

Mediterranean Marine Science

Vol 17, No 2 (2016)



DNA BARCODING OF FISH SPECIES FROM THE MEDITERRANEAN COAST OF ISRAEL

A. SHIRAK, LIOR DOR, E. SEROUSSI, M. RON, G. HULATA, D. GOLANI

doi: [10.12681/mms.1384](https://doi.org/10.12681/mms.1384)

To cite this article:

SHIRAK, A., DOR, L., SEROUSSI, E., RON, M., HULATA, G., & GOLANI, D. (2016). DNA BARCODING OF FISH SPECIES FROM THE MEDITERRANEAN COAST OF ISRAEL. *Mediterranean Marine Science*, 17(2), 459–466. <https://doi.org/10.12681/mms.1384>

Supplementary Data

DNA barcoding of fish species from the Mediterranean coast of Israel
A. SHIRAK, L. DOR, E. SEROUSSI, M. RON, G. HULATA and D. GOLANI

Mediterranean Marine Science, 2016, 17 (2)

Table S1. Fish samples by collection date.

Species No.	Taxonomic classification	Common name	Collection dates				Total
			Feb 2009	Sep 2009	Jan 2010	Jun 2014	
1	Pagrus caeruleostictus	Bluespotted seabream	6	0	0	0	6
2	Lithognathus mormyrus	Striped seabream	6	0	1	0	7
3	Atherina boyeri	Big-scale sand smelt	5	0	1	0	6
4	Decapterus russelli	Indian scad	5	3	6	0	14
5	Arnoglossus spp		2	3	3	0	8
6	Pagellus erythrinus	Common pandora	2	6	6	0	14
7	Pagellus acarne	Axillary seabream	1	4	5	6	16
8	Citharus linguatula	Atlantic spotted flounder	4	5	6	3	18
9	Spicara maena	Blotched picarel	6	0	1	5	12
10	Spicara smaris		2	0	2	0	4
11	Solea spp		1	0	0	0	1
12	Equulites klunzingeri		6	6	1	6	19
13	Diplodus annularis	Annular seabream	4	6	1	0	11
14	Upeneus pori	Por's goatfish	6	2	5	0	13
15	Ariosoma balearicum	Bandtooth conger	1	0	5	6	12
16	Nemipterus randalli	Randall's threadfin bream	5	3	6	6	20
17	Callionymus filamentosus	Blotchfin dragonet	6	0	6	6	18
18	Lagocephalus sceleratus	Silverstripe blaasop	2	0	0	0	2
19	Saurida undosquamis	Brushtooth lizardfish	2	0	6	6	14
20	Cynoglossus sinusarabici	Pelada Del Mar Rojo	5	4	4	6	19
21	Bothus podas	Wide-eyed flounder	6	0	6	6	18
22	Apogon smithi		3	6	6	6	21
23	Stephanolepis diaspros	Reticulated leatherjacket	6	6	4	5	21
24	Boops boops	Bogue	6	6	3	3	18
25	Lagocephalus guntheri	Half-smooth golden pufferfish	5	6	4	2	17
26	Lagocephalus suezensis		6	6	6	6	24
27	Plotosus lineatus	Striped eel catfish	5	6	6	6	23
28	Oxyurichthys petersii		0	1	0	0	1
29	Mullus barbatus	Red mullet	0	6	0	0	6
30	Sardinella aurita	Round sardinella	0	6	0	0	6
31	Serranus hepatus	Brown comber	0	5	5	6	16
32	Sphyaena chrysotaenia	Green-and-gold barracuda	0	1	0	0	1
33	Trachurus mediterraneus	Mediterranean scad	0	6	0	6	12
34	Herklotsichthys punctatus	Spotback herring	0	0	6	0	6
35	Trichiurus lepturus	Largehead hairtail	0	0	1	0	1
36	Serranus cabrilla	Comber	0	0	6	1	7
38	Uranoscopus scaber	Atlantic stargazer	0	0	4	0	4
39	Trigloporus lastoviza	Streaked gurnard	0	0	1	0	1
40	Upeneus moluccensis	Gold band goatfish	0	0	0	2	2
41	Gobius niger	Black goby	0	0	0	1	1
42	Siganus rivulatus	Rabbitfish	0	0	0	2	2
43	Torquigener flavimaculosus	Yellowspotted puffer	0	0	0	4	4
44	Apogonichthyoides pharaonis		0	0	0	1	1
46	Ostorhinchus fasciatus	Broadbanded cardinalfish	0	0	0	6	6
47	Raja miraletus	Twineye Skate	0	0	0	4	4
48	Torpedo torpedo	Eyed electric ray	0	0	0	2	2
49	Synodus saurus	Atlantic lizardfish	0	0	0	1	1
50	Scomber colias	Atlantic chub mackerel	0	0	0	6	6
51	Pomadasys stridens	Striped grunt	0	0	0	2	2

