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APPENDIX I: Data used for CPUE analyses, constraints applied, and examples of errors

A. Number of vessels reporting catches on CELR and TLCER forms (HL = handline, PL = pole-and-line, PS = purse seine, SLL = longline, T = troll)

CELR

Fishing Year	Method HL	PL	PS	SLL	T	Total
1989–90	30	3	9	11	213	266
1990–91	17	3	6	13	230	269
1991–92	17	1	7	10	256	291
1992–93	12	7	5	10	391	425
1993–94	12	13	6	7	470	508
1994–95	18	15	5	36	450	524
1995–96	5	9	6	32	398	450
1996–97	5	3	7	9	289	313

TLCER

Fishing Year	Fleet Charter	Domestic	Foreign	Total
1989–90	5	0	39	44
1990–91	3	5	46	54
1991–92	5	13	28	46
1992–93	5	23	19	47
1993–94	5	35	1	41
1994–95	5	55	2	62
1995–96	0	52	0	52
1996–97	5	44	0	49

B. Amount of longline effort, by target species and form type, (all fleets combined, 1989–97)

Target	No. sets TLCER	CELR	Total	% TLCER	Hooks (thousands) TLCER	CELR	Total	% TLCER
ALB	715	577	1292	55.3	622.6	350.6	973.2	64.0
BIG	7332	3970	11302	64.9	8558.7	2850.5	11409.2	75.0
SBT	16911	791	17702	95.5	45786.5	638.7	46425.2	98.6
YFN	110	232	342	32.2	89.6	92.1	181.7	49.3
SWO	25	10	35	71.4	65.1	4.9	70.0	93.0
Other sp.	14	6	20	70.0	22.9	2.2	25.1	91.2
Unidentified	752	0	752	100.0	1568.9	0.0	1568.9	100.0
Total	25859	5586	31445	82.2	56714.3	3939.0	60653.3	93.5

C. Effort data by target species, year and form type, (all fleets combined)

Year	No. BIG Sets		%	No. SBT Sets		%
	TLCER	CELR	TLCER	TLCER	CELR	TLCER
1989	222	0	100.0	2964	0	100.0
1990	487	373	56.6	2435	185	92.9
1991	247	668	27.0	3922	43	98.9
1992	507	374	57.5	2807	1	100.0
1993	764	173	81.5	1661	3	99.8
1994	1236	130	90.5	651	73	89.9
1995	1272	578	68.8	1194	209	85.1
1996	1371	1280	51.7	534	276	65.9
1997	1226	394	75.7	676	1	99.9

D. Constraints applied to catch and effort data

Fishing method	Species	Constraint applied
purse seine	skipjack tuna	catch per set ≤ 160 t
		sets per day ≤ 7
		USA purse seiners excluded
trolling	albacore	no. fish per trip ≤ 2000 and weight of catch per trip ≤ 10 t
		2.0 kg ≤ average fish weight in landing ≤ 40.0 kg
		5 ≤ no. hooks ≤ 20
		4 ≤ hours fished ≤ 17
		USA trollers excluded
longline	all targets	1 ≤ sets per day ≤ 2 and
		50 ≤ hooks per set ≤ 4000
		2 kg ≤ average albacore weight ≤ 40 kg (CELR data only)
		14 kg ≤ average yellowfin weight ≤ 176 kg (CELR data only)
		16 kg ≤ average swordfish weight ≤ 540 kg (CELR data only)
longline	bigeye tuna	19 kg ≤ average fish weight ≤ 197 kg (CELR data only)
longline	southern bluefin tuna	19 kg ≤ average fish weight ≤ 200 kg (CELR data only)

E. Amount of CELR data (number of fishing trips) available for CPUE analyses after each data constraint was applied.

Sub-surface fishing methods

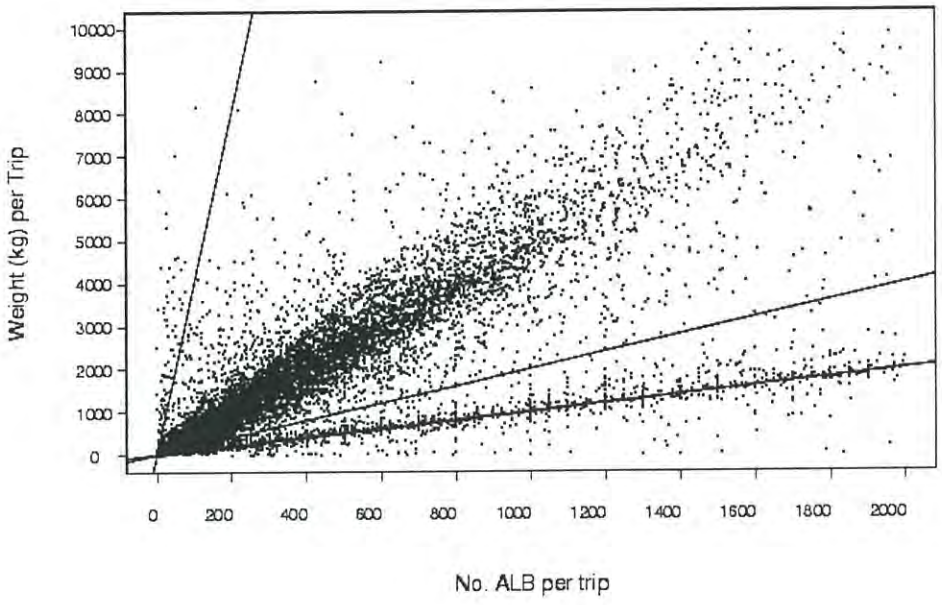
	Handline				Longline					
Constraint applied	**ALB**	**SKJ**	**SBT**	**YFN**	**ALB**	**BIG**	**SKJ**	**SBT**	**YFN**	**SWO**
No constraints	60	13	1133	83	633	4205	6	1204	271	10
Catch without landings removed	8	0	9	6	620	4095	6	820	268	10
USA vessels removed	8		9	6	620	4095	6	820	268	10
Catch per trip too large	8		9	6	620	4095	6	820	268	10
Fishing effort outside limits	8		9	6	426	2974	4	626	169	8
0.0< catch/landing<1.2	6		4	6	397	2632	4	571	155	8
Avg. weight of ALB outside limits	6		4	6	378	2453	4	515	152	8
Avg. weight of BIG outside limits	6		4	6	377	2377	4	508	152	8
Avg. weight of SBT outside limits	6		4	6	376	2375	4	485	152	8
Avg. weight of SWO outside limits	6		4	6	357	2246	4	464	149	8
Avg. weight of YFN outside limits	6		4	6	350	2179	4	462	141	8
Data discarded (%)	90.0	100.0	99.6	92.8	44.7	48.2	33.3	61.6	48.0	20.0

Surface fishing methods

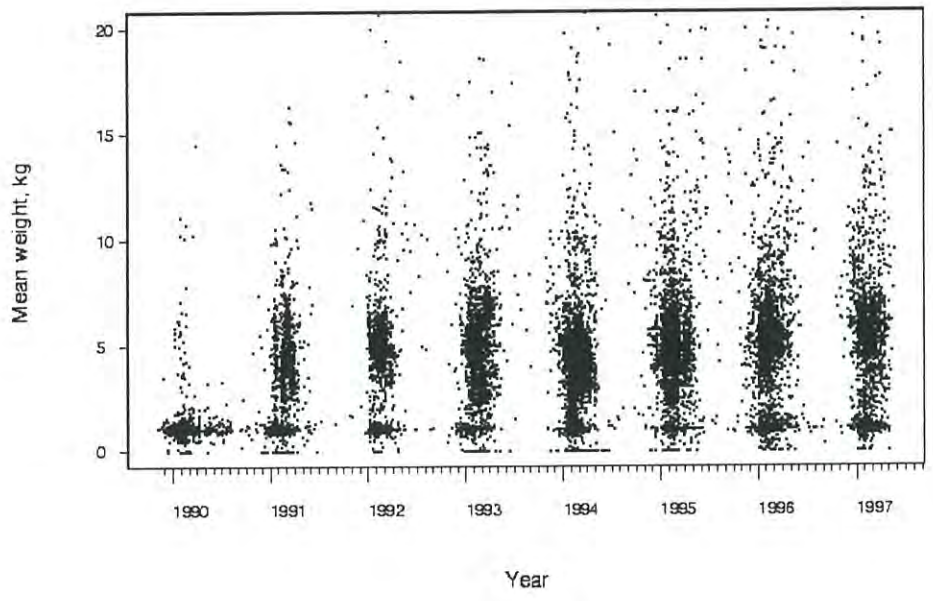
	Troll	Purse seine	Pole-and-line		
Constraint applied	**ALB**	**SKJ**	**ALB**	**SKJ**	**YFN**
No constraints	61582	1052	407	154	30
Catch without landings removed	59207	954	43	10	6
USA vessels removed	59049	925	43	10	6
Catch per trip too large	52556	656	43	10	6
Fishing effort outside limits	43841	646	36	10	6
0.0< catch/landing<1.2	43039	638	10	8	4
Avg. weight of ALB outside limits	41603	638	10	7	4
Avg. weight of BIG outside limits	41603	638	10	7	4
Avg. weight of SBT outside limits	41602	638	10	7	4
Avg. weight of SWO outside limits	41602	638	10	7	4
Avg. weight of YFN outside limits	41599	637	10	7	4
Data discarded (%)	32.4	39.4	97.5	95.5	86.7

F. Examples of errors in CELR catch data

Comparison of Albacore CELR catch data in number of fish (from top of the form) versus the landed weight (from the bottom of the form), each point represents a trip.



Comparison of the average weight of albacore per trip by month, 1990–97.



APPENDIX II: Characteristics of New Zealand tuna vessels fishing in 1996–97 (ALB = albacore, BIG = bigeye tuna, SKJ = skipjack tuna, SBT = southern bluefin tuna, YFN = yellowfin tuna, SWO = swordfish).

	Method	Purse seine	Longline	Longline	Longline	Longline	Trolling
	Target	SKJ	SBT	BIG	mixed	mixed	ALB
	Catching	SKJ	SBT	BIG	YFN	SWO	ALB
No. Vessels	Fishing	6	16	38	69	78	281
Vessel Age	mean	19.1	23.4	24.6	26.1	26.2	26.2
	std. dev.	3.44	13.45	14.36	14.86	14.83	15.08
	N	7	16	38	69	78	281
	minimum	16	2	2	4	6	1
	maximum	24	50	52	61	61	65
Length, m	mean	29.8	18.0	15.9	14.4	15.6	12.7
	std. dev.	4.43	10.12	3.89	3.87	5.51	2.99
	N	7	15	36	60	70	259
	minimum	22.1	7.5	5.9	5.7	9.8	5.8
	maximum	35.4	49.0	28.7	28.7	49.0	26.0
Beam, m	mean	8.9	5.1	5.0	4.5	4.6	4.0
	std. dev.	0.36	1.56	1.00	1.12	1.03	0.84
	N	3	16	38	69	78	281
	minimum	8.6	2.6	2.4	2.4	3.0	1.6
	maximum	9.3	8.5	8.0	7.5	8.5	7.2
GRT	mean	290.1	71.0	42.7	39.0	43.7	23.7
	std. dev.	88.80	95.96	32.28	34.50	47.34	19.17
	N	7	16	36	69	78	279
	minimum	119.0	3.5	1.5	1.7	3.0	0.5
	maximum	410.0	344.9	181.0	181.0	344.9	140.0

APPENDIX III: Catch composition by method and target species reported on CELR and TLCER forms

A. Purse seine catch composition (CELR data)

1989–90 to 1995–96

Code	Species	weight, t	cumm. %
SKJ	skipjack tuna	84416.646	90.9
EMA	blue mackerel	5134.114	96.5
JMA	jack mackerel	2419.769	99.1
KAH	kahawai	493.855	99.6
YFN	yellowfin tuna	278.065	99.9
FTU	frigate tuna	39.070	99.9
TRE	trevally	31.993	100.0
KIN	kingfish	15.271	
ALB	albacore	5.506	
FLY	flying fish	1.600	
POP	porcupine fish	0.874	
BAR	barracouta	0.813	
MAK	mako shark	0.455	
LEA	leatherjacket	0.453	
UNI	unidentified	0.423	
BAL	non-ITQ balance	0.320	
EGR	eagle ray	0.200	
POS	porbeagle shark	0.133	
SUN	sunfish	0.126	
BWS	blue shark	0.066	
SCH	school shark	0.062	
MOK	moki	0.060	
FLA	flatfish	0.039	
SSK	smooth skate	0.029	
SPE	sea perch	0.024	
TAR	tarakihi	0.022	
SNA	snapper	0.018	
BMA	blue maomao	0.009	
FRO	frostfish	0.006	
OCT	octopus	0.004	
STA	giant stargazer	0.003	
SQU	arrow squid	0.002	
GUR	gurnard	0.001	
	Total	92840.032	

1996–97

Code	Species	weight, t	cumm. %
SKJ	skipjack tuna	18188.903	94.7
EMA	blue mackerel	755.246	98.7
JMA	jack mackerel	126.515	99.3
TRE	trevally	72.730	99.7
KAH	kahawai	34.621	99.9
FTU	frigate tuna	10.392	99.9
YFN	yellowfin tuna	9.082	100.0
ALB	albacore	1.030	
FLY	flying fish	0.456	
SUN	sunfish	0.100	
UNI	unidentified	0.060	
MAK	mako shark	0.041	
KIN	kingfish	0.024	
EGR	eagle ray	0.023	
STR	stingray	0.020	
FRO	frostfish	0.010	
BAR	barracouta	0.004	
PAR	parore	0.003	
SNA	snapper	0.003	
STA	giant stargazer	0.001	
	Total	19199.264	

B. Troll fishery catch composition based on number of fish (CELR data)

Code	Species	1989/90 to 1995/96	1996/97	Cumm. %	Rank
ALB	albacore	3446288	320017	96.7	1
SKJ	skipjack tuna	36893	4600	97.7	2
KIN	kingfish	26755	619	98.4	3
KAH	kahawai	25754	1139	99.1	4
YFN	yellowfin tuna	12378	2986	99.5	5
RBM	Ray's bream	6025	164	99.7	6
BAR	barracouta	2547	185	99.8	7
UNI	unidentified	1267	313	99.8	8
ESO	NZ sole	0	930	99.8	9
OSD	other sharks & dogfish	500	310	99.8	10
STN	southern bluefin tuna	756	0	99.9	11
MAK	mako shark	596	99	99.9	12
SCH	school shark	477	60	99.9	13
SKI	gemfish	530	4	99.9	14
SLB	white-tail dogfish	134	280	99.9	15
STK	stokells smelt	0	400	99.9	16
BIG	bigeye tuna	183	127	99.9	17
THR	thresher shark	0	300	99.9	18
SNA	snapper	236	0	99.9	19
BWS	blue shark	233	0	99.9	20
LIN	ling	22	200	100.0	21
FLA	flatfish	200	0		
DOF	dolphin (fish)	198	0		
SWO	swordfish	144	0		
FLY	flyingfish	140	0		
FIS	fish	0	137		
YBF	yellow-belly flounder	73	48		
EMA	blue mackerel	60	25		
HPB	hapuku/bass	80	0		
SPO	rig	51	0		
SPD	spiny dogfish	50	0		
SLK	slickhead	47	0		
BCO	blue cod	40	0		
TRU	trumpeter	38	0		
BNS	bluenose	35	0		
MOO	moonfish	35	0		
SSI	silverside	35	0		
BSH	seal shark	30	0		
BWH	bronze whaler shark	30	0		
RSN	red snapper	24	5		
MOK	moki	25	0		
GUR	gurnurd	20	0		
HAK	hake	20	0		
SPE	sea perch	20	0		
OFH	oilfish	18	0		
TRE	trevally	14	0		
STU	slender tuna	12	0		

