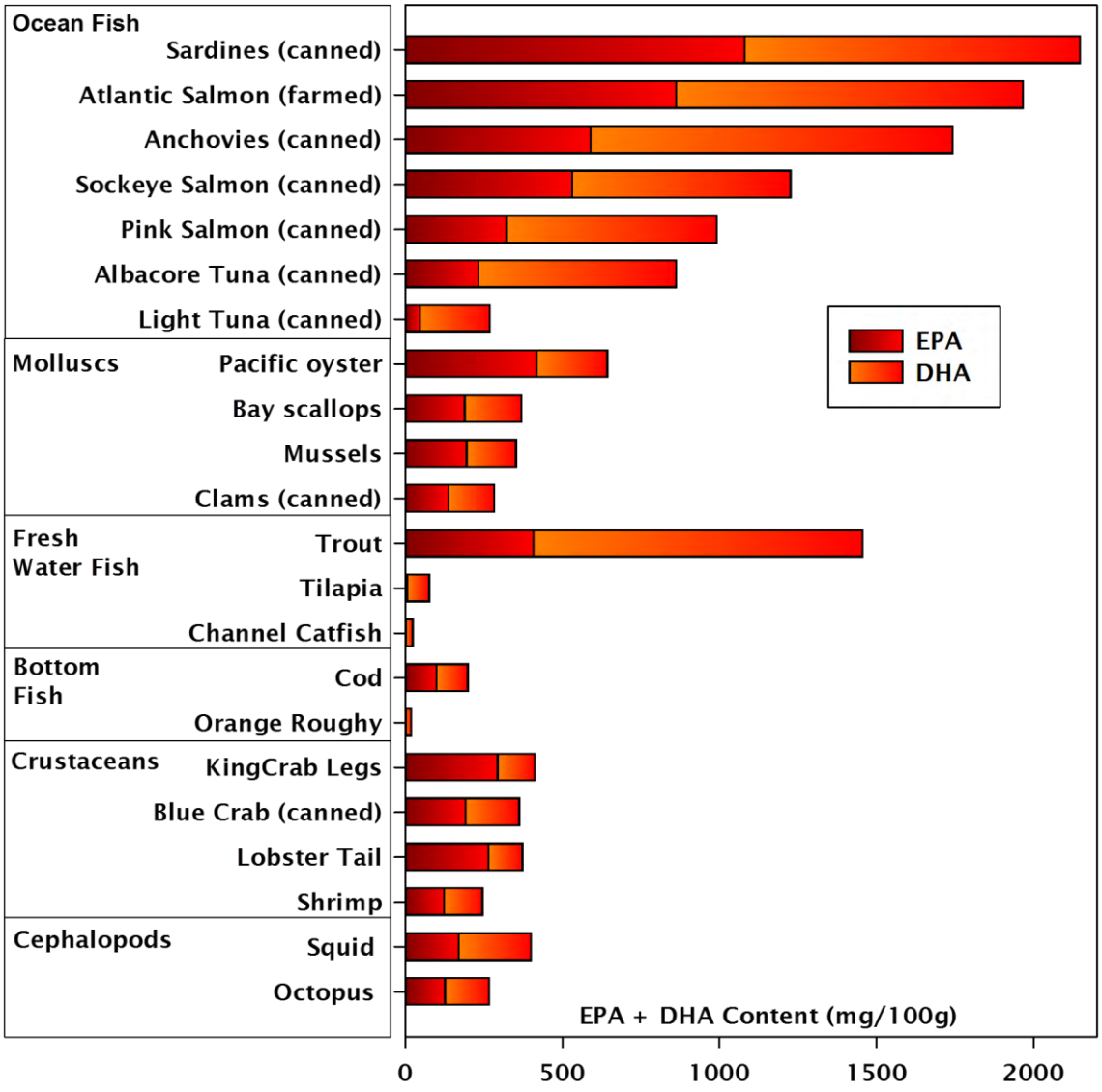
Table 2
The number of species included per seafood group as well as the distribution of the concentration of the different compounds of interest (mean, median and 95th percentile) per seafood group together with the number of data points (*N*) available per compound and per seafood group (between brackets).