Table S2. Sample accession numbers in BOLD and GenBank.

Species	Sample ID	BOLD	GenBank
Apogon smithi	ApSm22A-C	JFS084-09...JFS086-09	KM538174, 76, 77
	ApSm22G-L	JFS157-14...JFS162-14	KM538181-82, 87-89, 92
	ApSm22M-R	JFS289-14...JFS294-14	KM538175, 78-80, 83-84
	ApSm22S-X	JFS397-14...JFS402-14	KM538185-86, 90-91, 93-94
Apogonichthyoidea pharaonis	ApPh44S	JFS447-14	KM538173
Ariosoma balearicum	ArBa15A	JFS057-09	KM538206
	ArBa15M-Q	JFS256-14...JFS260-14	KM538196-99
	ArBa15S-W	JFS361-14...JFS365-14	KM538200-204
	ArBa15X	JFS366-14	KM538205
Arnoglossus spp.	ArSp5A-B	JFS023-09...JFS024-09	KM538207, 214
	ArSp5G-I	JFS118-14...JFS120-14	KM538208, 212-213
	ArSp5M-O	JFS226-14...JFS228-14	KM538209-211
Atherina boyeri	AtBo3A-E	JFS013-09...JFS017-09	KM538215-17, 19, 20
	AtBo3M	JFS219-14	KM538218
Boops boops	BoBo24A-F	JFS093-09...JFS098-09	KM538222-24,30,31,35
	BoBo24G-L	JFS169-14...JFS174-14	KM538221, 25-29
	BoBo24M-O	JFS299-14...JFS301-14	KM538236-38
	BoBo24S-U	JFS408-14...JFS410-14	KM538232-34
Bothus podas	BoPo21A-F	JFS078-09...JFS083-09	KM538240-42, 44-45, 56
	BoPo21M-R	JFS283-14...JFS288-14	KM538239, 50-52, 54-55
	BoPo21S-X	JFS391-14...JFS396-14	KM538243, 46-49, 53
Callionymus filamentosus	CaFi17A-F	JFS063-09...JFS068-09	KM538258-63
	CaFi17M-R	JFS267-14...JFS272-14	KM538257, 70-74
	CaFi17S-X	JFS373-14...JFS378-14	KM538264-69
Citharus linguatula	CiLi8A-D	JFS028-09...JFS031-09	KM538275-78
	CiLi8G-K	JFS131-14...JFS135-14	KM538288-92
	CiLi8M-R	JFS240-14...JFS245-14	KM538279-80, 82-85
	CiLi8S-U	JFS347-14...JFS349-14	KM538281, 86-87