B. continued

Code	Species	1989/90 to 1995/96	1996/97	Cumm. %	Rank
PMA	pink maomao	11	0		
RBY	ruby fish	11	0		
SSP	scallop sprat	8	0		
SPP	splendid perch	0	7		
DOS	dredge oyster spat	6	0		
NSD	northern spiny dogfish	6	0		
SRP	silver carp	5	0		
TUR	turbot	5	0		
SKA	skate	4	0		
BAS	bass/groper	3	0		
BTU	butterfly tuna	3	0		
KAI	swallower	0	2		
BMA	blue maomao	1	0		
MIX	mixed fish	1	0		
NTU	northern bluefin tuna	1	0		
RIB	ribaldo	1	0		
SHF	shark fins	1	0		
	Total	3563080	332957		

C. Longline fishery catch composition based on number of fish (CELR and TLCER data)

Bigeye tuna target sets

		1989/90 to 1996/97		1996/97		1989/90 to 1996/97 Cumm.	
Code	Species	CELR	TLCER	CELR	TLCER	%	Rank
ALB	albacore	26205	157716	1340	20135	55.0	1
BWS	blue shark	12593	22800	390	2951	65.6	2
MOO	moonfish	18539	14681	2428	1534	75.5	3
BIG	bigeye tuna	2238	16879	129	699	81.2	4
SWO	swordfish	7059	4330	40	743	84.6	5
YFN	yellowfin tuna	1576	9587	351	2189	88.0	6
OFH	oilfish	6531	1759	147	310	90.4	7
OSD	other sharks & dogfish	7354	848	1050	95	92.9	8
MAK	mako shark	1821	4850	1	939	94.9	9
SHA	shark	889	1796	100	1058	95.7	10
STM	striped marlin	516	884	13	261	96.1	11
UNI	unidentified	813	567	300	270	96.5	12
RUD	rudderfish	376	749	2	233	96.8	13
SHF	shark fins	145	932	0	135	97.2	14
BSH	seal shark	771	264	0	234	97.5	15
STN	southern bluefin tuna	136	888	2	288	97.8	16
KIN	kingfish	887	87	2	22	98.1	17
SKJ	skipjack tuna	272	493	1	31	98.3	18
RBM	Ray's bream	100	613	0	38	98.5	19
THR	thresher shark	40	601	0	0	98.7	20
MIX	mixed fish	500	0	0	0	98.9	21
BTU	butterfly tuna	287	190	0	11	99.0	22
SFN	spinyfin	335	26	0	0	99.1	23
GSE	snake mackerel	2	300	2	46	99.2	24
SUN	sunfish	0	291	0	4	99.3	25
MAR	marlin	280	0	0	0	99.4	26
OIL	fish oil	228	5	198	0	99.4	27
LEP	escolar	115	98	95	52	99.5	28
ESQ	enoplotheuthid squid	195	0	0	0	99.6	29
SCH	school shark	37	151	0	0	99.6	30
NTU	northern bluefin tuna	4	159	0	19	99.7	31
SNA	snapper	150	0	0	0	99.7	32
POR	porae	0	137	0	0	99.8	33
STU	slender tuna	31	101	1	46	99.8	34
SEV	sevengill shark	130	0	0	0	99.8	35
POS	porbeagle shark	0	84	0	38	99.9	36
DOF	dolphin (fish)	31	45	0	2	99.9	37
STR	stingray	60	0	0	0	99.9	38
SWA	silver warehou	45	15	0	15	99.9	39
BWH	bronze whaler shark	0	45	0	1	99.9	40
SKA	skate	40	0	0	0	99.9	41
BAR	barracouta	30	0	0	0	100.0	42
SLB	whit-tail dogfish	26	0	26	0		
DSM	unknown code	25	0	25	0		
SSF	shortbill spearfish	2	20	2	0		

Bigeye tuna target sets (continued)

		1989/90 to 1996/97		1996/97		1989/90 to 1996/97 Cumm.	
Code	Species	CELR	TLCER	CELR	TLCER	%	Rank
TRE	trevally	21	0	1	0		
SAI	sailfish	15	4	0	0		
FRO	frostfish	0	11	0	0		
SKI	gemfish	5	3	0	0		
CDL	cardinalfish	0	6	0	0		
BNS	bluenose	0	5	0	0		
HOK	hoki	0	4	0	0		
DOS	dredge oyster spat	0	3	0	0		
ORH	orange roughy	0	3	0	0		
BUT	butterfish	0	2	0	0		
KAH	kahawai	0	2	0	0		
RMO	red moki	2	0	0	0		
BBA	black barracouta	0	1	0	1		
BEM	blue marlin	1	0	1	0		
HHS	hammerhead shark	0	1	0	0		
MDO	mirror dory	1	0	1	0		
POP	porcupine fish	0	1	0	0		
STA	giant stargazer	0	1	0	1		
	Total	91459	243038	6648	32401		

Southern bluefin tuna target sets

		1989/90 to 1996/97		1996/97		1989/90 to 1996/97 Cumm.	
Species		CELR	TLCER	CELR	TLCER	%	Rank
ALB	albacore	3357	110807	5	4831	30.9	1
BWS	blue shark	3785	97609	0	5753	58.3	2
STN	southern bluefin tuna	2079	59290	0	4241	74.8	3
BTU	butterfly tuna	525	14307	0	913	78.9	4
UNI	unidentified	0	13435	0	13040	82.5	5
MOO	moonfish	1759	9924	0	346	85.6	6
SWO	swordfish	1463	10179	0	434	88.8	7
SHA	shark	2940	6634	0	196	91.4	8
RBM	Ray's bream	485	8906	0	1979	93.9	9
MAK	mako shark	726	5520	0	252	95.6	10
OFH	oilfish	807	2929	0	56	96.6	11
BIG	bigeye tuna	83	2839	0	64	97.4	12
SHF	shark fins	0	2374	0	1322	98.0	13
POS	porbeagle shark	218	883	0	169	98.3	14
SCH	school shark	97	986	0	294	98.6	15
THR	thresher shark	0	814	0	20	98.9	16
RUD	rudderfish	461	167	0	80	99.0	17
OAR	oarfish	500	0	0	0	99.2	18
OSD	other sharks & dogfish	410	89	20	16	99.3	19
NTU	northern bluefin tuna	80	410	0	18	99.4	20
DEA	dealfish	0	342	0	342	99.5	21

Southern bluefin tuna target sets (continued)

Species		1989/90 to 1996/97 CELR	1989/90 to 1996/97 TLCER	1996/97 CELR	1996/97 TLCER	1989/90 to 1996/97 Cumm. %	1989/90 to 1996/97 Rank
YFN	yellowfin tuna	8	249	0	61	99.6	22
AGR	ribbonfish	255	0	0	0	99.7	23
STU	slender tuna	17	218	0	2	99.7	24
BSH	seal shark	0	174	0	0	99.8	25
BUT	buterfish	126	0	0	0	99.8	26
MAR	marlin	110	0	0	0	99.8	27
MIX	mixed fish	0	110	0	0	99.9	28
STM	striped marlin	0	86	0	29	99.9	29
POR	porae	0	84	0	0	99.9	30
BRI	brill	80	0	0	0	99.9	31
SUN	sunfish	0	76	0	3	99.9	32
GSE	snake mackerel	0	36	0	15	100.0	33
DWD	deepwater dogfish	0	32	0	32		
SKJ	skipjack tuna	0	24	0	0		
BWH	bronze whaler shark	0	19	0	0		
BAR	barracouta	0	16	0	15		
RIB	ribaldo	15	0	0	0		
BEM	blue marlin	0	7	0	0		
DOF	dolphin (fish)	6	1	0	0		
KIN	kingfish	0	7	0	0		
GSC	giant spider crab	0	6	0	6		
BSP	big-scale pomfret	0	5	0	0		
HPB	hapuku/bass	4	0	0	0		
SPD	spiny dogfish	0	4	0	0		
DIS	discfish	0	3	0	3		
BBA	black barracouta	0	2	0	2		
SSF	shortbill spearfish	0	1	0	0		
	Total	20396	349604	25	34534		

APPENDIX IV: Summary of groomed catch and effort data by target species, method and fleet. (Source: Ministry of Fisheries CELR and TLCER data). Units of effort are 100 hook-hours for troll, 1000 hooks for longline and number of sets for purse seine fishing methods.

A. Albacore

				Catch in Number					
Method	Fleet	Fish. Yr.	Effort	ALB	BIG	SKJ	SBT	YFN	SWO
Troll	D	1988–89	1.3	55	0	560	0	83	0
Troll	D	1989–90	27.4	20182	0	874	0	741	0
Troll	D	1990–91	487.1	323820	1	2616	0	164	80
Troll	D	1991–92	625.6	455866	1	2030	132	401	0
Troll	D	1992–93	861.3	442402	24	3322	0	676	0
Troll	D	1993–94	1410.7	805553	111	12007	99	2270	0
Troll	D	1994–95	1334.7	814322	6	7268	456	2532	0
Troll	D	1995–96	964.2	598828	122	8310	69	5778	64
Troll	D	1996–97	647.5	305304	45	4406	0	2695	0
Longline	D	1990–91	3.1	127	7	0	0	0	150
Longline	D	1991–92	4.5	339	0	0	1	0	140
Longline	D	1992–93	13.8	1234	5	10	2	0	4
Longline	D	1993–94	74.1	5331	18	0	12	92	23
Longline	D	1994–95	186.8	12135	43	46	39	209	63
Longline	D	1995–96	157.0	11471	75	53	34	314	127
Longline	D	1996–97	104.8	5224	48	0	29	123	111
Longline	F(Japan)	1981–82	110.9	2053	105	0	48	14	40
Longline	F(Japan)	1982–83	5.2	15	0	0	1	0	0
Longline	F(Japan)	1983–84	0.0	0	0	0	0	0	0
Longline	F(Japan)	1984–85	122.4	1302	473	0	6	89	192
Longline	F(Japan)	1985–86	253.1	5122	422	0	2	634	336
Longline	F(Japan)	1986–87	729.6	11244	1633	0	13	984	1459
Longline	F(Japan)	1987–88	135.0	2363	161	0	1	148	39
Longline	F(Japan)	1988–89	0.0	0	0	0	0	0	0
Longline	F(Japan)	1989–90	0.0	0	0	0	0	0	0
Longline	F(Japan)	1990–91	19.2	155	0	0	7	0	22
Longline	F(Japan)	1991–92	32.2	243	0	0	6	0	35
Longline	F(Korea)	1980–81	1078.6	26207	2734	0	0	1244	96
Longline	F(Korea)	1981–82	409.3	9829	1146	0	0	484	57
Longline	F(Korea)	1982–83	694.3	30231	566	0	0	457	3
Longline	F(Korea)	1983–84	970.5	30572	731	0	0	541	86
Longline	F(Korea)	1984–85	1462.7	45831	1274	0	0	2853	73
Longline	F(Korea)	1985–86	717.5	43983	362	0	0	169	106
Longline	F(Korea)	1986–87	913.4	57019	535	0	0	1474	54
Longline	F(Korea)	1987–88	1438.6	53096	727	0	0	1228	91
Longline	F(Korea)	1988–89	100.9	2491	32	0	0	53	2

B. Bigeye tuna

				Catch in Number					
Method	Fleet	Fish. Yr.	Effort	ALB	BIG	SKJ	SBT	YFN	SWO
Longline	D	1989–90	15.3	766	283	95	100	35	700
Longline	D	1990–91	105.6	6361	1119	1	7	476	4321
Longline	D	1991–92	296.1	7287	820	0	33	109	660
Longline	D	1992–93	713.6	22640	1274	40	96	78	502
Longline	D	1993–94	980.2	42733	979	21	44	1248	1086
Longline	D	1994–95	1139.1	32244	1102	226	34	2676	1767
Longline	D	1995–96	1154.5	43737	992	343	67	3988	1627
Longline	D	1996–97	1211.0	42200	1301	37	350	3789	1400
Longline	C	1989–90	51.8	419	246	0	0	0	26
Longline	C	1990–91	53.7	726	342	0	26	0	0
Longline	C	1991–92	68.2	928	209	0	5	2	0
Longline	C	1992–93	0.0	0	0	0	0	0	0
Longline	C	1993–94	38.9	329	51	0	0	2	33
Longline	C	1994–95	16.0	465	5	0	0	18	3
Longline	F(Japan)	1979–80	851.4	3616	5208	0	343	316	576
Longline	F(Japan)	1980–81	1938.1	8564	6464	0	299	1480	2619
Longline	F(Japan)	1981–82	3739.6	32193	10983	0	540	1463	2876
Longline	F(Japan)	1982–83	2146.9	19511	9496	0	144	590	2062
Longline	F(Japan)	1983–84	1585.6	12989	11266	0	204	1607	702
Longline	F(Japan)	1984–85	1416.8	10771	9131	0	182	730	745
Longline	F(Japan)	1985–86	1958.5	23205	11584	0	115	1802	1407
Longline	F(Japan)	1986–87	2316.4	23171	11594	0	43	3792	1353
Longline	F(Japan)	1987–88	1188.1	16041	5312	0	22	1585	275
Longline	F(Japan)	1988–89	645.8	8038	3174	0	9	535	33
Longline	F(Japan)	1989–90	1411.1	14506	7066	1	35	1137	332
Longline	F(Japan)	1990–91	654.5	9123	2635	0	277	271	169
Longline	F(Japan)	1991–92	309.9	3187	986	0	35	5	24
Longline	F(Japan)	1992–93	39.2	942	50	0	2	1	0

C. Skipjack tuna

Method	Fleet	Fish. Yr.	Effort	SKJ (t.)
purse seine	D	1988–89	3	55.0
purse seine	D	1989–90	288	2961.1
purse seine	D	1990–91	278	3644.5
purse seine	D	1991–92	100	1425.0
purse seine	D	1992–93	89	1226.5
purse seine	D	1993–94	128	1847.2
purse seine	D	1994–95	67	862.5
purse seine	D	1995–96	167	2983.2
purse seine	D	1996–97	187	5102.2

D. Southern bluefin tuna

				Catch in Number					
Method	Fleet	Fish. Yr.	Effort	ALB	BIG	SKJ	SBT	YFN	SWO
Longline	D	1989–90	1.4	240	0	0	0	0	0
Longline	D	1990–91	12.5	84	0	0	2	0	400
Longline	D	1991–92	31.0	216	5	0	44	0	5
Longline	D	1992–93	170.9	3663	29	0	184	0	43
Longline	D	1993–94	308.2	6941	72	11	546	95	61
Longline	D	1994–95	879.2	12531	41	2	5093	81	404
Longline	D	1995–96	579.3	17073	123	11	1039	39	1009
Longline	D	1996–97	379.2	6991	85	0	1184	99	211
Longline	C	1988–89	1423.4	1704	10	0	3553	0	48
Longline	C	1989–90	1498.7	2436	45	0	3144	0	345
Longline	C	1990–91	965.1	1074	4	0	1322	0	104
Longline	C	1991–92	1512.7	2787	11	0	3027	0	279
Longline	C	1992–93	1530.9	1157	1	0	2612	0	97
Longline	C	1993–94	766.2	136	0	0	3476	0	2
Longline	C	1994–95	1202.0	311	0	0	3103	0	17
Longline	C	1995–96	0.0	0	0	0	0	0	0
Longline	C	1996–97	1217.6	1171	3	0	3079	0	382
Longline	F(Japan)	1979–80	25020.6	15830	594	0	119286	40	4508
Longline	F(Japan)	1980–81	24201.8	40336	2053	0	90515	748	6040
Longline	F(Japan)	1981–82	18293.1	29245	1001	0	45517	84	4322
Longline	F(Japan)	1982–83	12947.8	26761	1802	0	25846	49	2561
Longline	F(Japan)	1983–84	10312.1	21448	2088	0	21980	141	2474
Longline	F(Japan)	1984–85	9593.0	19852	2057	0	24590	61	2033
Longline	F(Japan)	1985–86	9783.1	21231	2252	0	18636	35	3847
Longline	F(Japan)	1986–87	12931.9	26383	664	0	21563	33	3758
Longline	F(Japan)	1987–88	11460.4	32591	1132	0	11591	21	3606
Longline	F(Japan)	1988–89	7157.2	17138	854	0	7621	38	2499
Longline	F(Japan)	1989–90	5580.2	20558	705	0	10920	29	2602
Longline	F(Japan)	1990–91	10562.4	23227	1109	0	11168	53	2727
Longline	F(Japan)	1991–92	6614.6	24426	803	0	8123	0	2907
Longline	F(Japan)	1992–93	3016.3	4865	2	0	3138	0	355
Longline	F(Japan)	1993–94	129.6	374	1	0	378	0	35
Longline	F(Japan)	1994–95	211.3	100	0	0	579	0	2