Compound	Statistics	Ce	Cr	Mo	DM	PM	OM	FF
Number of species		13	39	27	104	92	15	97
EPA&DHA (mg/100 g)	*N*	17	58	50	169	314	3	116
	Mean	366.2	341.0	371.0	377.8	1445.5	981.0	559.8
	Median	400.0	303.5	298.8	290.0	1300.0	843.0	334.5
	P95	910.0	700.0	950.1	1049.0	3247.5	1900.0	1673.9

Ce, cephalopods; Cr, crustacean; Mo, molluscs; DM, demersal marine fishes; PM, pelagic marine fishes; OM, other marine fishes; FF, fresh water fishes; NA, no data available; totTEQ, sum of dl PCBs and PCDD/Fs; *N*, number of data per seafood group and per compound; P95, 95th percentile.


Cost to Consume 500 mg DHA + EPA
Ounces Required per Week to Consume 500 mg DHA + EPA per Day
Fresh Water fish (n=11)
Demersal Marine Fishes (n=6)
Seaweeds (n=2)
Milk and Milk Substitutes (n=2)
Molluscs (n=44)
Crustaceans (n=33)
Cephalopods (n=11)
Other Marine Fishes (n=9)
eggs (n=5)
Pelagic Marine Fishes (n=78)
Sardines, Canned (n=13)
Salmon, Canned (n=6)
Fish Oil Supplements (n=9)
0 2 4 6 8 10 12 14 16 27 30
Cost ($)
0 25 50 75 100 125 150 175 200 225 400 500
Ounces/Week

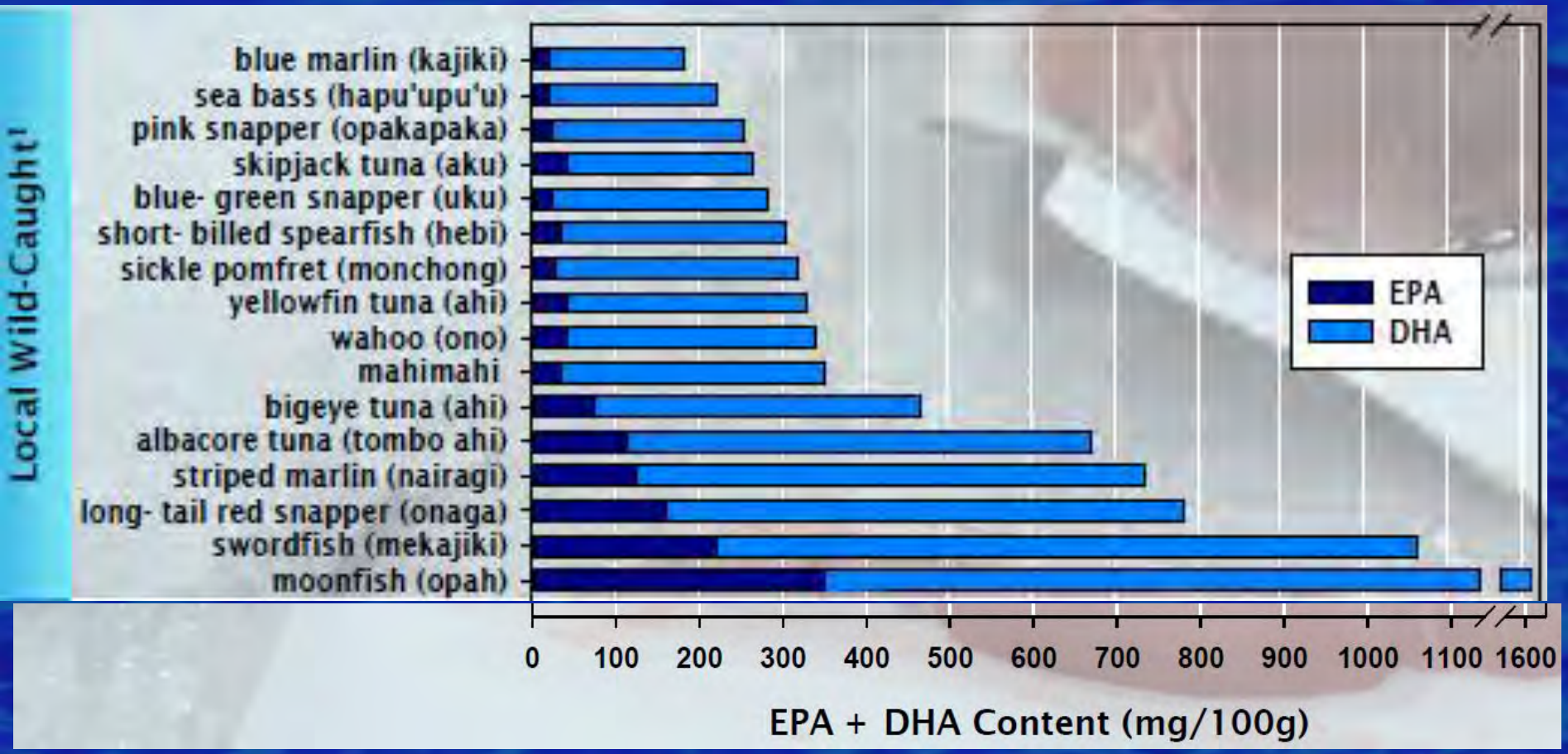
EPA and DHA Content of Selected Non- Local Seafood Available for Purchase in Hawai'i



