

VITAMIN A AND D IN FISH LIVERS AND VISCERA

By Charles Butler*

During the past five or six years, interest in vitamin-bearing raw materials has become more wide-spread due to the mushroom growth of vitamin oil production. Many new, or hitherto unidentified, species of livers, especially those from the shark group, have become commercially important. The need for a tabulation of data on vitamin A and D in fish livers and viscera has often been apparent. Tables 1, 2, and 3 of this report have been prepared, therefore, to serve as a ready reference to pertinent data that are available on several of the factors influencing the value of fish livers and viscera.

Table 1 includes the data for those fish that contribute the major portion of the raw materials for the vitamin A industry of the United States and Canada. The order of the listing in this table is based on the approximate importance of the species in the vitamin A production for 1944. Since that time, some changes have undoubtedly occurred. For example, the landings of soupfin shark livers at Seattle have declined very substantially, and very probably, livers from other species such as the grayfish (dogfish) have fallen off to a lesser degree. Nevertheless, in general, the same order of importance holds for the several species reported.

In Table 2, all the vitamin A data for the other miscellaneous species is grouped according to area of capture.

The vitamin D potency ranges for miscellaneous fish livers and viscera are presented in Table 3. The grouping is again by area of capture.

In each of these three tabulations the basic data have been collected from all available sources and converted, as nearly as possible, to a comparable unit basis. Wherever a sufficient number of analyses were available, an evaluation of the oil content and vitamin content data was made in the determination of the ranges for these values as used in the tables.

Any attempt to acknowledge all the contributions of data from individuals, companies, or institutions that were considered in making up these tables would result in a list of references considerably longer than the compilations themselves. Several major sources of valuable information were:

1. The published reports of the fisheries research laboratories of Canada, South Africa, and Australia, and of the International Halibut Commission.
2. Published and unpublished data collected over a number of years at the Seattle Technological Laboratory of the Fish and Wildlife Service in connection with the vitamin A investigation.
3. Numerous reports in the scientific literature of investigations on new or slightly utilized species by individuals and organizations.

In a compilation of this type it is difficult to assign an accurate single value for many of the individual items, such as the oil content or the vitamin A content, because of the extreme variations encountered in fish. These variations may be due, in part, to one or all of the following: Sex, maturity, stage in the season or migration, food supply, etc. Exceptional analyses, such as that of a halibut liver oil assaying over 1,000,000 units of vitamin A per gram, or a grayfish (dogfish) liver assaying 100,000 units, have not been considered in arriving at the ranges used in these tables. Where only one value is listed, that is the only information available for the particular species, and it usually represents the result from a single analysis or from a limited number of analyses.

Tables 1, 2, and 3 appear on the following pages.

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Table 1 - Vitamin A Content of Oils from Fishery Sources having Commercial Importance in the United States & Alaska^{1/}