E. Yellowfin tuna

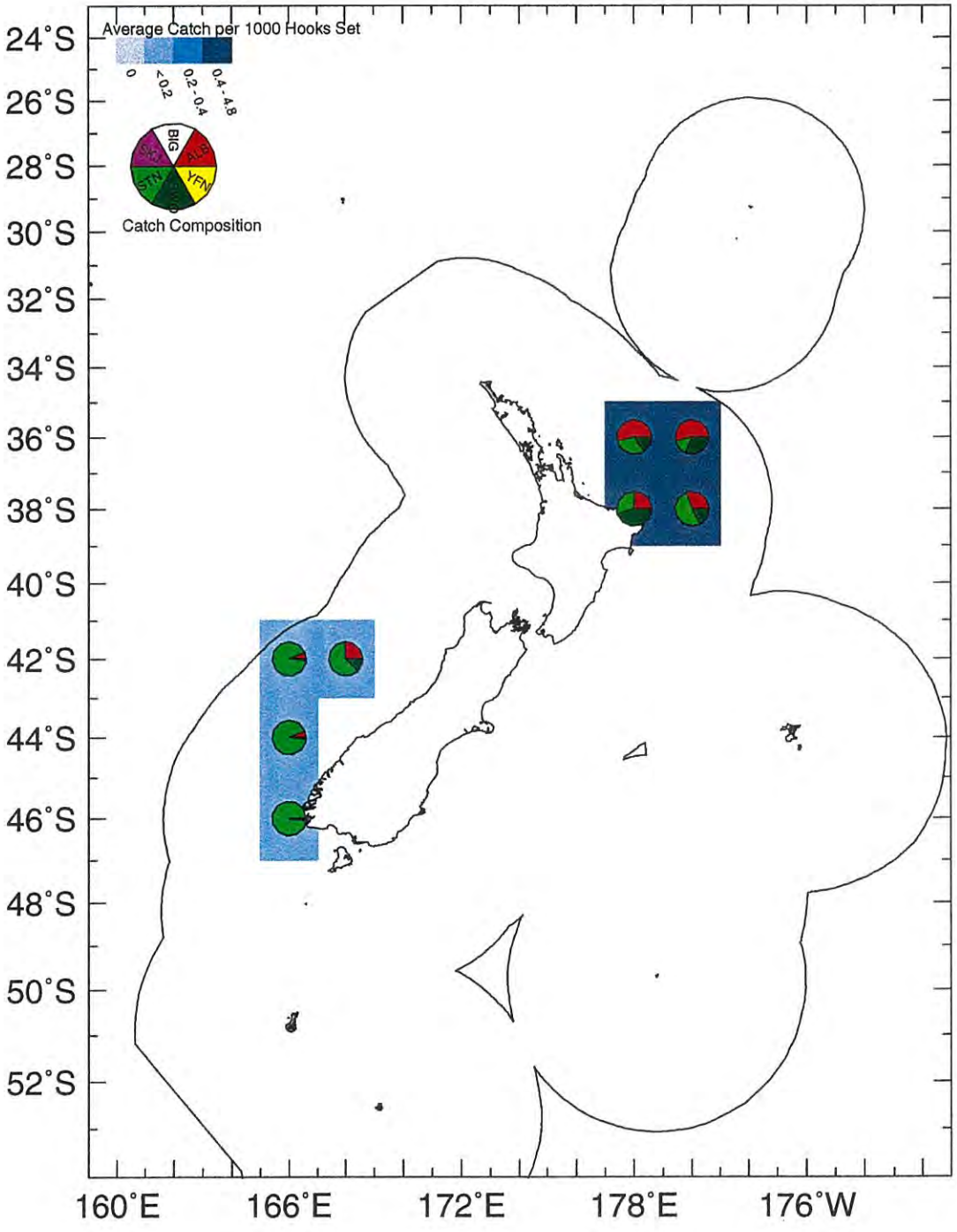
				Catch in Number					
Method	Fleet	Fish. Yr.	Effort	ALB	BIG	SKJ	SBT	YFN	SWO
Longline	D	1989–90	0.4	0	0	25	0	0	0
Longline	D	1990–91	1.2	0	0	0	0	11	0
Longline	D	1991–92	0.5	0	0	0	0	200	1
Longline	D	1992–93	6.4	173	0	0	0	10	1
Longline	D	1993–94	0.7	13	0	0	0	0	0
Longline	D	1994–95	29.5	1309	2	73	0	307	5
Longline	D	1995–96	22.6	1712	1	12	1	380	28
Longline	D	1996–97	33.9	644	3	7	0	226	12
Longline	F(Japan)	1980–81	2.5	5	0	0	0	5	0
Longline	F(Japan)	1985–86	247.4	4027	456	0	0	152	776
Longline	F(Japan)	1986–87	8.4	7	8	0	0	24	3
Longline	F(Japan)	1987–88	16.5	106	2	0	0	64	6
Longline	F(Japan)	1990–91	11.2	191	7	0	0	56	2

F. Swordfish

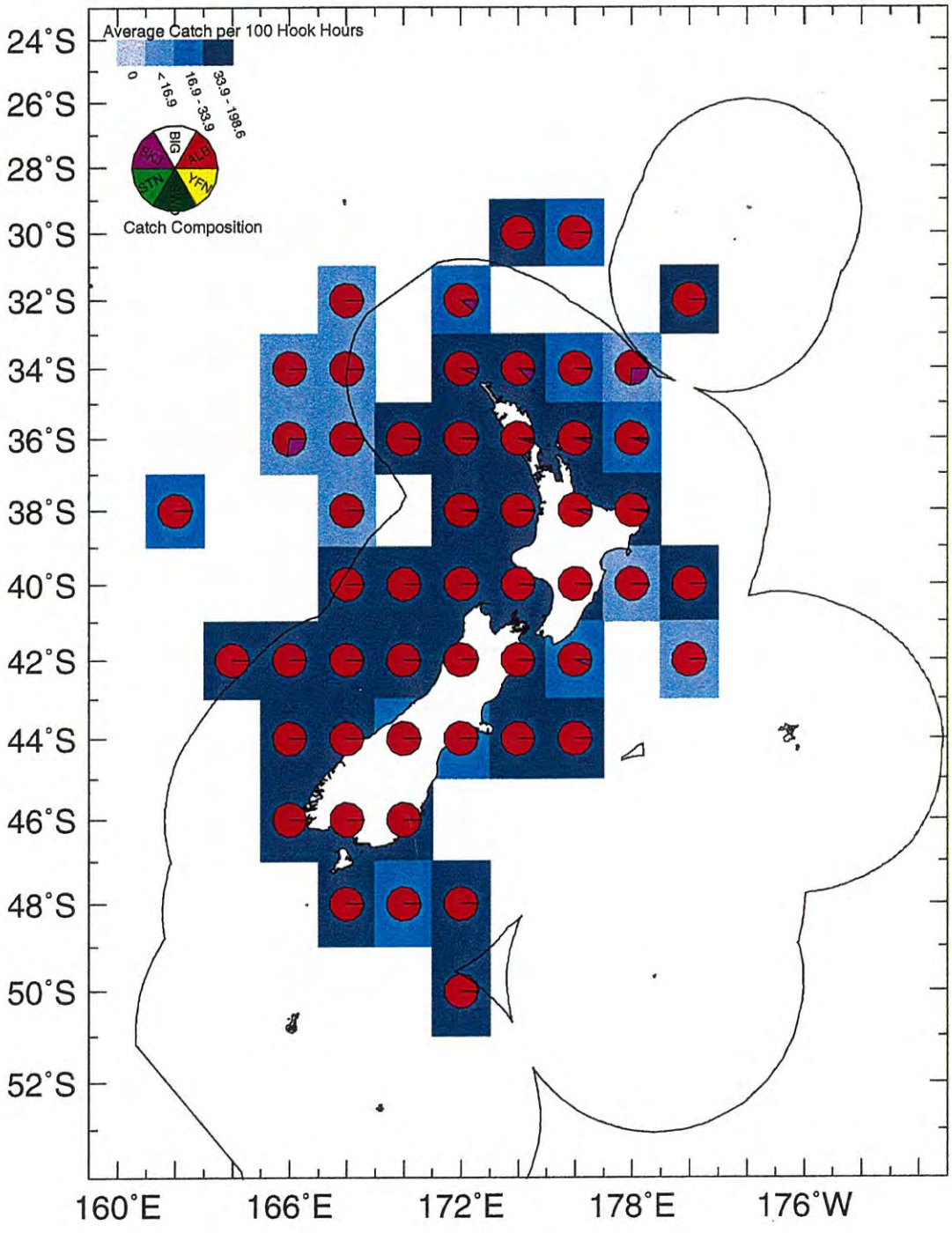
				Catch in Number					
Method	Fleet	Fish. Yr.	Effort	ALB	BIG	SKJ	SBT	YFN	SWO
Longline	D	1994–95	1.4	85	0	0	0	2	4
Longline	D	1995–96	0.0	0	0	0	0	0	0
Longline	D	1996–97	1.0	13	7	0	0	11	0
Longline	F(Japan)	1980–81	29.1	61	19	0	3	5	499
Longline	F(Japan)	1981–82	95.6	260	33	0	4	15	482
Longline	F(Japan)	1982–83	97.1	270	37	0	8	43	596
Longline	F(Japan)	1983–84	142.7	450	58	0	5	14	1018
Longline	F(Japan)	1984–85	91.3	457	170	0	1	94	556
Longline	F(Japan)	1985–86	266.8	1577	325	0	0	166	1569
Longline	F(Japan)	1986–87	303.9	1084	170	0	5	113	1453
Longline	F(Japan)	1987–88	0.0	0	0	0	0	0	0
Longline	F(Japan)	1988–89	0.0	0	0	0	0	0	0
Longline	F(Japan)	1989–90	0.0	0	0	0	0	0	0
Longline	F(Japan)	1990–91	20.4	37	0	0	5	0	31
Longline	F(Japan)	1991–92	43.4	277	3	0	23	0	526

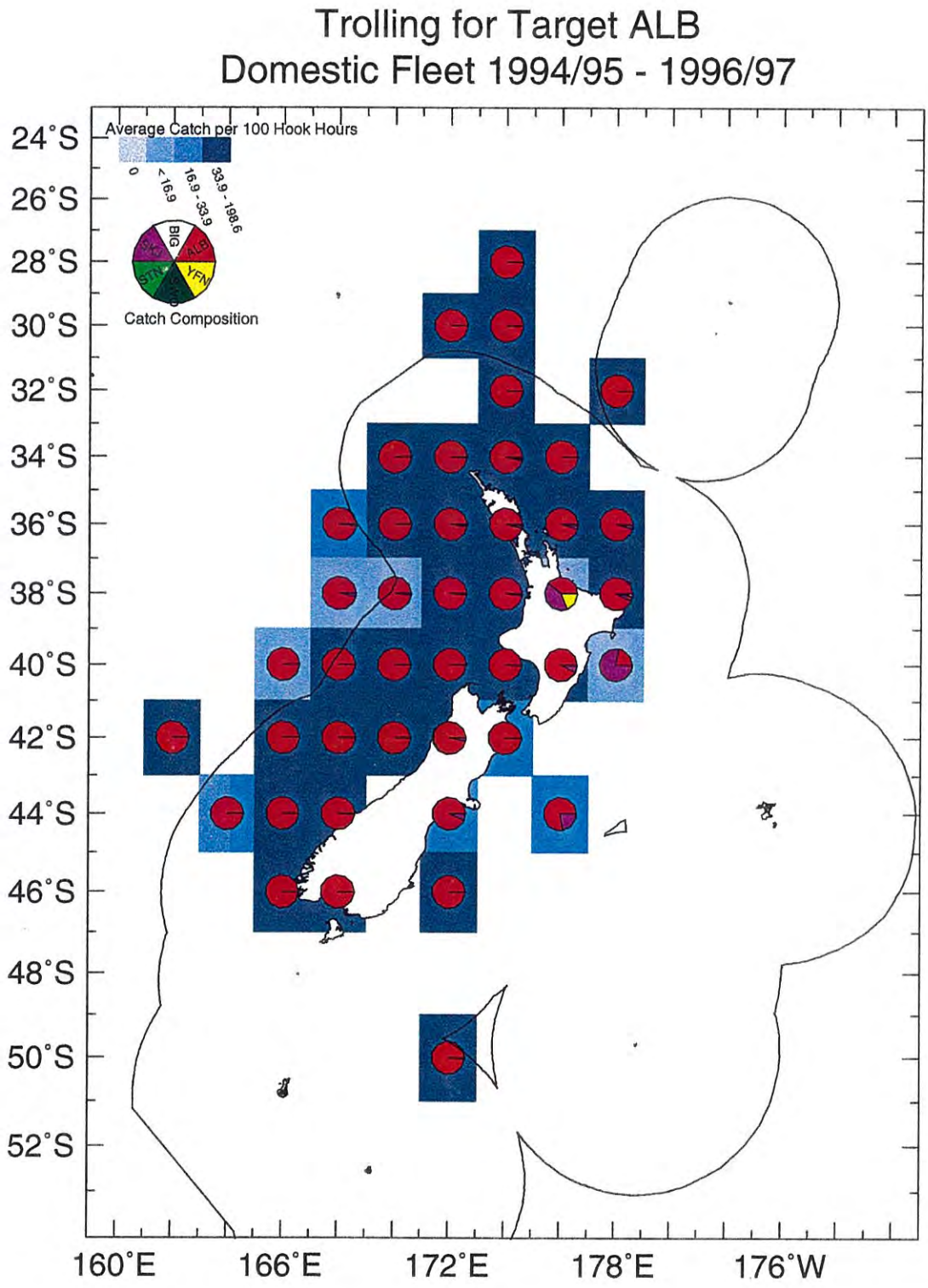
APPENDIX V: Spatial distribution of CPUE and catch composition by species, method and fleet