Cynoglossus sinusarabici	CySi20A-E	JFS073-09...JFS077-09	KM538299-303
	CySi20G-J	JFS153-14...JFS156-14	KM538304-07
	CySi20M-P	JFS279-14...JFS282-14	KM538308-11
Decapterus russelli	CySi20S-X	JFS385-14...JFS390-14	KM538293..98
	DeRu4A-E	JFS018-09...JFS022-09	KM538312-13, 19, 22-23
	DeRu4G-I	JFS115-14...JFS117-14	KM538316, 24-25
	DeRu4M-R	JFS220-14...JFS225-14	KM538314-15, 17-18, 20-21
Diplodus annularis	DiAn13A-D	JFS047-09...JFS050-09	KM538327-29, 35
	DiAn13G-L	JFS142-14...JFS147-14	KM538326, 31-34, 36
	DiAn13M	JFS250-14	KM538330
Equulites klunzingeri	EqKl12A-F	JFS041-09...JFS046-09	KM538337, 41, 45-46, 49-50
	EqKl12G-L	JFS136-14...JFS141-14	KM538340, 42-43, 47-48, 51
	EqKl12M	JFS249-14	KM538344
Gobius niger	EqKl12S-X	JFS355-14...JFS360-14	KM538338-39, 52-55
	GoNi41S	JFS440-14	KM538356
Herklotsichthys punctatus	HePu34M-R	JFS323-14...JFS328-14	KM538357-62
Lagocephalus sceleratus	LaSc18A-B	JFS069-09...JFS070-09	KM538363-64
	LaSp25A-E	JFS099-09...JFS103-09	KM538365,68-71
	LaSp25G-L	JFS175-14...JFS180-14	KM538376-81
	LaSp25M-P	JFS302-14...JFS305-14	KM538372-75
Lagocephalus spadiceus	LaSp25S-T	JFS411-14...JFS412-14	KM538366-67
	LaSu26A-F	JFS104-09...JFS109-09	KM538389-90, 95, 98, 400, 403
	LaSu26G-L	JFS181-14...JFS186-14	KM538382-85, 404-405
	LaSu26M-R	JFS306-14...JFS311-14	KM538388, 91-94, 96
Lagocephalus suezensis	LaSu26S-X	JFS413-14...JFS418-14	KM538386-87, 97, 99, 401-402
	LiMo2A-F	JFS007-09...JFS012-09	KM538406-11
	LiMo2M	JFS218-14	KM538412
Lithognathus mormyrus	MuBa29G-L	JFS194-14...JFS199-14	KM538413-18