Common name	Scientific name	Area in which fish are caught	Source of oil	Percent of round weight ^{2/}	Oil content, percent	Vitamin A content in U. S. Pharmacopoeia units per gram of oil		
						Range	Average	
Southern shark	Galeorhinus zyopterus	Pacific (male)	liver	10	55-68	45,000-	200,000	120,000
" "	" "	" (female)	"	10	65-72	15,000-	40,000	32,000
Grayfish (dogfish)	Squalus suckleyi	" -Alaska	"	10	67-72	2,000-	20,000	5,000
" "	" "	" -Hecate Strait	"	10	65-70	7,000-	15,000	10,000
" "	" "	" -Wash.-Ore.	"	10	50-70	8,000-	25,000	14,000
" "	" "	" -N. Calif.	"	10	62-68	12,000-	20,000	15,000
Halibut	Hippoglossus hippoglossus	Pacific-Area ^{3/}	liver	1.5-3	8-21	40,000-	160,000	87,000
" "	" "	" - " ^{4/}	"	1 -1.75	17-27	20,000-	65,000	40,000
" "	" "	" "	viscera ^{5/}	2.5-5	2-5	70,000-	700,000	200,000
Sablefish	Anoplopoma fimbria	Pacific	liver	2 -2.5	10-26	50,000-	190,000	90,000
" "	" "	"	viscera	3 -4	5-12	90,000-	250,000	125,000
Lingcod	Ophiodon elongatus	Pacific	liver	1 -1.5	8-20	40,000-	550,000	175,000
" "	" "	"	viscera	1.8-3	4-15	10,000-	175,000	40,000
Sleeper shark	Somniosus microcephalus	Pacific	liver	10 -15	40-55	5,000-	15,000	7,000
Mud shark	Hexanchus griseus	"	"	10 -15	60-65	5,000-	7,000	5,500
Great blue shark	Prionace glauca	"	"	6/	30-45	7,000-	27,000	20,000
Hammerhead shark	Sphyrna zygaena	" -Atlantic	"	6/	30-40	30,000-	120,000	50,000
" "	" diplana	"	"	6/	55-75	20,000-	150,000	60,000
" "	" "	Atlantic	"	6/	6/	5,000-	140,000	40,000
" "	" tudes	Florida	"	6/	6/	10,000-	125,000	50,000
Little black tip	Isogomphodon maculipinnis	Florida	"	6/	40-60	5,000-	25,000	5,000
Tiger shark	Galeocerdo arcticus	"	"	6/	45-60	2,000-	5,000	3,000
Sand-bar shark	Carcharinus milberti	"	"	6/	6/	3,000-	15,000	8,000
Nurse shark	Giglymostoma cirratum	"	"	6/	6/	1,000-	10,000	3,000
Dusky shark	Carcharinus obscurus	"	"	6/	6/	5,000-	60,000	25,000
Leopard shark	Triakis semifasciatus	Pacific	"	6/	40-50	1,000-	5,000	3,000
Bay shark	Carcharias lamiella	"	"	6/	60-75	2,000-	20,000	10,000
Thresher shark	Alopias vulpas	"	"	6/	45-55	1,000-	5,000	3,000
Mexican shark	Eulamia lamiella	"	"	6/	40-50	20,000-	80,000	40,000
Gray smooth hound	Mustelatus californicus	"	"	6/	50-60	10,000-	25,000	20,000
Cazon shark	Unknown	Argentina-Brazil	"	7 -10	30-45	10,000-	200,000	50,000
Albacore tuna	Germo alalunga	Pacific	"	1.5-2	7-20	10,000-	60,000	25,000
Bluefin tuna	Thunnus thynnus	"	"	6/	4-6	25,000-	100,000	75,000
Yellowfin tuna	Neothunnus macropterus	"	"	6/	3-5	35,000-	90,000	50,000
Skipjack tuna	Euthynnus pelayms	"	"	6/	4-6	30,000-	60,000	40,000
Bonito	Sarda chiliensis	"	"	6/	4-12	15,000-	60,000	35,000
Swordfish	Xyphias gladius	Pacific-Atlantic	"	1.4-2.6	8-35	20,000-	400,000	250,000
" "	" "	" "	viscera	3 -6	6-12	2,000-	30,000	10,000
Black sea bass	Stereolepis gigas	Pacific	liver	6/	13-20	100,000-	1,000,000	300,000

(Continued on the following page)

Table 1 - Vitamin A Content of Oils from Fishery Sources having Commercial Importance in the United States & Alaska^{1/}(Cont.)

Common name	Scientific name	Area in which fish are caught	Source of oil	Percent of round weight ^{2/}	Oil content, percent	Vitamin A content in U. S. Pharmacopoeia units per gram of oil	
						Range	Average
Totuava	<i>Cynoscion nobilis</i>	Pacific	liver	6/	15-25	40,000-400,000	6/
Cod	<i>Gadus callarias</i>	Atlantic	"	3-5	20-60	1,000- 6,000	2,000
Rosefish	<i>Sebastes marinus</i>	"	waste ^{7/}	6/	2-4	3,000- 5,000	6/
Halibut	<i>Hippoglossus hippoglossus</i>	"	liver	1.5-2.5	15-25	40,000	6/
Rockfish	<i>Sebastes</i>	Pacific	"	1-1.5	5-25	14,000-300,000	6/
"	"	"	viscera	1.5-2.5	2-15	15,000-125,000	6/
Petrale sole	<i>Eopsetta jordani</i>	Pacific	liver	1-1.5	6-25	4,000-175,000	6/
Herring	<i>Clupea pallasii</i>	"	body	6/	5-25	50- 300	90
Pilchard	<i>Sardina caerulea</i>	"	"	6/	5-25	50- 800	100
Menhaden	<i>Brevoortia tyrannus</i>	Atlantic	"	6/	5-20	500	6/