Hawaii seafood

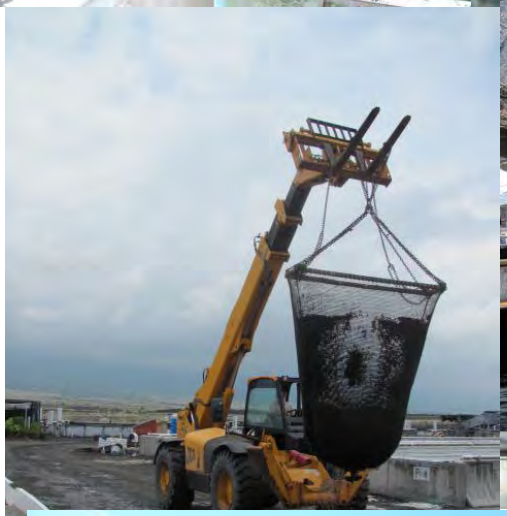
HawaiiSeafood
Hawaii Seafood Council

Local Wild-Caught!




Part III
Aquaculture
Seafood



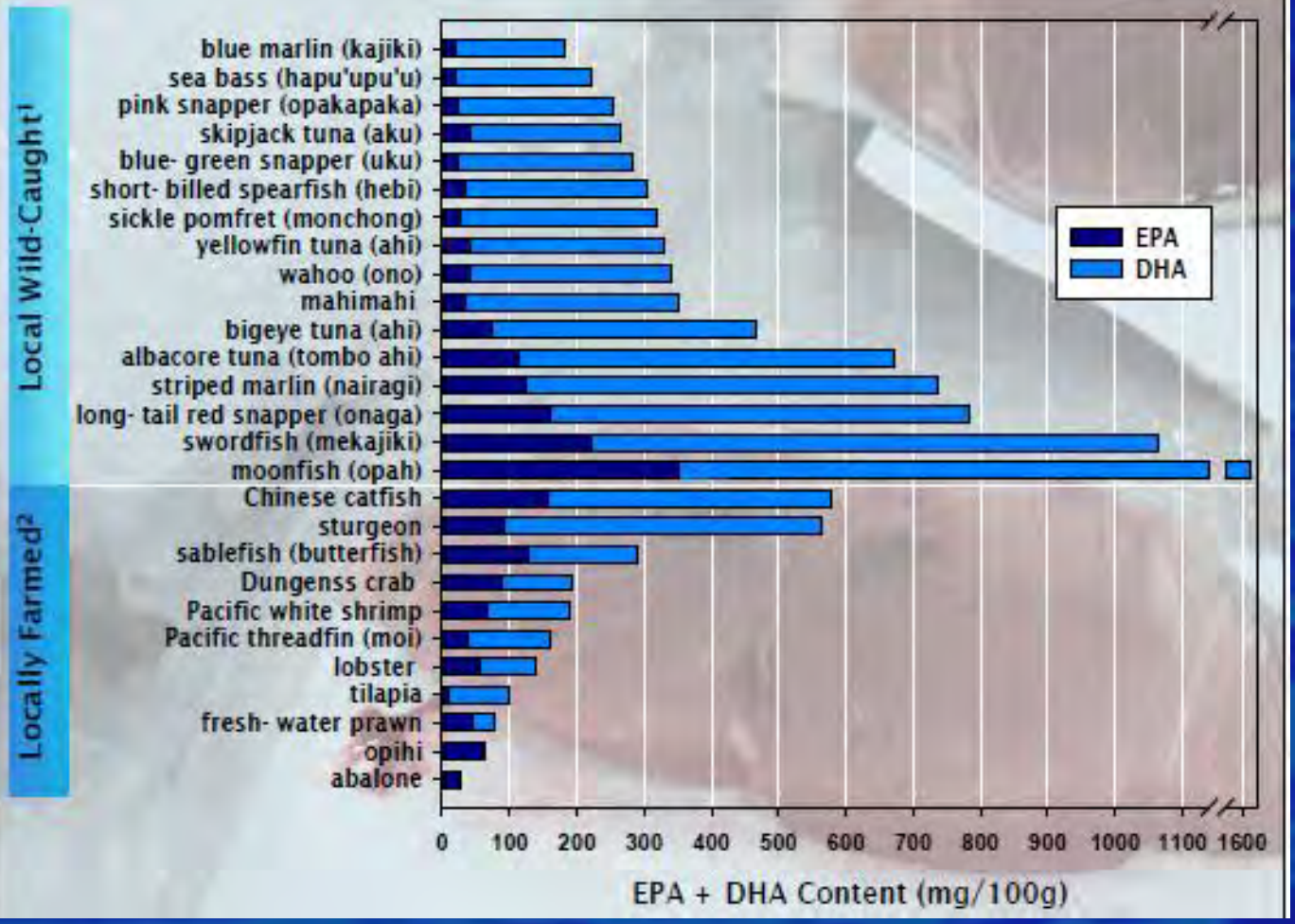




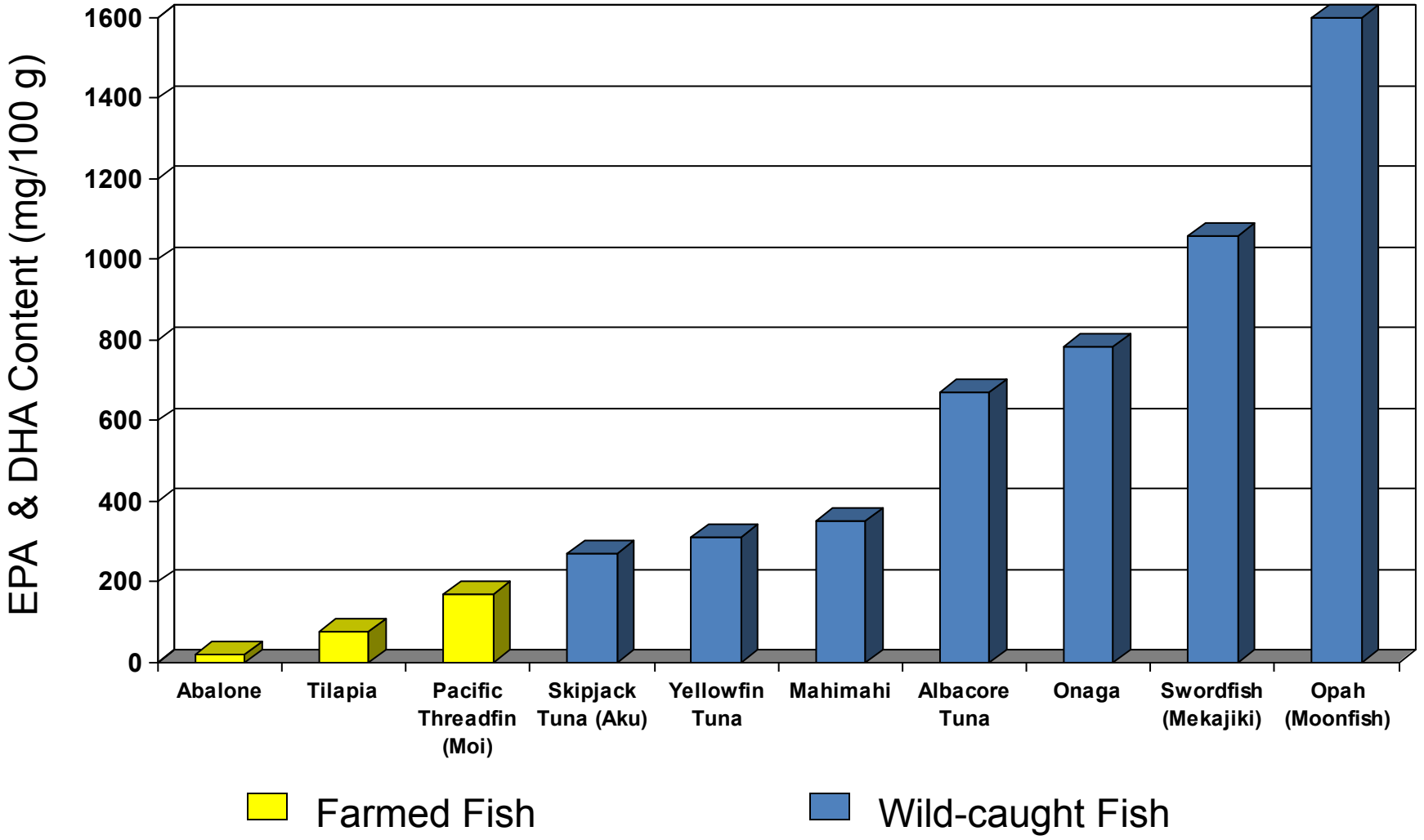
PRAWNS
SHRIMP


Healthy Seafood Hawaii

Long-Chain Omega-3s (EPA and DHA) in Locally Farmed and Wild-Caught Seafood



Long-Chain Omega-3 Content: Local Fish (100 g serving)



Nutritional Enhancement of Long-Chain Omega-3s in Tilapia

- Farm-raised tilapia have low levels of EPA + DHA, which may reflect the nutritional composition of the feed.
- The study objective was to investigate the effect of supplementation of fish oil and dried algae *Schizochytrium sp.*, a rich source of DHA, on growth and fatty acid composition of tilapia.

Tilapia Finishing Feed Trial
Enhancing Catfish Feed with DHA-Rich Algae

1. Freeze-dried Schizochytrium algae

2. Blending algae with water To create slurry

3. Adding slurry to catfish feed

4. Warm-air drying feed to remove added water

Methods

Feeds
- 4 feeds with varying levels of long-chain omega-3 fatty acids

Tanks
- Each feed replicated with 3 tanks
  25 juvenile tilapia each.
- Fish fed once daily to satiation.