(continued)

Supp. Table 2 (continued)

Species	Sample ID	BOLD	GenBank
Nemipterus randalli	NeRa16A-E	JFS058-09...JFS062-09	KM538420-21, 27-29
	NeRa16G-I	JFS150-14...JFS152-14	KM538422-23, 35
	NeRa16M-X	JFS261-14...JFS372-14	KM538419, 24-26, 30-34, 36-38
Ostorhinchus fasciatus	ApFa46S-X	JFS448-14...JFS453-14	KM538439-44
Oxyurichthys petersii	OxPe28G	JFS193-14	KM538445
	PaAc7A	JFS027-09	KM538456
	PaAc7G-J	JFS127-14...JFS130-14	KM538446, 53-55
Pagellus acarne	PaAc7M-Q	JFS235-14...JFS239-14	KM538457-61
	PaAc7S-X	JFS341-14...JFS346-14	KM538447-52
	PaEr6A-B	JFS025-09...JFS026-09	KM538474-75
Pagellus erythrinus	PaEr6G-L	JFS121-14...JFS126-14	KM538466, 68, 70-73
	PaEr6M-R	JFS229-14...JFS234-14	KM538462-65, 67, 69
Pagrus caeruleostictus	PaCo1A-F	JFS001-09...JFS006-09	KM538476-81
	PILi27A-E	JFS110-09...JFS114-09	KM538482, 01-504
	PILi27G-L	JFS187-14...JFS192-14	KM538495-500
Plotosus lineatus	PILi27M-R	JFS312-14...JFS317-14	KM538489-94
	PILi27S-X	JFS419-14...JFS424-14	KM538483-88
	PoSt51S-T	JFS467-14...JFS468-14	KM538505-06
Pomadasys stridens	PoSt51S-T	JFS467-14...JFS468-14	KM538505-06
Raja miraletus	RaMi47S-V	JFS454-14...JFS457-14	KM538507-10
Sardinella aurita	SaAu30G-L	JFS200-14...JFS205-14	KM538511-16
	SaUn19A-B	JFS071-09...JFS072-09	KM538526-27
Saurida undosquamis	SaUn19M-R	JFS273-14...JFS278-14	KM538517, 20-21, 25, 29-30
	SaUn19S-X	JFS379-14...JFS384-14	KM538518-19, 22-24, 28
Scomber colias	ScCo50S-X	JFS461-14...JFS466-14	KM538531-36
Serranus cabrilla	SeCa36M-R	JFS330-14...JFS335-14	KM538537-39, 41-43
	SeCa36S	JFS437-14	KM538540
	SeHe31G-K	JFS206-14-FS210-14	KM538546, 49-51, 56
Serranus hepatus	SeHe31M-Q	JFS318-14...JFS322-14	KM538544-45, 47, 52-53
	SeHe31S-X	JFS425-14...JFS430-14	KM538548, 54-55, 57-59
Siganus rivulatus	SiRi42S-T	JFS441-14...JFS442-14	KM538560-61
Solea spp.	SoSp11A	JFS040-09	KM538562
Sphyræna chrysaena	SpCh32G	JFS211-14	KM538563
	SpMa9A-F	JFS032-09...JFS037-09	KM538564-67, 70-71
Spicara maena	SpMa9M	JFS246-14	KM538569
	SpMa9S-W	JFS350-14...JFS354-14	KM538568, 72-75
	SpSm10A-B	JFS038-09...JFS039-09	KM538577-78
Spicara smaris	SpSm10M-N	JFS247-14...JFS248-14	KM538576, 79
	StDi23A-F	JFS087-09...JFS092-09	KM538593-98
	StDi23G-L	JFS163-14...JFS168-14	KM538580-83, 99, 600
	StDi23M-P	JFS295-14...JFS298-14	KM538584-87
Stephanolepis diaspros	StDi23S-W	JFS403-14...JFS407-14	KM538588-92
	SySa49S	JFS460-14	KM538601
Synodus saurus	SySa49S	JFS460-14	KM538601
Torpedo torpedo	ToTo48S-T	JFS458-14...JFS459-14	KM538602-03
Torquigener flavimaculosus	ToFl43S-V	JFS443-14...JFS446-14	KM538604-07
Trachurus mediterraneus	TrMe33G-L	JFS212-14...JFS217-14	KM538608-10, 17-19
	TrMe33S-X	JFS431-14...JFS436-14	KM538611-16
Trichiurus lepturus	TrLe35M	JFS329-14	KM538620
Trigloporus lastoviza	TrLa39M	JFS340-14	KM538621
Upeneus moluccensis	UpMo40S-T	JFS438-14...JFS439-14	KM538622-23
	UpPo14A-F	JFS051-09...JFS056-09	KM538628-30, 34-36
Upeneus pori	UpPo14G-H	JFS148-14...JFS149-14	KM538624, 31
	UpPo14M-Q	JFS251-14...JFS255-14	KM538625-27, 32-33
Uranoscopus scaber	UrSc38M-P	JFS336-14...JFS339-14	KM538637-40

Table S3. Morphology- and sequence-based classifications of fish samples and their geographic origin.