1/ These data compiled from reports of research at the laboratories of the Fish and Wildlife Service and of the Fisheries Research Board of Canada, and from articles published by representatives of commercial processors of fish livers and viscera. For the most part, the data are based on large lots of material or on samples taken over the normal season for the species. Vitamin D data for some of these species are included in Table 3.

2/ Percent of round weight means the proportion of liver weight to the weight of the entire fish (undressed) expressed as percent.

3/ Area 3 is defined by the International Halibut Commission regulations as follows: "Area 3 shall include all the convention waters off the coast of Alaska that are between Area 2 and a straight line running south from the southwestern extremity of Cape Sagak on Umnak Island, at a point approximately latitude 52° 49' 30" N., longitude 169° 07' 00" W., according to Chart 8802, published January, 1942, by the United States Coast and Geodetic Survey, and that are south of the Alaska Peninsula and of the Aleutian Islands and shall also include the intervening straits or passes of the Aleutian Islands."

4/ Area 2 includes: "all convention waters off the coasts of the United States of America and of Alaska and of the Dominion of Canada between Area 1B and a line running through the most westerly point of Glacier Bay, Alaska, to Cape Spencer Light as shown on Chart 8304, published in June, 1940, by the United States Coast and Geodetic Survey, which light is approximately latitude 58° 11' 57" N., longitude 136° 38' 18" W., thence south one-quarter east and is exclusive of the areas closed to all halibut fishing in Section 9 of these regulations."

5/ Viscera, unless otherwise designated, means the contents of the body cavity minus the liver, stomach, and gonads.

6/ The source from which information listed here was obtained did not supply data under this heading.

7/ Waste is the entire body of the rosefish minus the fillet or edible portion. It includes head, backbone, skin, and viscera.

Table 2 - Vitamin A Content of Oils from Fishery Sources having Little or No Present Commercial Importance in the U.S. & Alaska^{1/}