Data Collection
- Fish weighed and counted at the onset of the study and monthly.

Fatty Acid Analysis
- At two-month intervals a subsample of fish was removed from each tank and euthanized, weighed and filleted.
- Sample fatty acids were analyzed at the UH Cancer Research Center.

Tilapia Finishing Feed Trial Results

- Long-chain omega-3 fatty acid content in fillets reflects level in feed

Feed	Protein %	Fat %	EPA + DHA (mg/100g)
Control	31.4%	4.4%	4
Schizochytrium	31.5%	4.3%	1280
Fish oil	31.4%	4.4%	735
Silver cup	40.0%	10.0%	1047

Feed	EPA + DHA Content (mg/100g)	N
Control	120 B	9
Schizochytrium	185 A	9
Fish Oil	138 AB	6
Silver Cup	177 A	9

Reference: **Watters C.A.,** Rosner L.S., Franke A.A., Dominy W.G., Klinger-Bowen RE, Tamaru C.S, 2013. Nutritional Enhancement of Long-Chain Omega-3 Fatty Acids in Tilapia (*Oreochromis honorum*), 8 pages. *The Israeli Journal of Aquaculture*

Dr. Watters, RD, Fred Lau, Mari's Garden, Sodexo Chef Phil Shon, Erika Chinn-Galindo,

College of Tropical Agriculture
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University of Hawai'i at Mānoa

Foods and Nutrition
July 2012
FN-11

Nutrition Considerations in Aquaculture: The Importance of Omega-3 Fatty Acids in Fish Development and Human Health

Corilee Watters[1], Scott Iwamura[1], Harry Ako[2], Dong-Fang Deng[3]
[1]Department of Human Nutrition, Food and Animal Science, [2]Molecular Biosciences and Bioengineering, College of Tropical Agriculture and Human Resources, [3]Aquatic Feeds and Nutrition Department, Oceanic Institute