Surface Longlining for SWO
Charter Fleet 1996/97

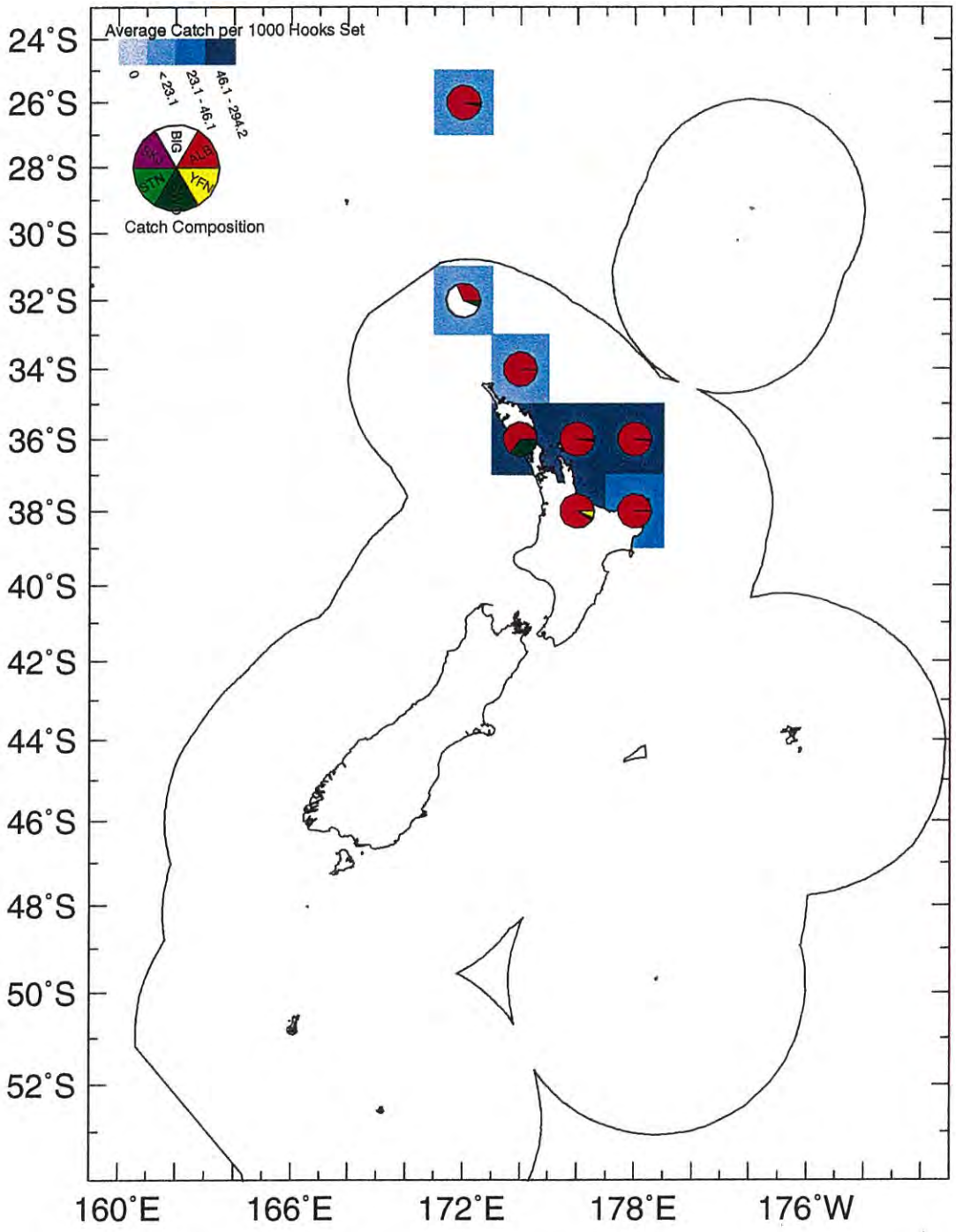


Trolling for Target ALB
Domestic Fleet 1989/90 - 1993/94

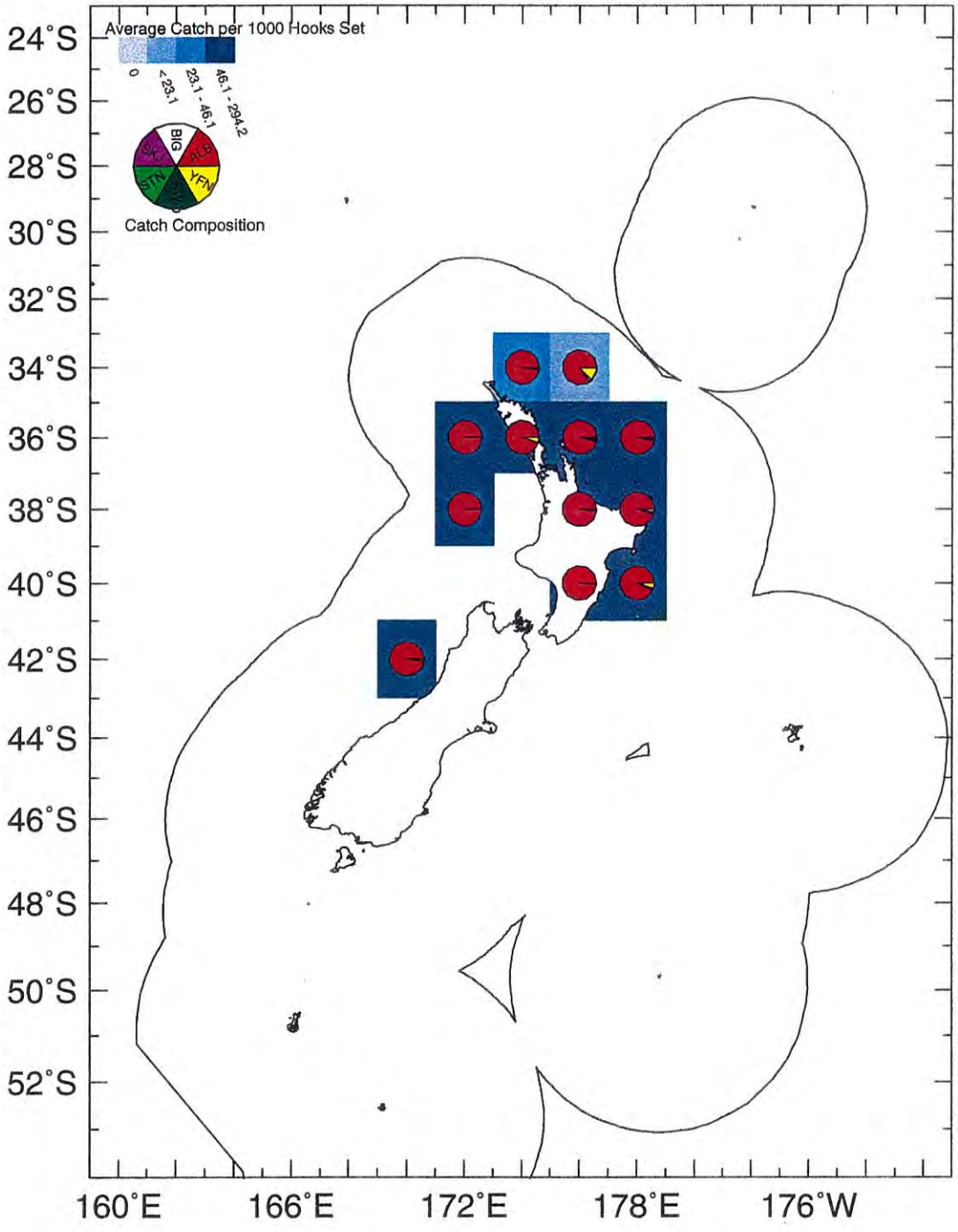


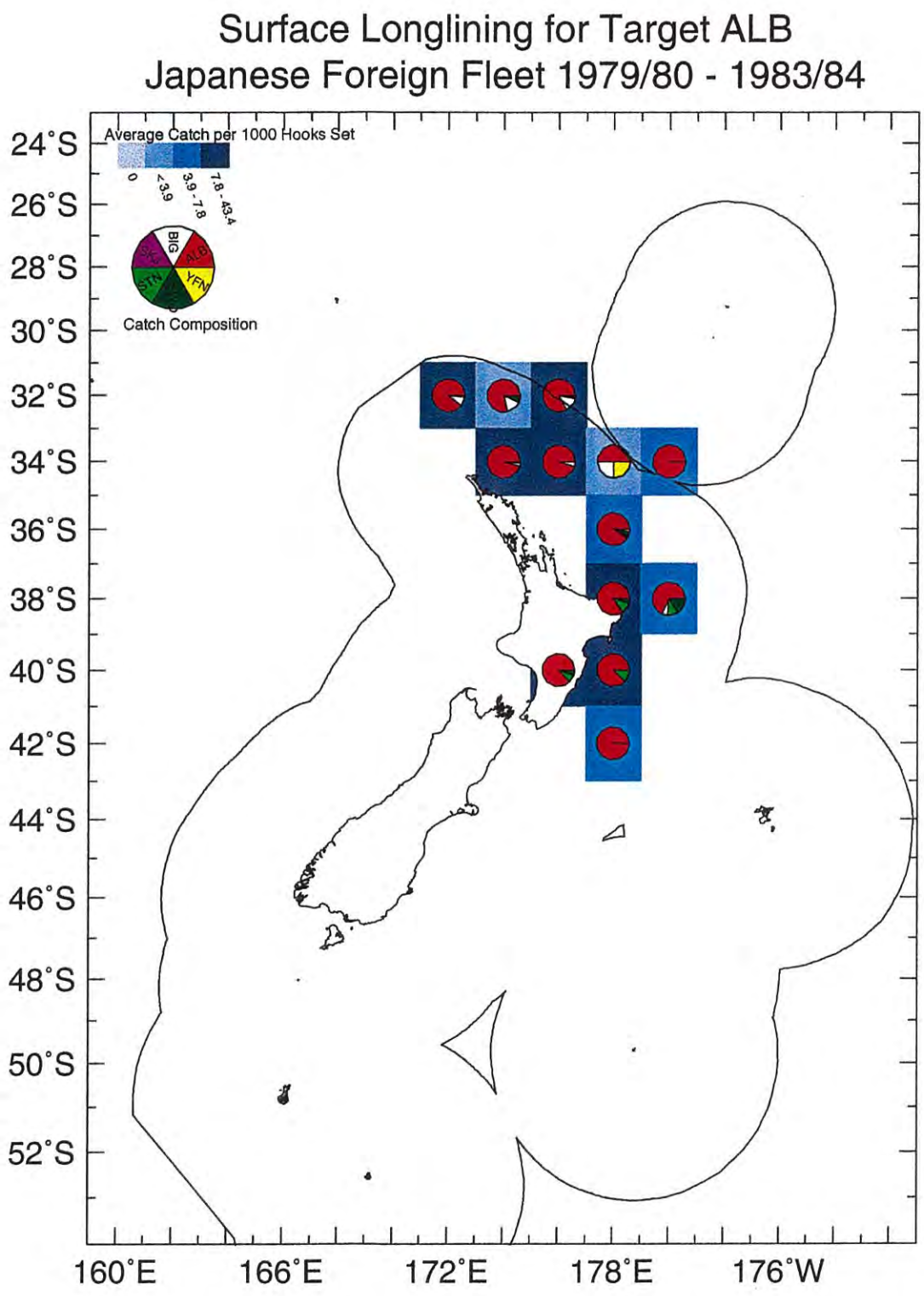

Trolling for Target ALB
Domestic Fleet 1994/95 - 1996/97
Average Catch per 100 Hook Hours
0
<16.9
16.9 - 33.9
33.9 - 198.6
BIG
ALB
YFN
SKI
STN
SKJ
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

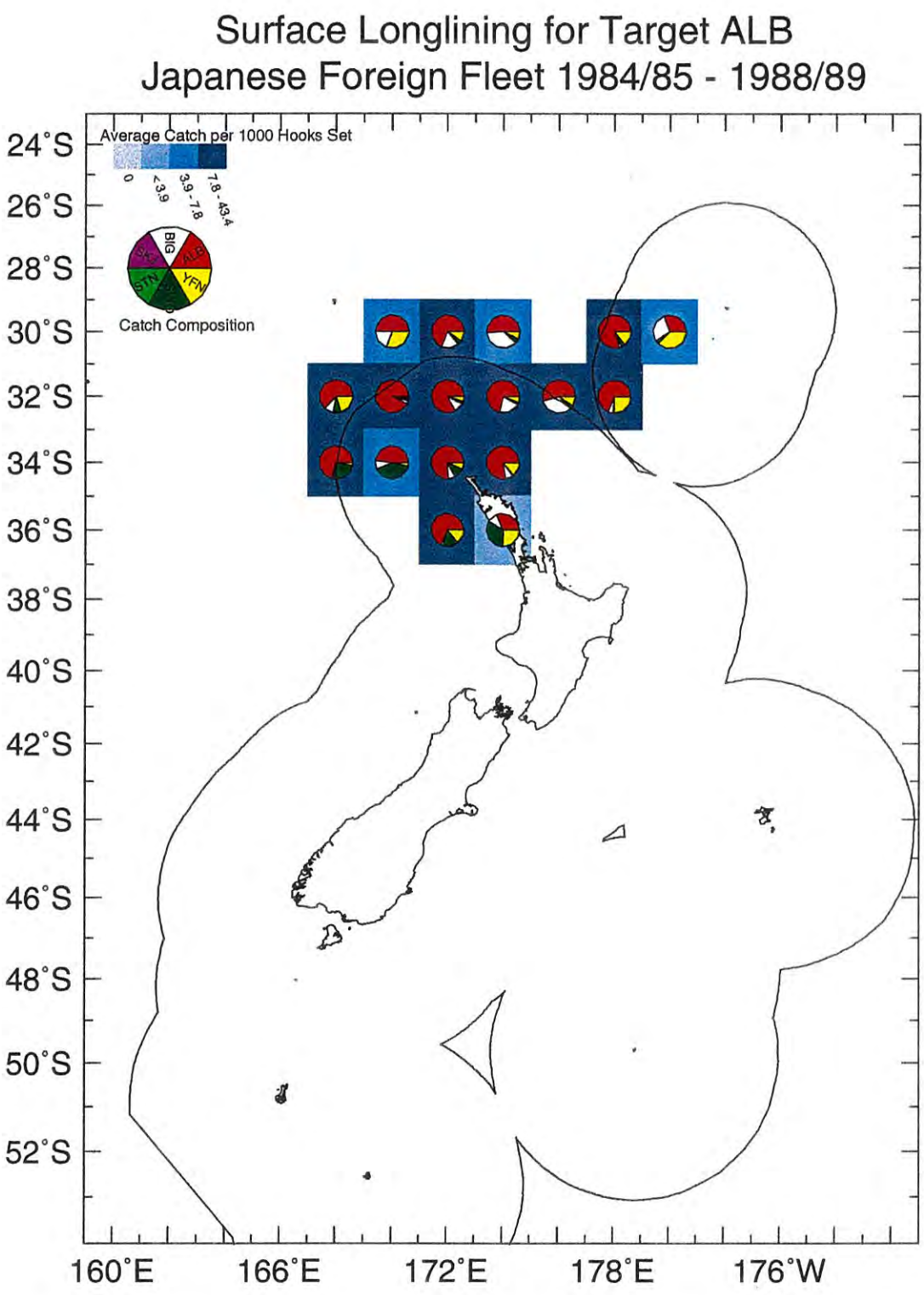
Surface Longlining for Target ALB
Domestic Fleet 1989/90 - 1993/94