Common name	Scientific name	Area in which fish are caught	Source of oil	Percent of round weight ^{2/}	Oil content, percent	Vitamin A content in U. S. Pharmacopoeia units per gram of oil
Basking shark	Cetorhinus maximus	Pacific	liver	3/	60-70	300
Spotted cow shark	Notorynchus maculatus	"	"	6	29	1,400
Cod	Gadus macrocephalus	"	"	1.5-4	25-45	5,000- 17,000
"	"	"	viscera ^{4/}	3.2-3.6	1.4-2.6	36,000-112,000
Cabrilla	Epinephelus analogus	"	liver	3/	13	164,000
Cormuda	Unknown	"	"	3/	50	30,000
Pejerala	"	"	"	3/	27	98,000
Yellowtail	Seriola dorsalis	"	"	3/	5-7	20,000- 40,000
Arrow-tooth halibut	Atheresthes stomias	"	"	3/	10-15	10,000- 80,000
English sole	Parophrys vetulus	"	"	1 -1.5	5-10	5,000
Starry flounder	Platichthys stellatus	"	"	1.5-2	10-15	1,000- 25,000
King salmon	Oncorhynchus tshawytscha	"	"	3/	4-8	10,000- 40,000
"	"	"	offal ^{5/}	30	10-15	1,500- 2,000
Sockeye ^{6/}	" nerka	"	liver	1.5-2	5-8	10,000- 50,000
"	"	"	offal	33	10-20	500- 5,000
Silver ^{6/}	" kisutch	"	liver	1.5-2.5	4-6	10,000- 30,000
"	"	"	offal	33	10-15	500- 3,000
Pink ^{6/}	" gorbuscha	"	liver	3/	4-6	1,000- 40,000
"	"	"	offal	35	10-12	500- 3,000
Chum ^{6/}	" keta	"	liver	1.5-2.5	2-6	5,000- 15,000
"	"	"	offal	33	5-10	none
Steelhead	Salmo gairdneri	"	liver	2/	10-20	10,000- 20,000
Skate	Raja binoculata	"	"	3/	30-60	500- 3,000
Starry skate	" stellulata	"	"	3/	10-30	4,000- 30,000
Ratfish	Hydrolagus colliei	"	"	3/	70-85	100- 1,000
Finback whale	Balaenoptera velefera	"	"	3/	0.8	40,000
Sperm whale	Physeter macrocephalus	"	"	3/	1.0	440,000
Beluga ^{6/}	Delphinapterus leucas	"	"	3/	0.3	10,000
Stockfish	Merlucius capensis (Castel.)	South Africa	"	2.5-4	28-50	6,000- 28,000
"	" " "	" "	viscera	0.7-1.0	2.5-3.5	80,000-650,000
Kingklip	Genypterus capensis (Smith)	" "	liver	1.3-3.3	25-45	7,000- 52,000
"	" " "	" "	viscera	2.0	1-2	10,000- 32,000
Kabeljou	Sciaena hololepidota (Lacep.)	" "	liver	3/	25	85,000
Stone-bass	Polyprion americanus (Bl. & Schn.)	" "	"	1.6	10-20	75,000-700,000
Blue shark	Unknown	" "	"	3/	3/	15,000- 30,000
Dogfish	"	" "	"	3/	3/	4,000- 6,000
John Dory	Zeus capensis (C. & V.)	" "	"	4-5	13-37	8,000- 44,000
"	" " "	" "	viscera	3-3.5	1-5	20,000-100,000

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Table 2 - Vitamin A Content of Oils from Fishery Sources having Little or No Present Commercial Importance in the U.S. & Alaska^{1/}
(Continued)

Common name	Scientific name	Area in which fish are caught	Source of oil	Percent of round weight ^{2/}	Oil content, percent	Vitamin A content in U. S. Pharmacopoeia units per gram of oil
Halibut	Unknown	South Africa	liver	3/	3/	50,000
Cod	"	" "	"	3/	"	1,000
Snoek	Thyrsites atun (Euphrasen)	" "	"	1.5	16.5	14,000-560,000
"	" " "	" "	viscera	1.6	11.7	20,000-160,000
Horse mackerel	Trachurus trachurus, Lin.	" "	liver	1.25-2.75	5-15	80,000-600,000
" "	" " "	" "	viscera	1.25-3	2-15	20,000-130,000
Bonito	Isurus glaucus	Florida	liver	3/	40-50	500- 1,500
Mackerel shark	Carcharinus platyodon	"	"	3/	"	2,000- 4,500
Black-nose shark	" scronotus	"	"	3/	"	1,200
No-name shark	" falciformis	"	"	3/	"	6,600
Silky shark	" floridanus	"	"	3/	"	2,000- 5,000
Bonnet-head	Sphyrna tiburo	"	"	3/	"	900
Great white shark	Carcharodon carcharias	"	"	3/	"	700- 7,000
Spotted eagle ray	Stoasodon narinari	"	"	3/	"	35
Cow-nosed ray	Rhinoptera bonasus	"	"	3/	"	675
Manta	Manta birostris	"	"	3/	"	200- 400
Sawfish	Pristis pectinatus	"	"	3/	"	900- 7,000
Congrio negro	Genyoterus chilensis	Chile	"	3/	"	1,000- 2,000
Cow shark	Unknown	"	"	3/	54-70	1,600- 3,000
Raya	"	"	"	3/	30	13,000
Barn-door skate	"	"	"	3/	52	4,000
Tollo	Galeorhinus mento	"	"	3/	20-53	1,200- 87,000
Peje-gallo	Callorhynchus callorhynchus	"	"	3/	28-41	700- 1,600
Pinta roja	Unknown	"	"	3/	7-41	1,300- 4,600
Spiny dogfish	"	"	"	3/	41-46	6,000- 14,000
Six-gill shark	"	"	"	3/	85	1,500
Bacalao	Polyprion oxigensis	"	"	3/	0.3-5.4	16,000-425,000
Sierra	Thysitops lepidopoides	"	"	3/	0.8	208,000
Unknown shark	Galeorhinus	"	"	3/	57	49,000
Merluza	Unknown	"	"	3/	25-37	3,000- 4,000
Hammerhead shark	Sphyrna zygaena	Brazil	"	3/	"	175,000-200,000
Unknown	Carcharias limbatus	"	"	3/	"	50,000-125,000
"	" lamia	"	"	3/	"	50,000
"	Odontaspis americanus	"	"	3/	"	10,000- 50,000
"	Isurus oxyrhynchus	"	"	3/	"	25,000
"	Rhinoptera jussieuri	"	"	3/	"	3,000- 5,000
"	Galeocerdo maculatus	"	"	3/	"	1,000- 3,000
"	Manta chrenbergii	"	"	3/	"	3,000- 5,000