Figure 1. Overview of production to consumption in aquaculture

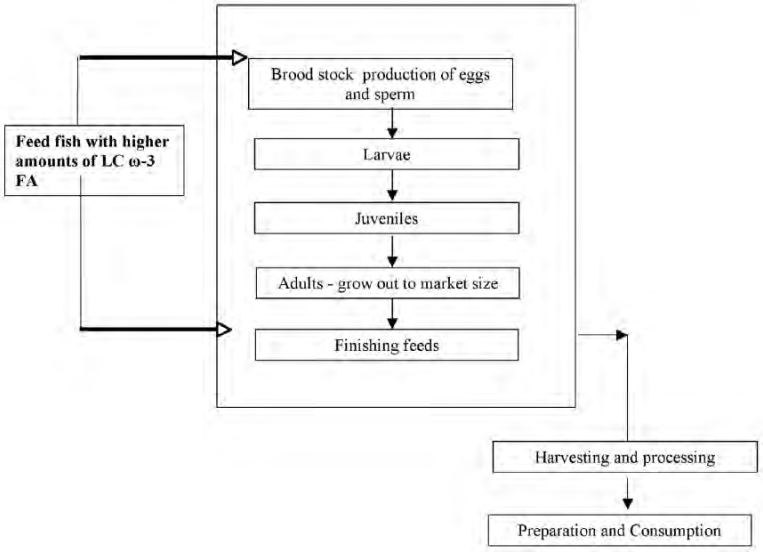


Table 1. Sources of LC ω-3 FA for use in fish feed

Type	Commercial Availability	Total LC ω-3 FA (mg/g dry weight)	EPA (mg/g dry weight)	DHA (mg/g dry weight)
Microalgae *Schizochytrium* sp.				
Algamac 3050 Flake (Larval & post-larval feed) [a]	Aquafauna Bio-Marine Inc., Hawthorne, CA.	24.4	1.6	22.8
Algamac Enhance (Broodstock feed) [a]	Aquafauna Bio-Marine Inc., Hawthorne, CA.	10.2	0	10.2
Fish Oils/Fishmeals				
Ika Omega-3 (Squid Oil) [a]	Aquafauna Bio-Marine Inc., Hawthorne, CA.	14	13.4	0.6
Menhaden oil [b]	Animalfeeds International Corp., Clark, NJ. Omega Protein Inc., Houston TX.	14.7	8.5	6.2
Krill oil [c]	Krill Canada Sales Corp., Langley, BC.	6.9	5.7	1.2
DHA Enrichment Supplements				
Formulated Diet, ABM 4000 Series for larval/post-larval fish; Japonicus Formula [a]	Aquafauna Bio-Marine Inc., Hawthorne, CA.	14.5	9.1	5.4
Isochrysis galbana, microalgae DHA supplement [d]	Reed Mariculture Inc., Campbell CA.	3.5	0.3	3.2

[a] Data from Aquafauna Bio-Marine Inc. Web site, http://www.aquafauna.com/Products.htm.
[b] Data provided by Osman et al. (2001) for standardized menhaden oil.
[c] Data for Antarctic krill from Krill Canada Sales Corp Web site, www.krill.ca/analysis.html.
[d] Data provided by Tokusoglu & Unal (2003).