Morphology-based identification	Similarity score of 1 st and 2 nd thresholds, %* (# of sequences**)		Closely related species	Cluster***	Geographic origin of samples****	
	Israeli cluster	Other clusters				
T. torpedo	99-100(8 ^a)	94-96(1 ^a ,7 ^b)	T. fuscomaculata	1	North Africa, PT, IT	-
R. miraletus	97-100(67 ^a)	93-94(24 ^a)		2	North Africa, PT, IT	South Africa
S. aurita	96-100(29 ^a ,43 ^c)	86(3 ^b ,3 ^c)	S. maderensis	2	IT	US, Argentina, Mexico
H. punctatus	99-100(7 ^a)	85(1 ^b)	Pseudocorynopoma doriae	1	-	-
A. balearicum	98-100(23 ^a)	97(4 ^a)		3	IT, Africa	USA, Mexico
S. undosquamis	99-100(14 ^a ,5 ^c)	93-95(28 ^a ,6 ^b)	S. grandisquamis	1	-	-
S. saurus	99-100(5 ^a)	95(1 ^a)	-	1	PT, IT	Bahamas
P. lineatus	99-100(28 ^a)	95-97(10 ^a)		1	-	-
A. boyeri	99-100(8 ^a)	88-89(12 ^a ,25 ^b ,9 ^c)	A. hepsetus	5	-	TR, Africa, PT
T. lastoviza	97-100(23 ^a)	93-94(45 ^b ,31 ^c)	Chelidonichthys cuculus	2	PT, UK, IT	Africa
S. hepatus	99-100(34 ^a)	88-89(23 ^b ,9 ^c)	S. scriba	1	PT, MT, IT	-
S. cabrilla	97-100(59 ^a ,12 ^c)	94(4 ^b)	S. atricauda	2	-	IL, PT, IT, ES
A. smithi	98-100(23 ^a)	95-96(11 ^a ,5 ^b)	A. ellioti	2	-	Australia
A. pharaonis	99-100(5 ^a)	90(9 ^b)	A. nigripinnis	1	-	-
O. fasciatus	99-100(23 ^a)	96-97(6 ^a ,4 ^b)	O. novemfasciatus	1	North Africa, India	-
D. russelli	98-100(38 ^a ,30 ^b ,7 ^c)	93(2 ^a ,5 ^b)	D. maruadsi	3	Africa	Malaysia, IR, India
T. mediterraneus	99-100(21 ^a)	98(1 ^a ,7 ^b ,3 ^c)	T. japonicus	2	TR, IT, ES	IL
E. klunzingeri	98-100(24 ^a ,11 ^b ,2 ^c)	94(3 ^b ,1 ^c)	E. leuciscus	2	-	ID, China
N. randalli	100(24 ^a)	99(6 ^b)	N. mesoprion	1	-	-
P. stridens	99-100(12 ^a)	87-88(7 ^b)	Isacia conceptionis	1	IR	-
P. caeruleostictus	99-100(16 ^a)	91-92(26 ^b ,1 ^c)	P. auriga	1	Atlantic Ocean	-
L. mormyrus	95-100(50 ^a)	88-89(37 ^b ,1 ^c)	Sparus aurata	4	IT	Africa, TR
P. erythrinus	99-100(54 ^a ,2 ^c)	94(3 ^b ,5 ^c)	P. natalensis	1	TR, ES, PT, IT	-
P. acarne	99-100(49 ^a ,2 ^b)	92-93(21 ^b ,1 ^c)	Oblada melanura	1	Africa, ES, PT, IT	-
D. annularis	99-100(18 ^a)	98(11 ^a)		2	TR, IT	TR, PT
B. boops	97-100(76 ^a ,2 ^c)	90(21 ^b)	Sarpa salpa	1	PT, IT, TR, Africa	-
S. maena	99-100(22 ^a ,1 ^c)	92-93(33 ^b ,4 ^a)	S. smararis	2	PT, IT	MT, FR
S. smararis	99-100(34 ^a)	92-93(26 ^b ,1 ^c)	S. maena	2	MT, IT	TR
U. pori	99-100(20 ^a ,8 ^c)	92-94(4 ^b ,6 ^c)	U. asymmetricus	2	North Africa	ID, India
M. barbatus	99-100(46 ^a)	89-91(2 ^a ,41 ^b)	M. surmuletus	1	PT, MT, TR, IT	-
U. moluccensis	98-100(48 ^a ,1 ^c)	93(3 ^b)	U. subvittatus	2	Africa, Far East	TR
U. scaber	99-100(10 ^a)	92(2 ^b)	U. polli	1	MT, IT, Africa	-
C. filamentosus	98-100(99 ^a)	nd	nd	nd	-	-
O. petersii	99-100(2 ^a ,1 ^b ,2 ^c)	96(4 ^b)	O. auchenolepis	1	-	-