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Table 2 - Vitamin A Content of Oils from Fishery Sources having Little or No Present Commercial Importance in the U.S. & Alaska^{1/}
(Continued)

Common name	Scientific name	Area in which fish are caught	Source of oil	Percent of round weight ^{2/}	Oil content, percent	Vitamin A content in U. S. Pharmacopoeia units per gram of oil
Sardinero	<i>Eulamia aethalorus</i>	Pacific-Mexico	liver	3/	66-78	3,000- 16,000
Gambruso	" <i>azureus</i>	" "	"	3/	68	17,500
Pilota	" <i>galapagensis</i>	" "	"	3/	32-55	8,000-110,000
Puro	" <i>velox</i>	" "	"	3/	69-79	20,000- 30,000
"	<i>Scoliodon longurio</i>	" "	"	3/	68	50,000
Unknown shark	Unknown	India	"	3/	50-70	8,000- 12,000
Sawfish	<i>Pristis pectinatus</i>	"	"	3/	3/	12,000
Unknown	<i>Scoliodon palasorrah</i>	Philippines	"	3/	5/	2,000
Sawfish	<i>Pristis microdon</i> , Lothan	"	"	3/	8	300
Sanga	<i>Mobula enegeodoo-tenke</i>	"	"	3/	3/	2,400
Unknown	<i>Mustelus canis</i> , Mitch.	Uruguay	"	3/	3/	50,000- 60,000
"	<i>Micropogon undulatus</i>	"	"	3/	3/	20,000- 50,000
Corvina	Unknown	"	"	3/	3/	20,000
Pescadilla	<i>Cynoscion</i>	"	"	3/	3/	25,000
Dogfish	<i>Squalus acanthias</i>	Atlantic	"	3/	40-60	1,000- 7,000
Yellowtail	<i>Seriola dorsalis</i>	Australia	"	3/	3/	42,000
Congrio colorado	<i>Genypterus blacodes</i>	"	"	3/	3/	1,000- 2,000
Ling	" "	New Zealand	"	3/	35	16,000- 24,000

1/ Vitamin D data for some of these species are included in Table 3.

2/ Percent of round weight means the proportion of liver weight to the weight of the entire fish (undressed) expressed as percent.

3/ The source from which information listed here was obtained did not supply data under this heading.

4/ Viscera indicates the contents of the body cavity minus stomach, liver, and gonads.

5/ Offal indicates cannery trimmings, including head and viscera.