Healthy Seafood Hawaii

A Splash OF ALOHA

A Healthy Guide to Fresh Hawaiian Seafood

KAPI'OLANI COMMUNITY COLLEGE
University of Hawai'i

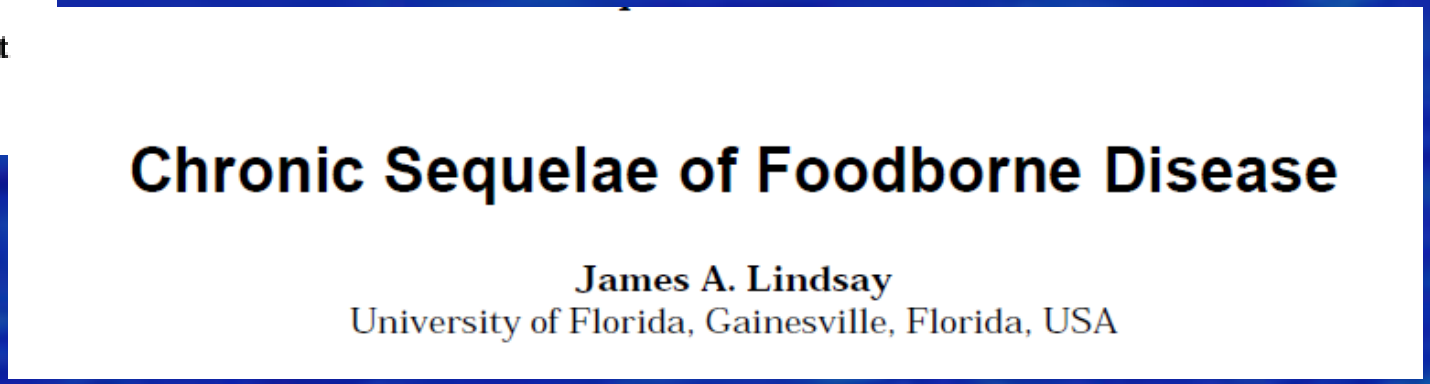
Fish Preparation and Cooking Methods

6. Place the fillet on the pan to sauté, presentation side down.

7. Check, and turn over when it is golden brown.

8. Cook the other side until it is also golden brown, or to desired doneness.

9. Place on serving plate and garnish or add your favorite sauce.

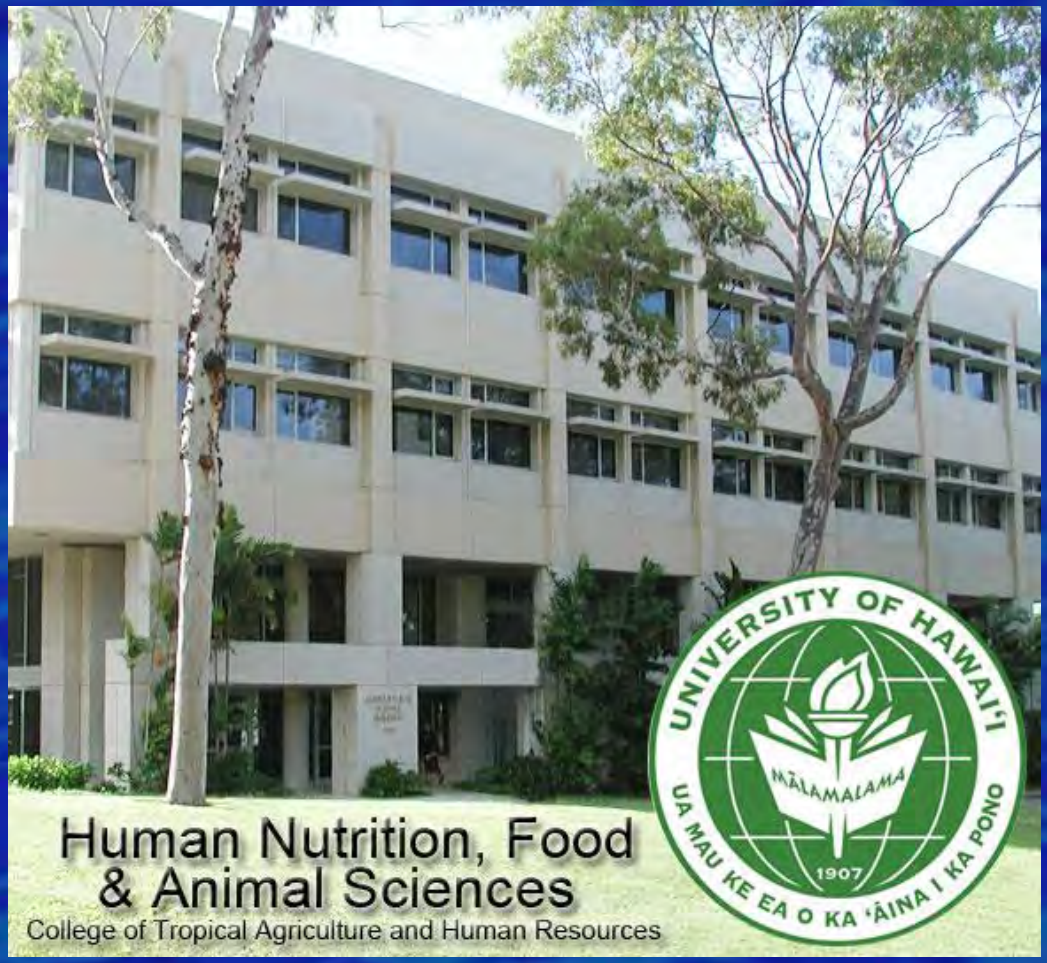


- - E.coli 0157: H7 causing hemolytic uremic syndrome and acute renal failure
  -Shigella, Salmmonella spp, Campylobacter jejuni, and E. coli can initiate aseptic or reactive arthritis.
  -**Campylobacter jejuni bacteriophage defence, virulence and Guillain-Barré syndrome (**Eur J Clin Microbiol Infect Dis. 2012 Sep 4.)
  -Ciguatera poisoning related to fin fish, acute toxicosis with cranial nerve dysfunction and cardiac arrhythmias; chronic symptoms may be misdiagnosed as chronic fatigue syndrome or multiple sclerosis

Teach someone to *fish* and they *eat* for a lifetime

Teach someone *how to cook and eat fish* **in a safe manner** and they'll be healthy for a lifetime.

http://www.ctahr.hawaii.edu/hnfas/



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