(continued)

Supp. Table 3 (continued)

Morphology-based identification	Similarity score of 1 st and 2 nd thresholds, %* (# of sequences**)		Closely related species	Cluster***	Geographic origin of samples****	
	Israeli cluster	Other clusters				
<i>S. rivulatus</i>	98-100(7 ^a)	96-97(2 ^a ,26 ^b ,1 ^c)	<i>S. sutor</i>	1	Saudi Arabia	-
<i>S. chrysotaenia</i>	99-100(15 ^a)	94(3 ^b ,2 ^c)	<i>S. pinguis</i> var Indo	1	Africa	-
<i>T. lepturus</i>	100(1 ^a)	96(10 ^a)		1	-	-
<i>S. colias</i>	100(2 ^a)	99(26 ^a)		1	-	-
<i>C. linguatula</i>	97-100(60 ^a)	83(5 ^b ,3 ^c)	<i>Atherinomorus vaiigiensis</i>	2	MT, PT, IT	TR
<i>Arnoglossus</i> sp. (<i>A. laterna</i>)	99-100(37 ^a)	85-86(10 ^b ,6 ^c)	<i>A. rueppelii</i>	1	PT, UK, Norway, FR	-
<i>Arnoglossus</i> sp. (<i>A. thori</i>)	98-100(8 ^a)	90-92(12 ^b ,6 ^c)	<i>A. capensis</i>	1	MT	-
<i>B. podas</i>	99-100(34 ^a)	90-91(5 ^b)	<i>B. mellissi</i>	2	IT, PT, Africa	UK
<i>Solea</i> spp (<i>B. luteum</i>)	98-100(23 ^a)	83-84(6 ^b ,9 ^c)	<i>Bathysolea profundicola</i>	1	North Sea, PT, UK	-
<i>C. sinusarabici</i>	99-100(23 ^a)	83-85(14 ^b ,13 ^c)	<i>C. kopsii</i>	1	-	-
<i>S. diaspros</i>	99-100(23 ^a ,2 ^c)	96-98(1 ^a ,21 ^b ,18 ^c)	<i>S. hispidus</i>	1	North Africa	-
<i>L. sceleratus</i>	99-100(11 ^a ,4 ^c)	89-91(9 ^a ,32 ^b)	<i>L. suezensis</i>	2	North Africa	Australia
<i>L. guntheri</i>	96-100(18 ^a ,22 ^c)	93-94(15 ^a ,5 ^b ,4 ^c)	<i>L. wheeleri</i>	3	-	India, IR, Taiwan, China
<i>L. suezensis</i>	98-100(28 ^a)	94-95(3 ^a ,9 ^b)	<i>L. sceleratus</i>	1	-	-
<i>T. flavimaculosus</i>	98-100(8 ^a ,8 ^c)	93(4 ^b ,1 ^c)	<i>T. brevipinnis</i>	2	Africa	IL, Africa, Australia

* Significant similarity score between thresholds by t-test ($p < 0.001$).

** ^aMorphology-based classification, ^bclosely related species, and ^cother related species or not determined (nd).

*** No. of clusters based on phylogenetic cluster analysis.

**** Country codes: Israel IL, Turkey TR, Portugal PT, Italy IT, Iran IR, France FR, Spain ES, Malta MT, Indonesia ID.