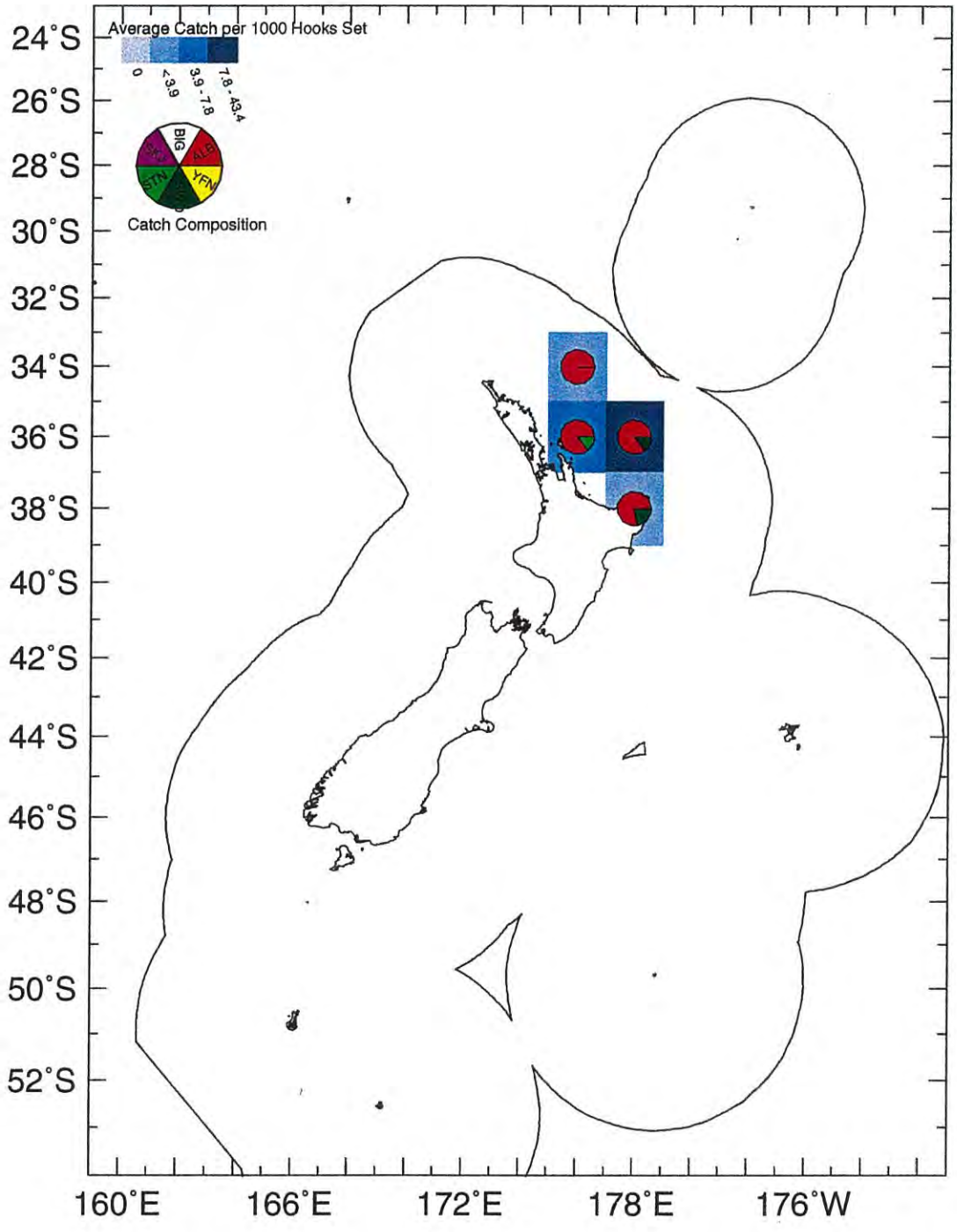
Surface Longlining for Target ALB
Domestic Fleet 1994/95 - 1996/97



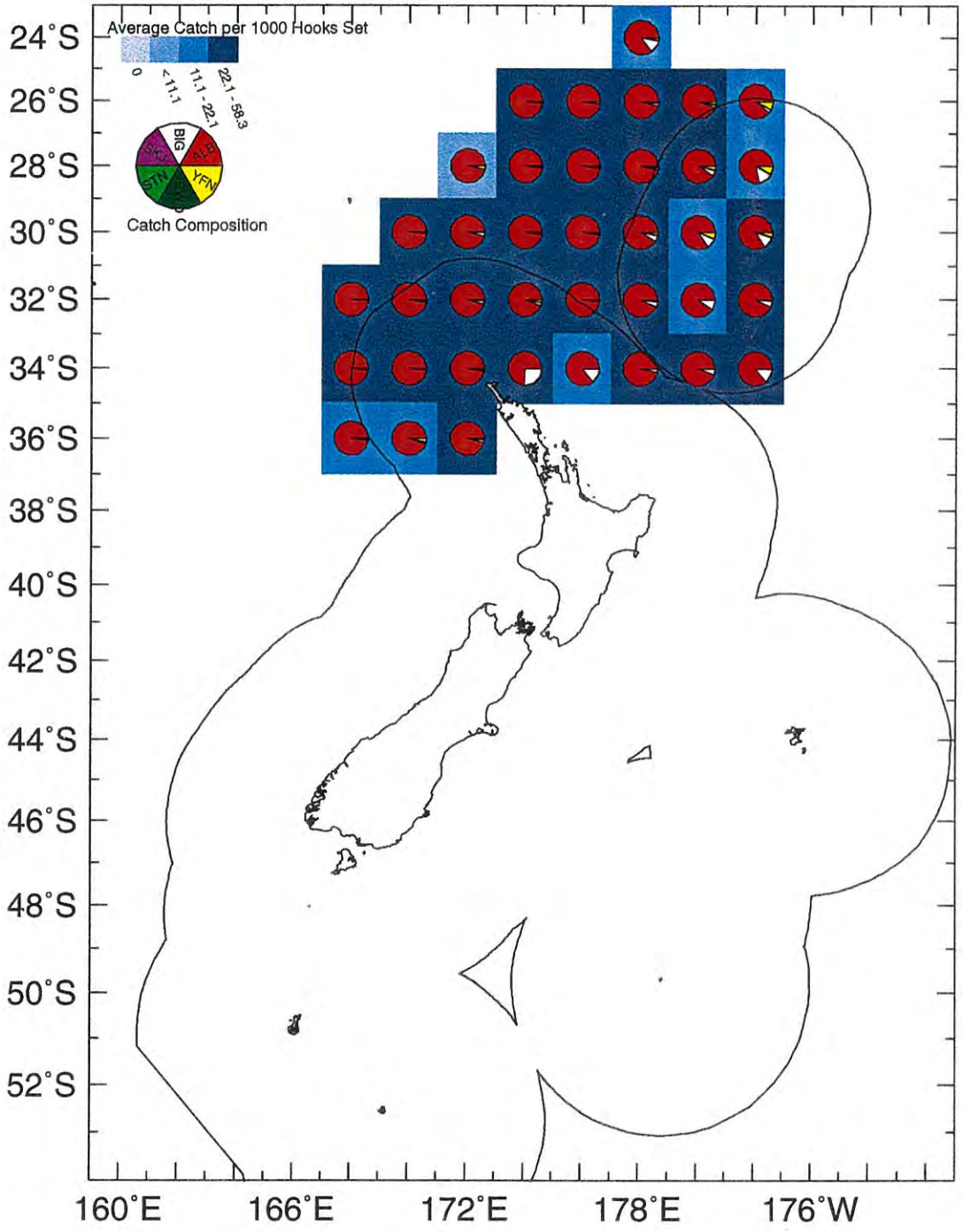

Surface Longlining for Target ALB
Japanese Foreign Fleet 1979/80 - 1983/84
Average Catch per 1000 Hooks Set
0
<3.9
3.9 - 7.8
7.8 - 43.4
BIG
ALB
YFN
STN
SKJ
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

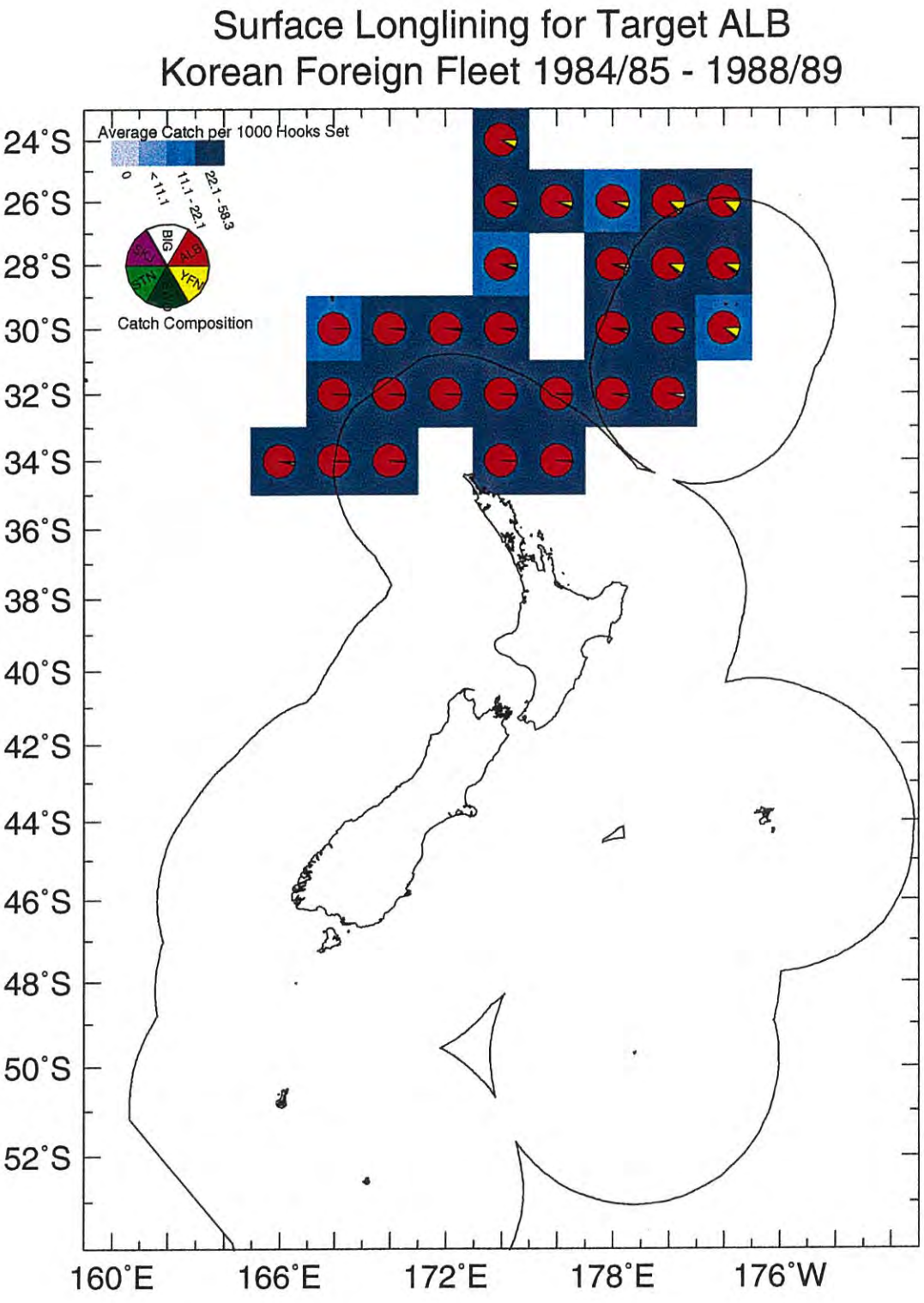

Surface Longlining for Target ALB
Japanese Foreign Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<3.9
3.9 - 7.8
7.8 - 43.4
BIG
ALB
YFN
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

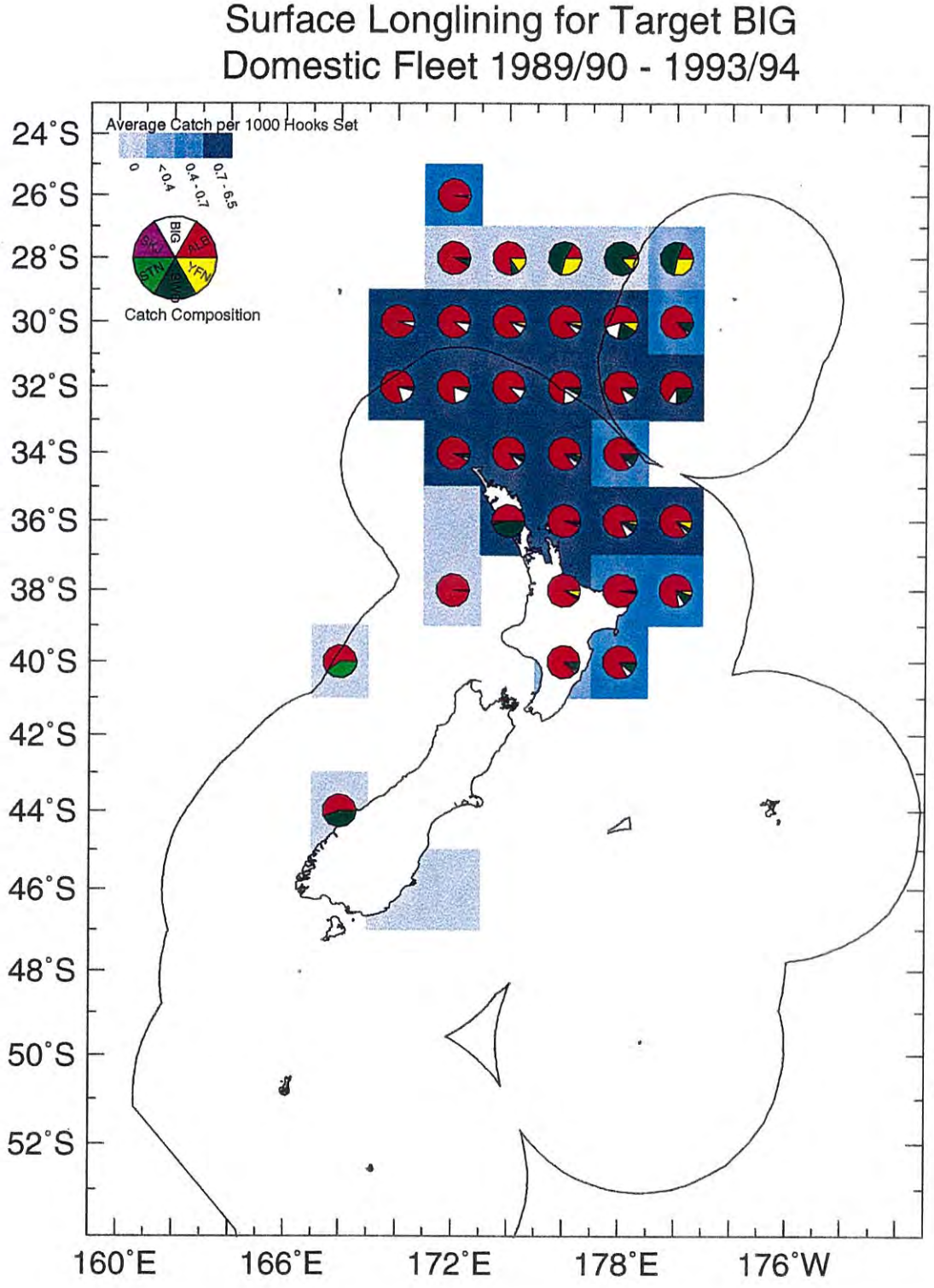
Surface Longlining for Target ALB
Japanese Foreign Fleet 1989/90 - 1993/94