Table 3 - Vitamin D Content of Oils from Fishery Sources

Common name	Scientific name	Area in which fish are caught	Source of oil	Vitamin D content in International units per gram of oil
Albacore tuna	<i>Germo alalunga</i>	Pacific	liver	25,000-250,000
Bluefin "	<i>Thunnus thynnus</i>	"	"	20,000- 70,000
Yellowfin "	<i>Neothunnus macropterus</i>	"	"	10,000- 45,000
Skipjack "	<i>Euthynnus pelayms</i>	"	"	25,000-250,000
Bonito	<i>Sarda chiliensis</i>	"	"	50,000
Swordfish	<i>Xyphias gladius</i>	" -Atlantic	"	2,000- 25,000
Mackerel, Pacific	<i>Scomber diego</i>	Pacific	"	1,400
Albacore tuna	<i>Germo alalunga</i>	"	waste ^{2/}	67
Halibut	<i>Hippoglossus hippoglossus</i>	"	liver	1,000- 5,000
"	"	"	viscera ^{3/}	100- 500
Sablefish	<i>Anaplopoma fimbria</i>	"	liver	600- 1,000
"	"	"	viscera	100
Lingcod	<i>Ophiodon elongatus</i>	"	liver	1,000- 6,000
"	"	"	viscera	100- 200
Rockfish	<i>Sebastes sp.</i>	"	liver	300- 5,000
Cod	<i>Gadus macrocephalus</i>	"	"	85- 500
Ishinagi	<i>Stereolepis</i>	"	"	3,800
Barracuda	<i>Sphyræna argentes</i>	"	"	2,000
Black sea bass	<i>Stereolepis gigas</i>	"	"	5,000
Beluga whale	<i>Delphinapterus leucas</i>	"	"	50- 100
Grayfish (Dogfish)	<i>Squalus suckleyi</i>	"	"	5- 25
"	"	"	body ^{4/}	29
Ratfish	<i>Hydrolagus colliei</i>	"	liver	2- 5
Soupin shark	<i>Galeorhinus zyopterus</i>	"	"	5- 25
Herring	<i>Clupea pallasii</i>	"	body ^{5/}	25- 160
"	"	"	liver	250
Pilchard	<i>Sardina caerulea</i>	"	body ^{5/}	20- 100
King salmon	<i>Oncorhynchus tshawytscha</i>	"	liver	100- 500
"	"	"	offal ^{6/}	50- 150
Sockeye "	" nerka	"	liver	200- 600
"	"	"	offal	100- 300
Silver "	" kisutch	"	liver	100- 500
"	"	"	offal	100- 200
Pink "	" gorbusha	"	liver	100- 600
"	"	"	offal	100- 300
Chum "	" keta	"	liver	100- 500
"	"	"	offal	50- 100
Starry flounder	<i>Platichthys stellatus</i>	"	liver	1,000
Rex sole	<i>Errex zachirus</i>	"	"	150
Skate	<i>Raja binoculata</i>	"	"	25
Mud shark	<i>Hexanchus griseus</i>	"	"	20
Snoek	<i>Thyrsites atun</i> (Euphrasen)	South Africa	"	500- 6,000
"	" " "	"	viscera	85
Stonebass	<i>Polyprion americanus</i> (Bl. & Schn.)	"	liver	700- 1,300
Stockfish	<i>Merlucius capensis</i> (Castel.)	"	"	50- 380
"	" " (Smith)	"	viscera	3
Kingklip	<i>Genypterus</i> "	"	liver	85- 600
Halibut	Unknown	"	"	1,000- 2,000
Cod	"	"	"	100
Ling	<i>Genypterus blacodes</i>	New Zealand	"	500
Yellowtail	<i>Seriola dorsalis</i>	Australia	"	9,000- 17,000
Halibut	<i>Hippoglossus hippoglossus</i>	Atlantic	"	2,000
Mackerel, common	<i>Scomber scombrus</i>	"	"	750
Rosefish	<i>Sebastes marinus</i>	"	waste ^{7/}	50
Dogfish	<i>Squalus acanthias</i>	"	liver	3

1/ Data on vitamin A content of most of these fish are to be found in Tables 1 and 2.

2/ Waste indicates offal from the cannery fish cleaning tables. The raw eviscerated fish is pre-cooked prior to this cleaning operation, hence some of the tuna body oil has been lost from this waste before it is made into meal and oil.

3/ Viscera indicates the contents of the body cavity minus the liver, stomach, and gonads.

4/ Body indicates the entire body of the fish minus the liver.

5/ Body indicates the entire body of the fish including the liver and viscera.

6/ Offal indicates the cannery trimmings, including heads, livers and viscera but not eggs.

7/ Waste indicates the entire body of the rosefish minus the fillet or edible portion. It includes head, backbone, skin, and viscera.