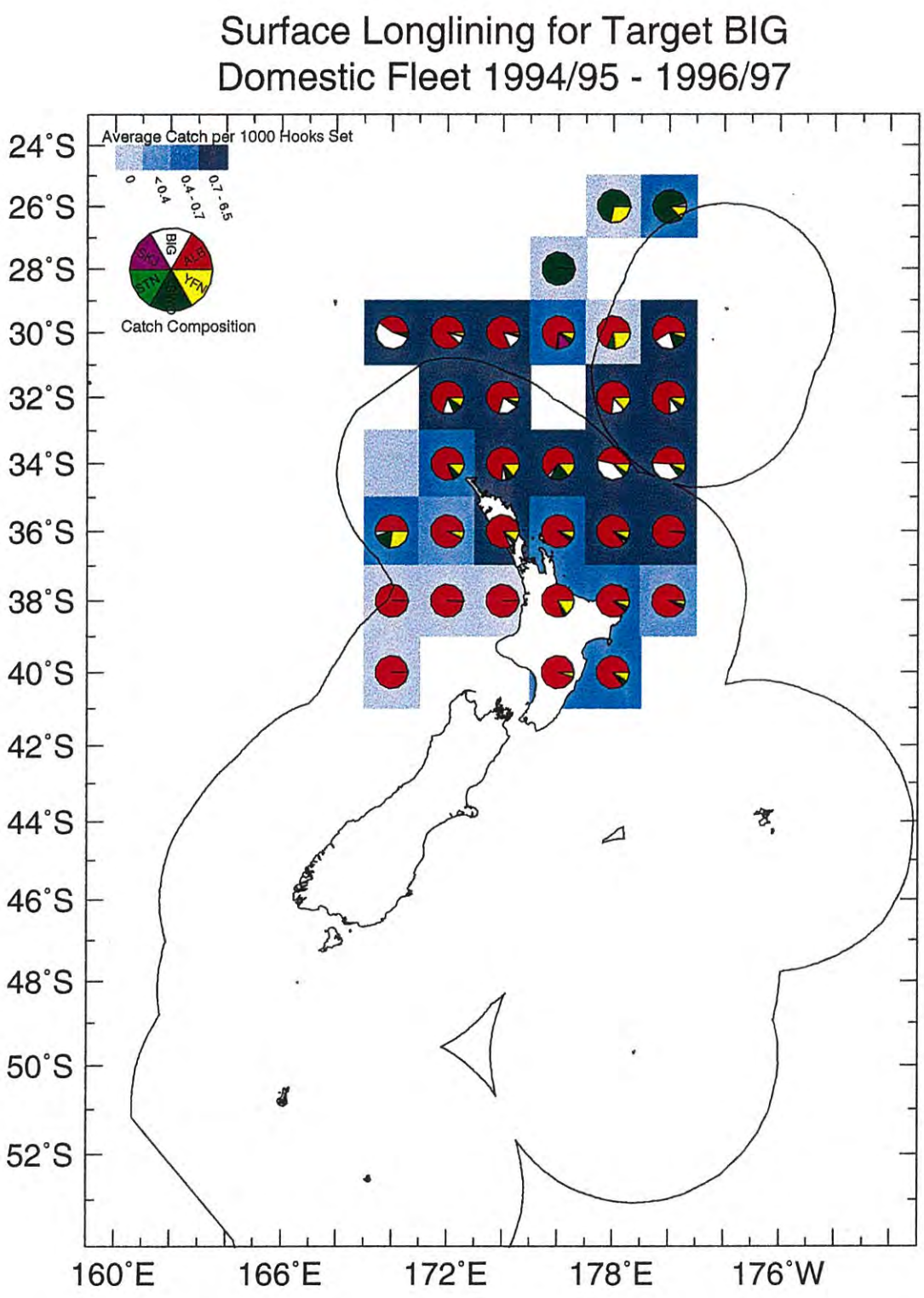


Surface Longlining for Target ALB
Korean Foreign Fleet 1979/80 - 1983/84

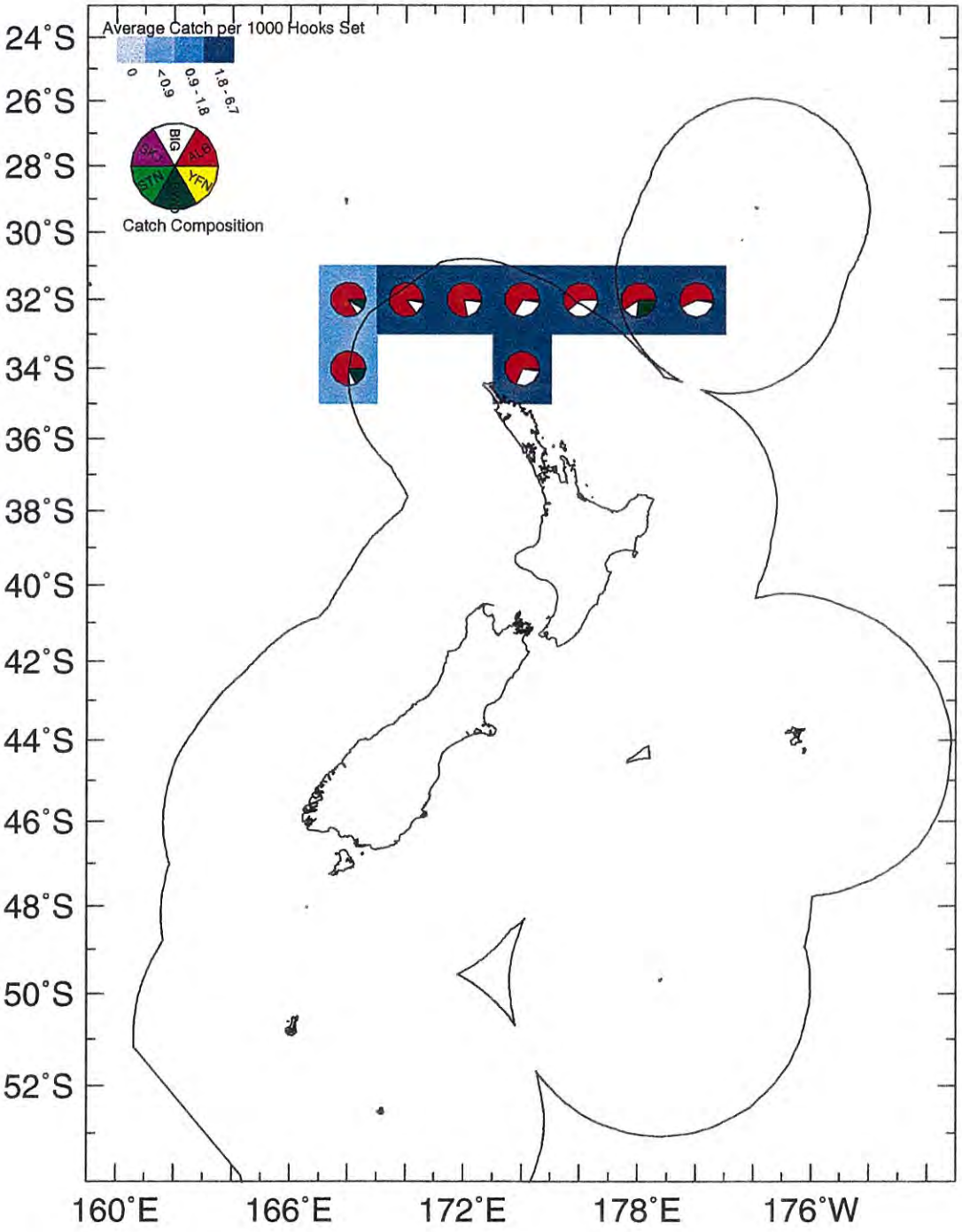



Surface Longlining for Target ALB
Korean Foreign Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<11.1
11.1 - 22.1
22.1 - 58.3
BIG
ALB
YFN
SKJ
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

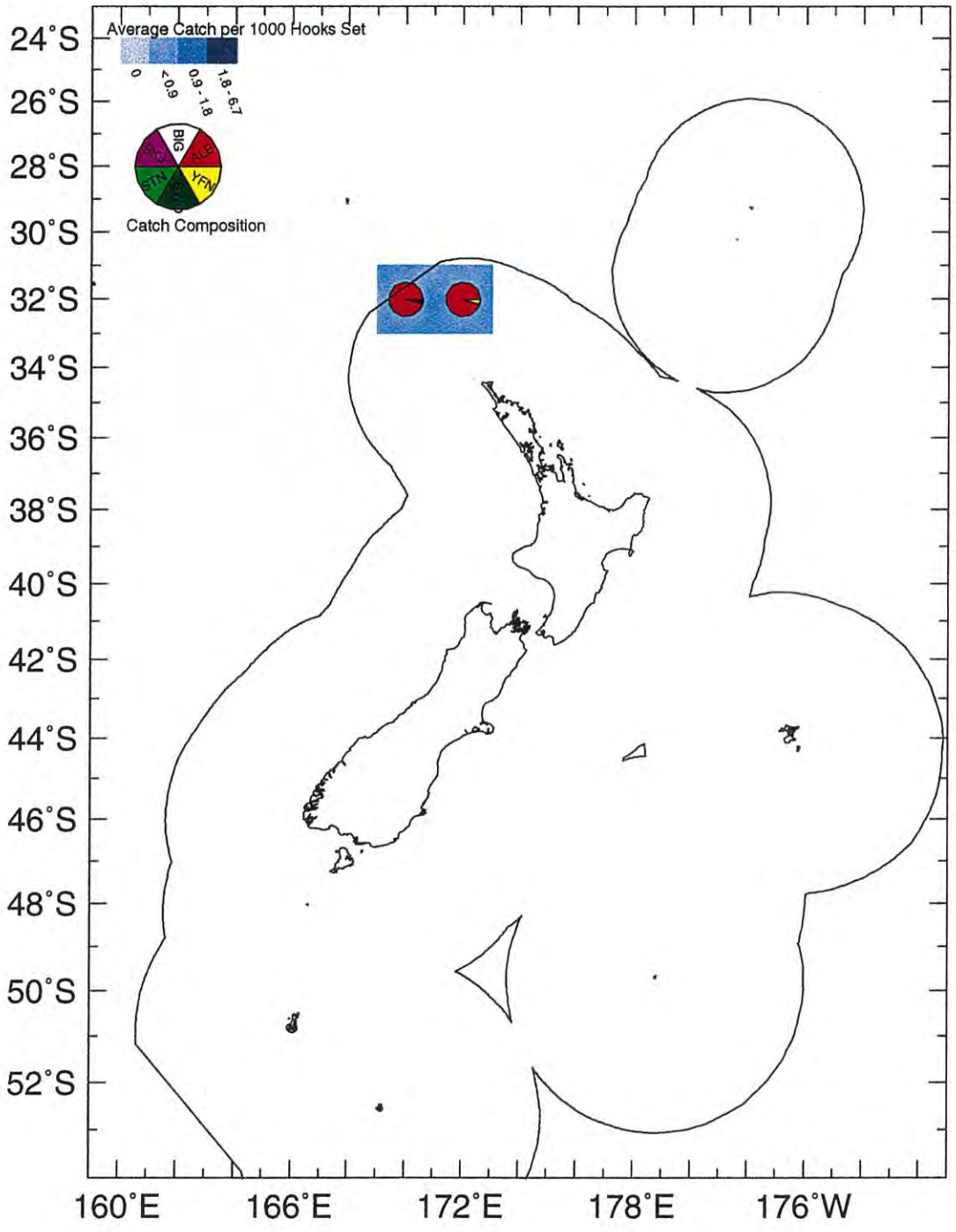

Surface Longlining for Target BIG
Domestic Fleet 1989/90 - 1993/94
Average Catch per 1000 Hooks Set
0
<0.4
0.4 - 0.7
0.7 - 6.5
BIG
ALB
YFN
SWO
BTN
SKI
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

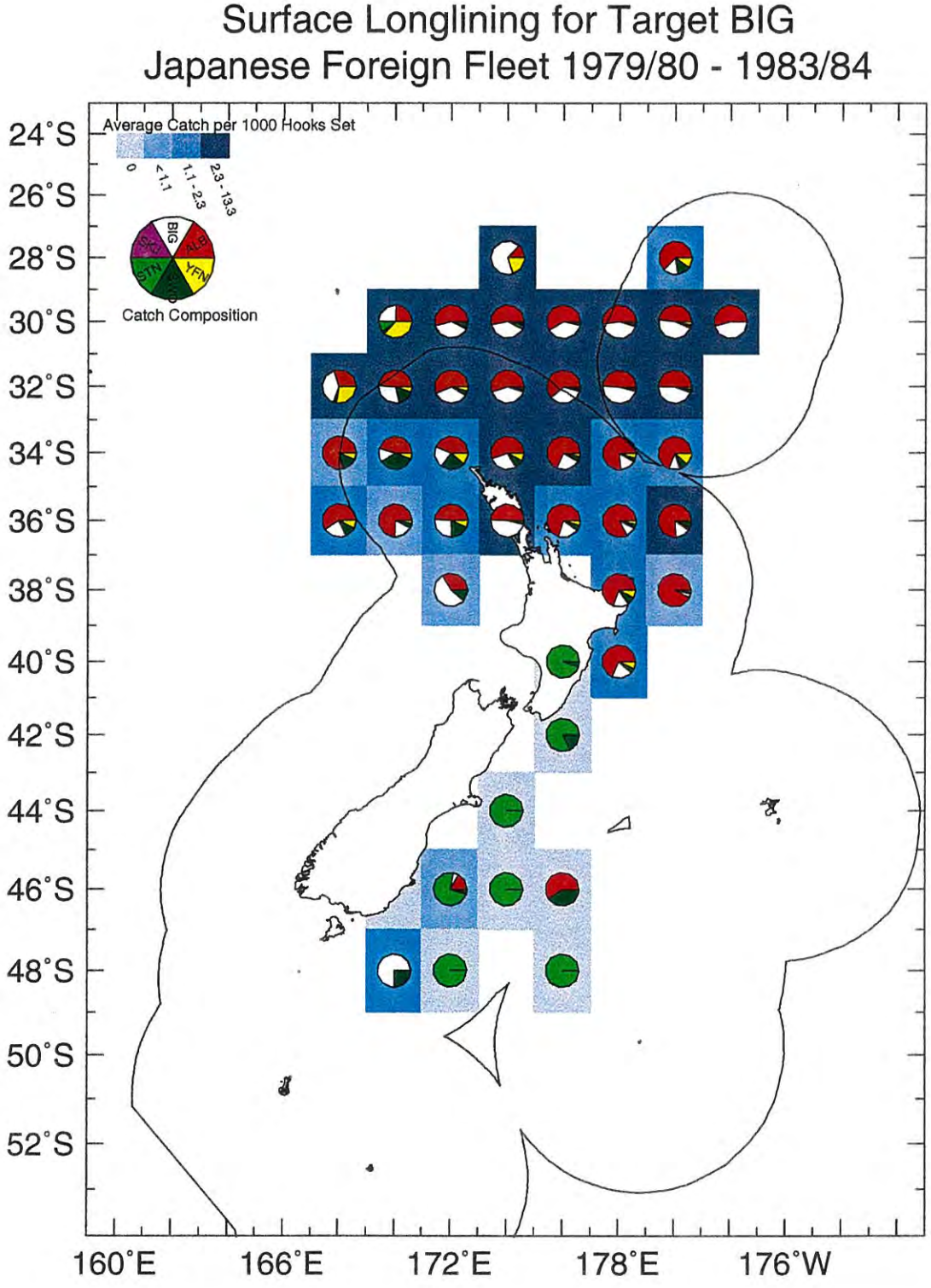

Surface Longlining for Target BIG
Domestic Fleet 1994/95 - 1996/97
Average Catch per 1000 Hooks Set
0
<0.4
0.4 - 0.7
0.7 - 6.5
BIG
ALB
YFN
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

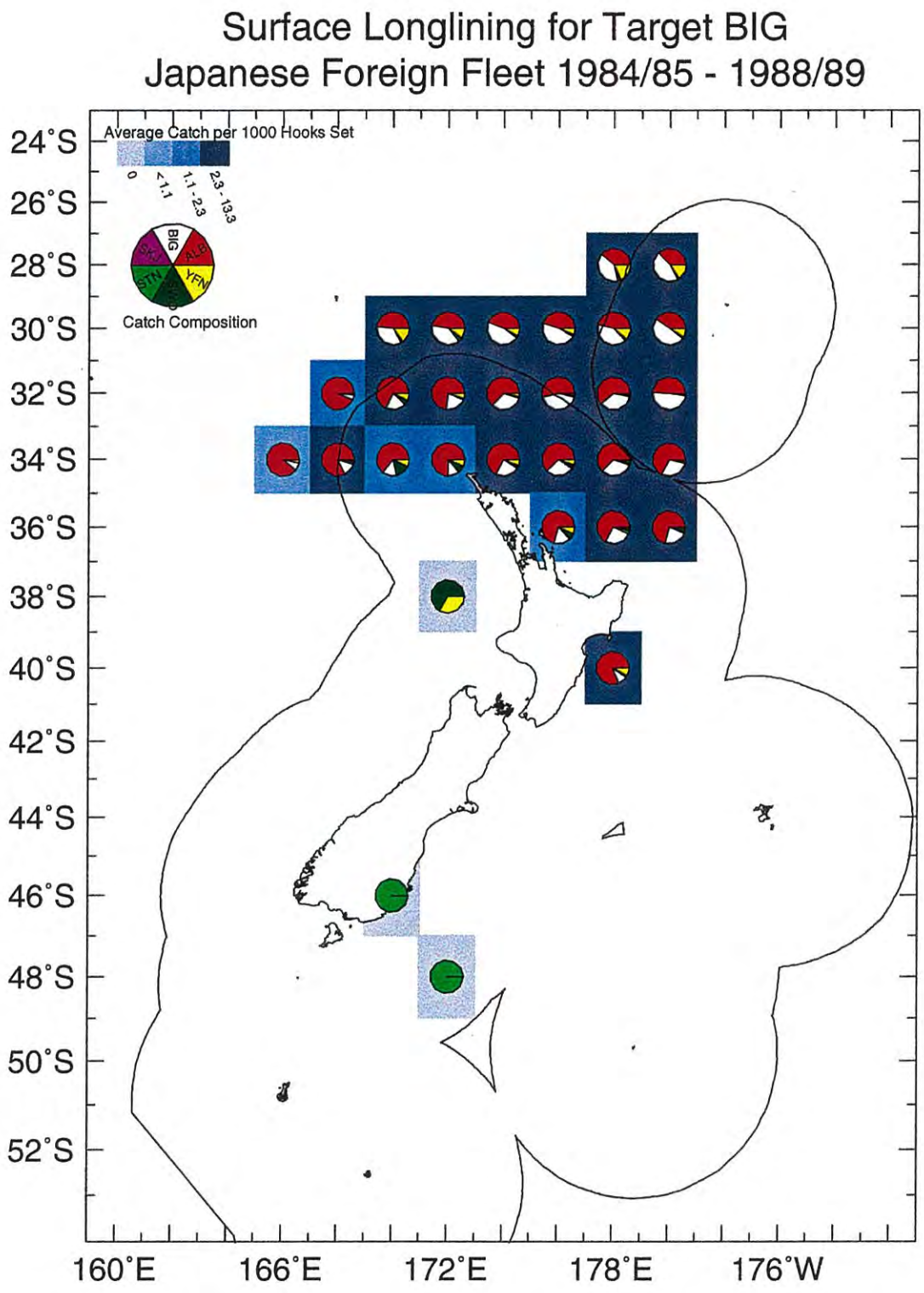
Surface Longlining for Target BIG
Charter Fleet 1989/90 - 1993/94

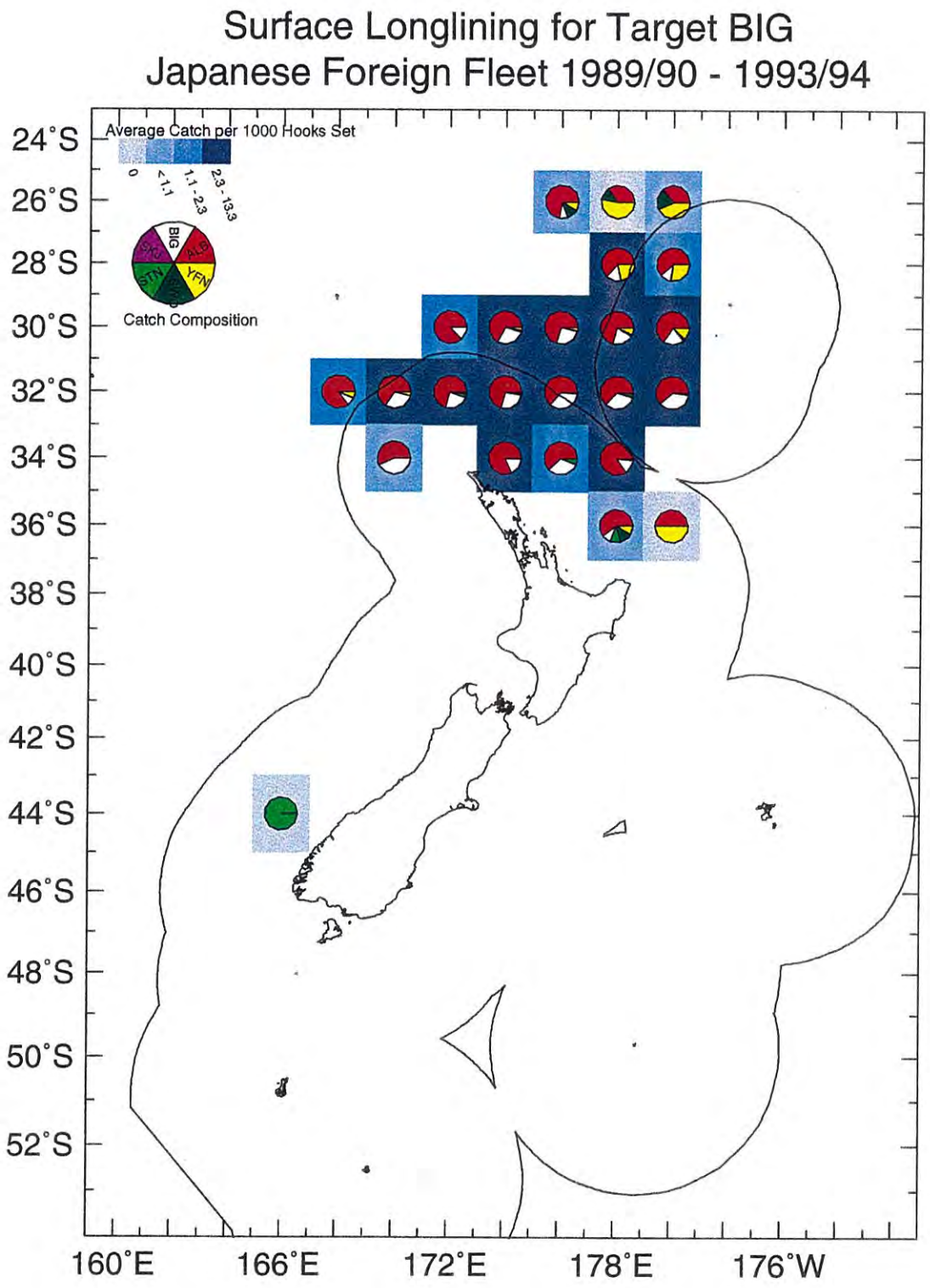


Surface Longlining for Target BIG
Charter Fleet 1994/95 - 1996/97

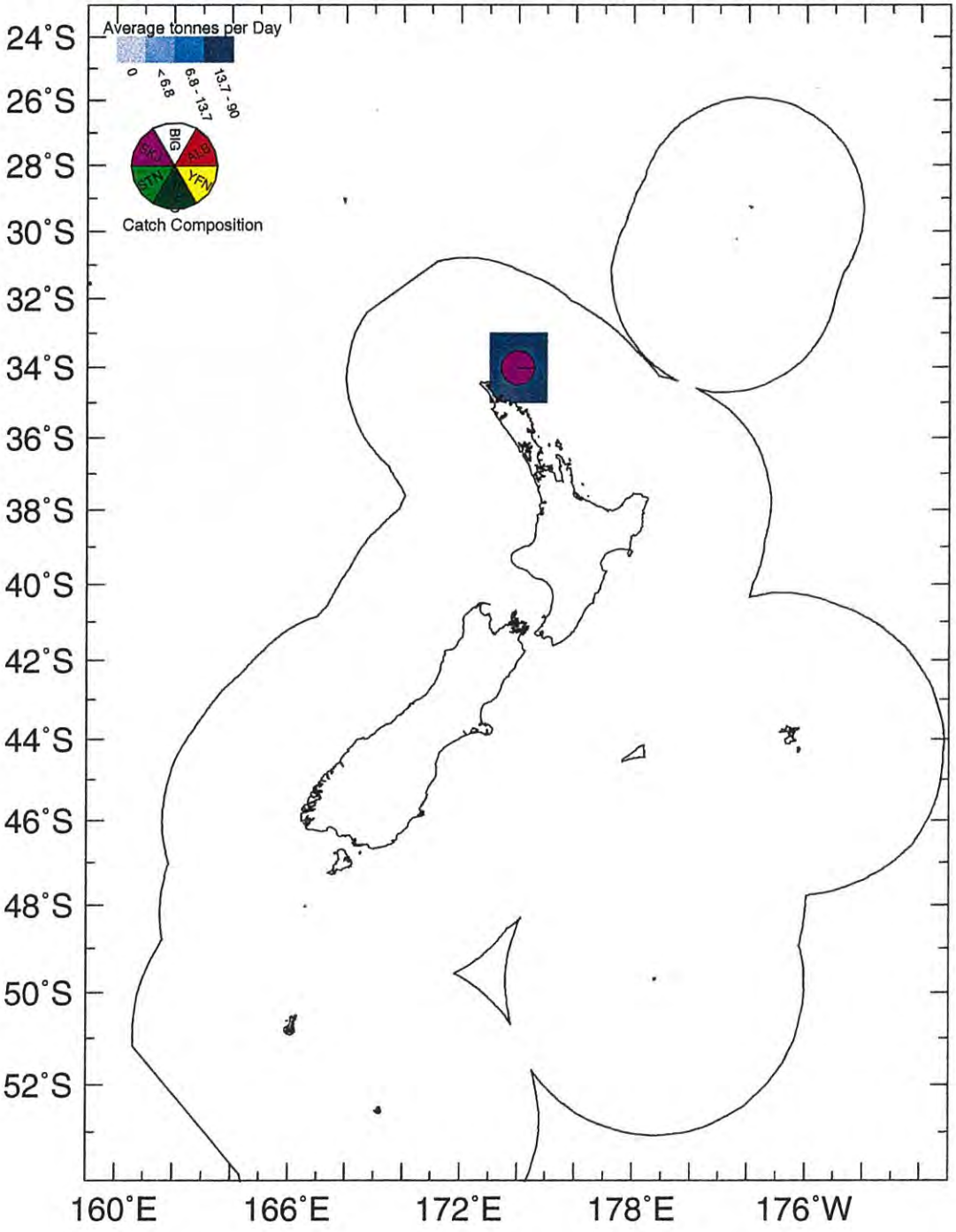



Surface Longlining for Target BIG
Japanese Foreign Fleet 1979/80 - 1983/84
Average Catch per 1000 Hooks Set
0
<1.1
1.1 - 2.3
2.3 - 13.3
BIG
ALB
YFN
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

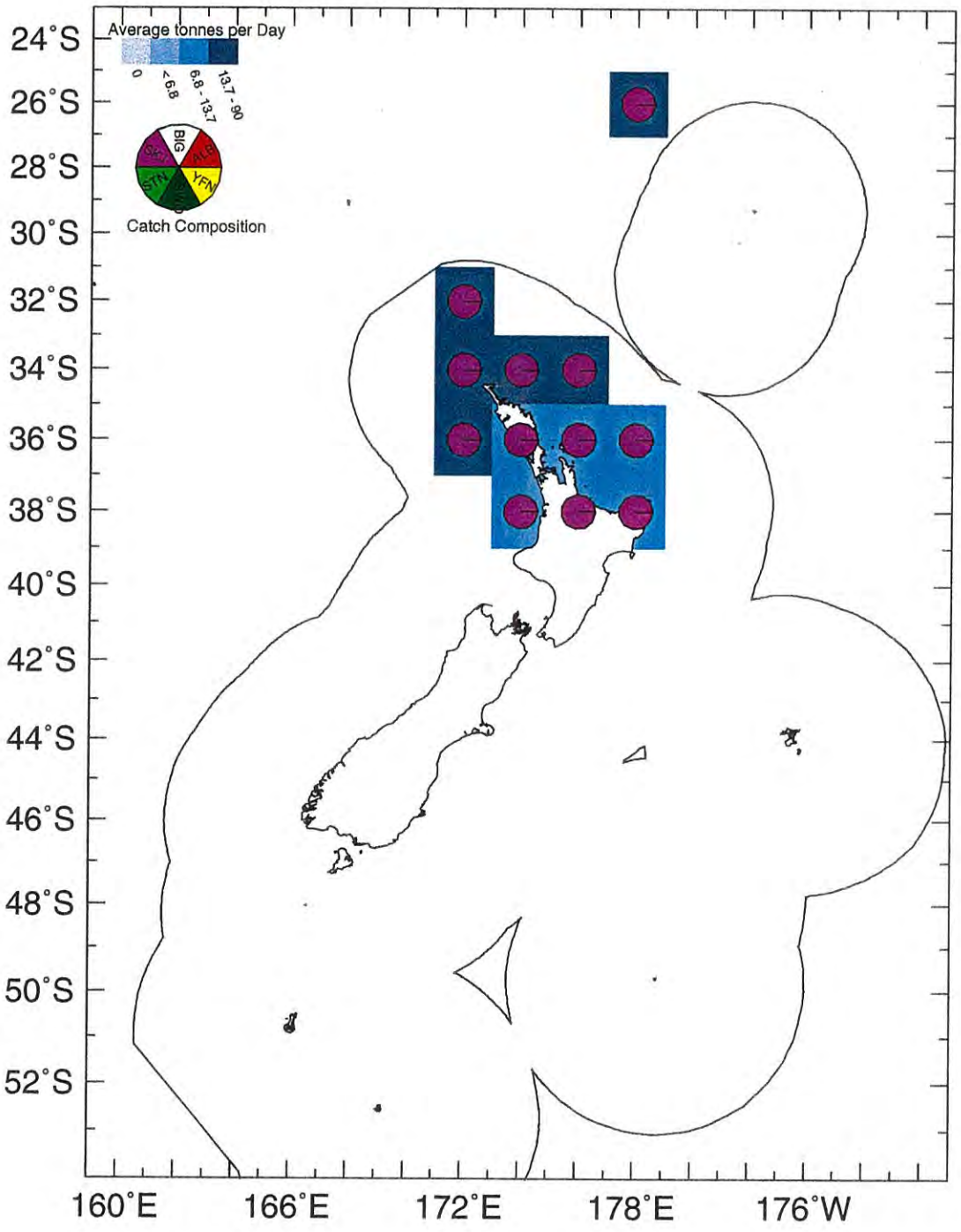

Surface Longlining for Target BIG
Japanese Foreign Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<1.1
1.1 - 2.3
2.3 - 13.3
BIG
ALB
YFN
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W


Surface Longlining for Target BIG
Japanese Foreign Fleet 1989/90 - 1993/94
Average Catch per 1000 Hooks Set
0
<1.1
1.1 - 2.3
2.3 - 13.3
BIG
ALB
YFN
BTH
SKJ
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

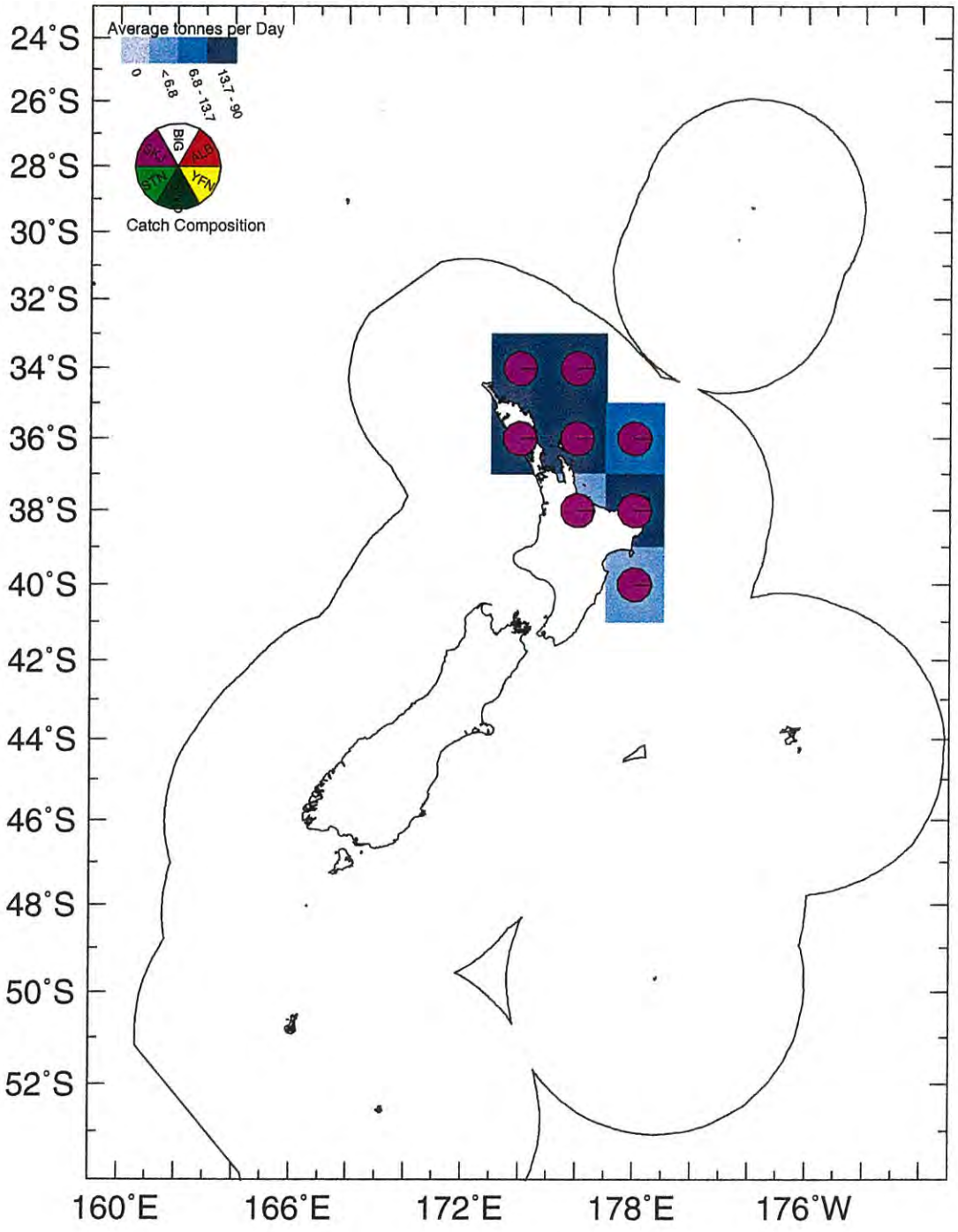
Purse Seine for Target SKJ
Domestic Fleet 1984/85 - 1988/89



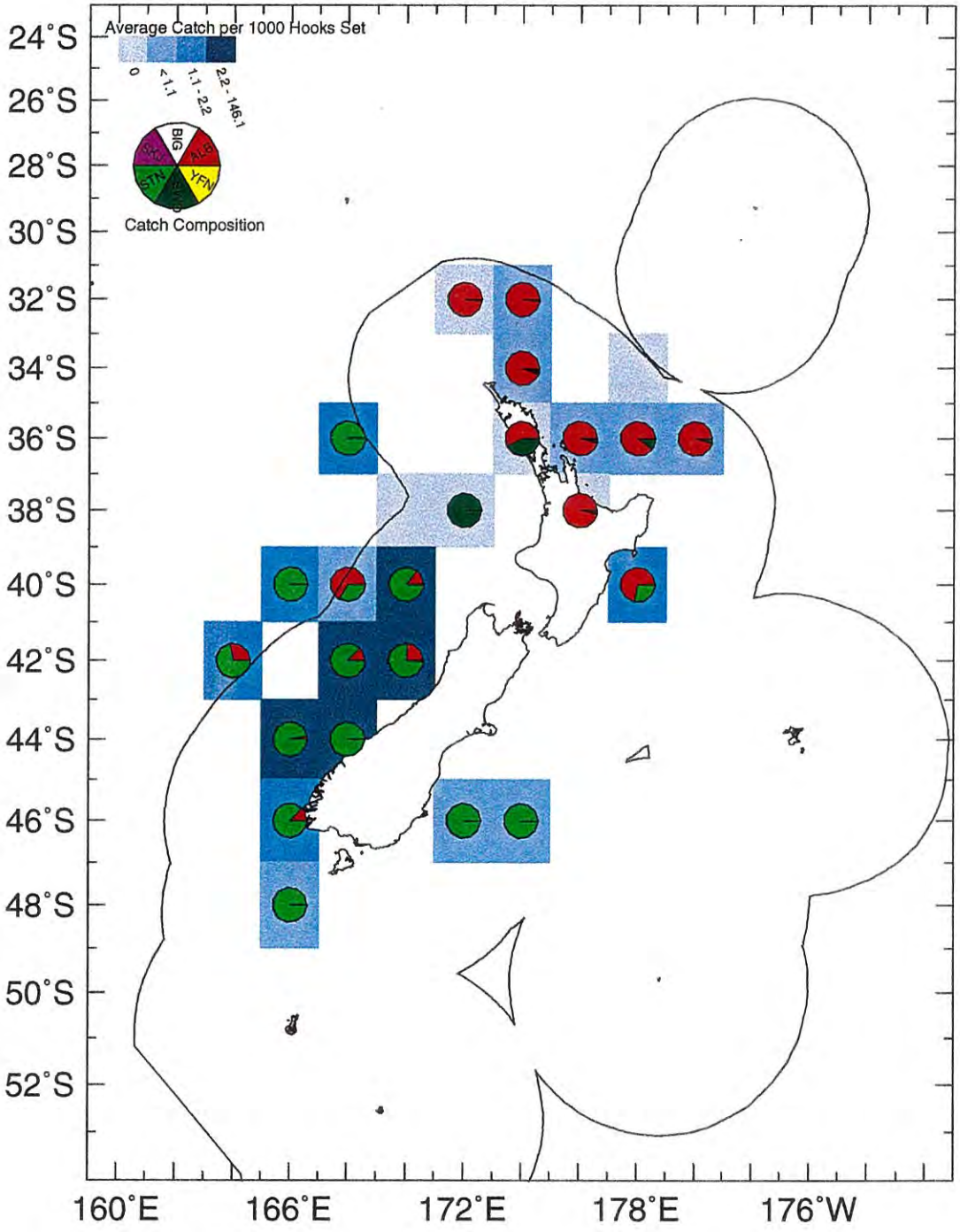
Purse Seine for Target SKJ
Domestic Fleet 1989/90 - 1993/94



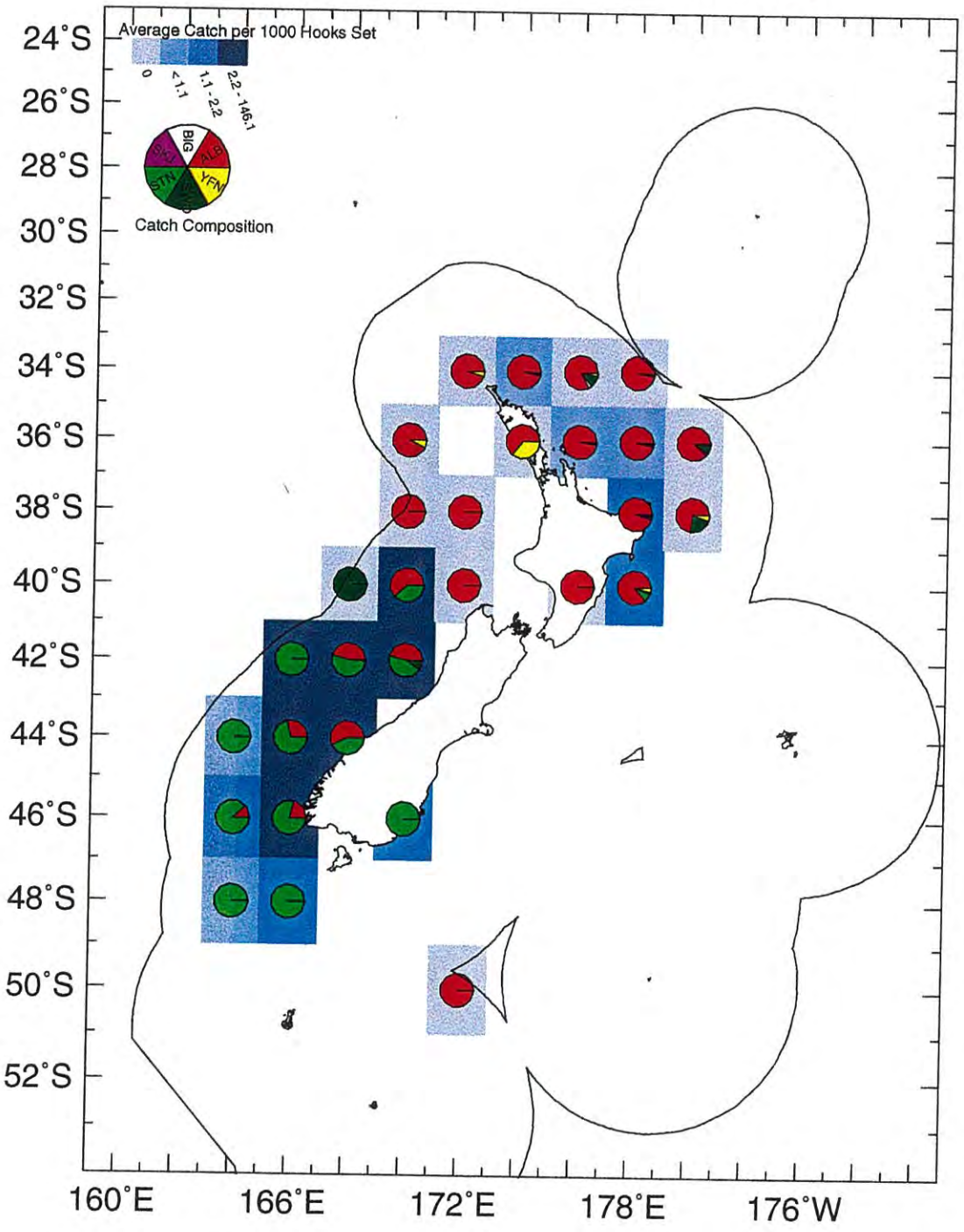
Purse Seine for Target SKJ
Domestic Fleet 1994/95 - 1996/97

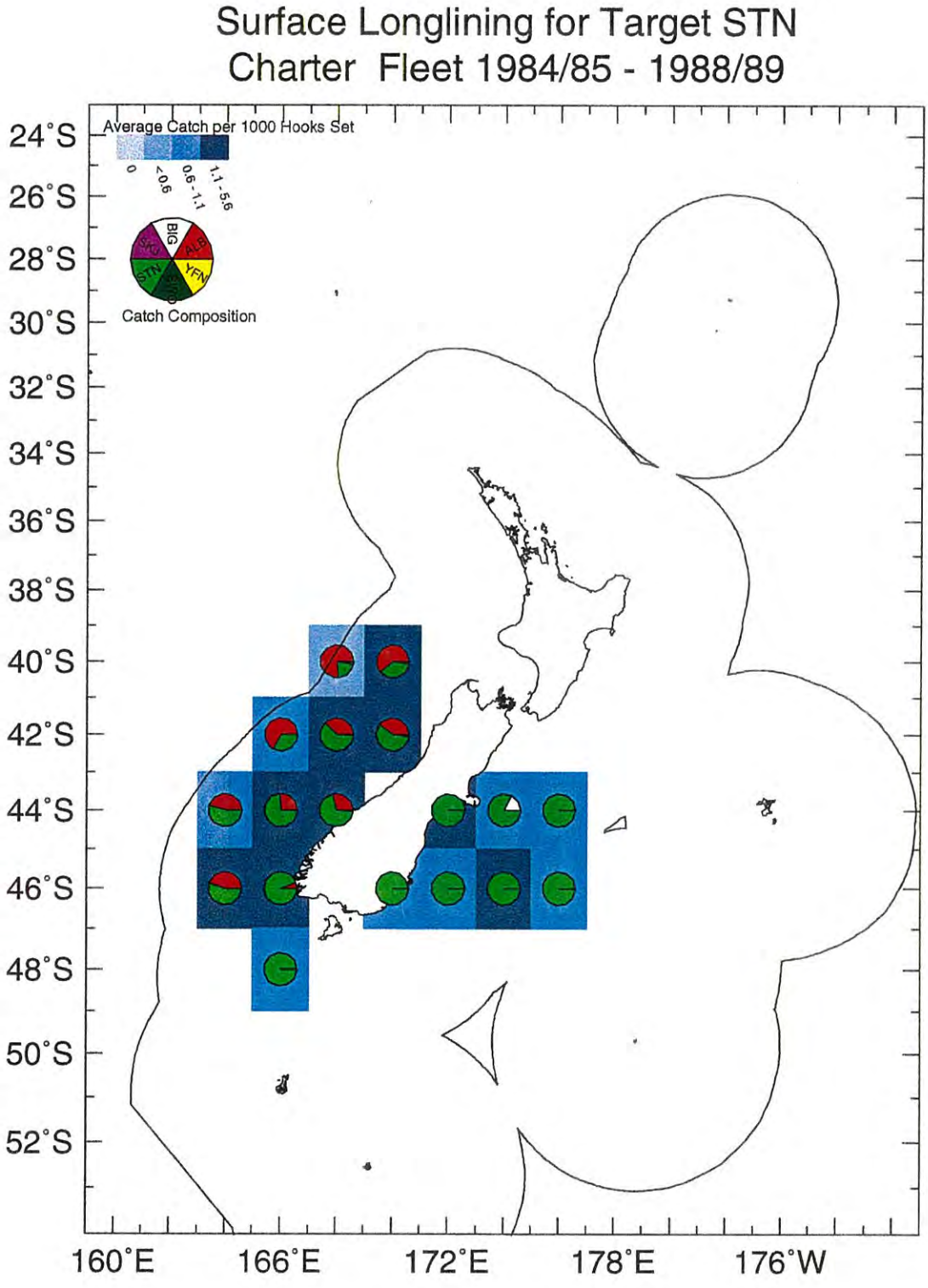


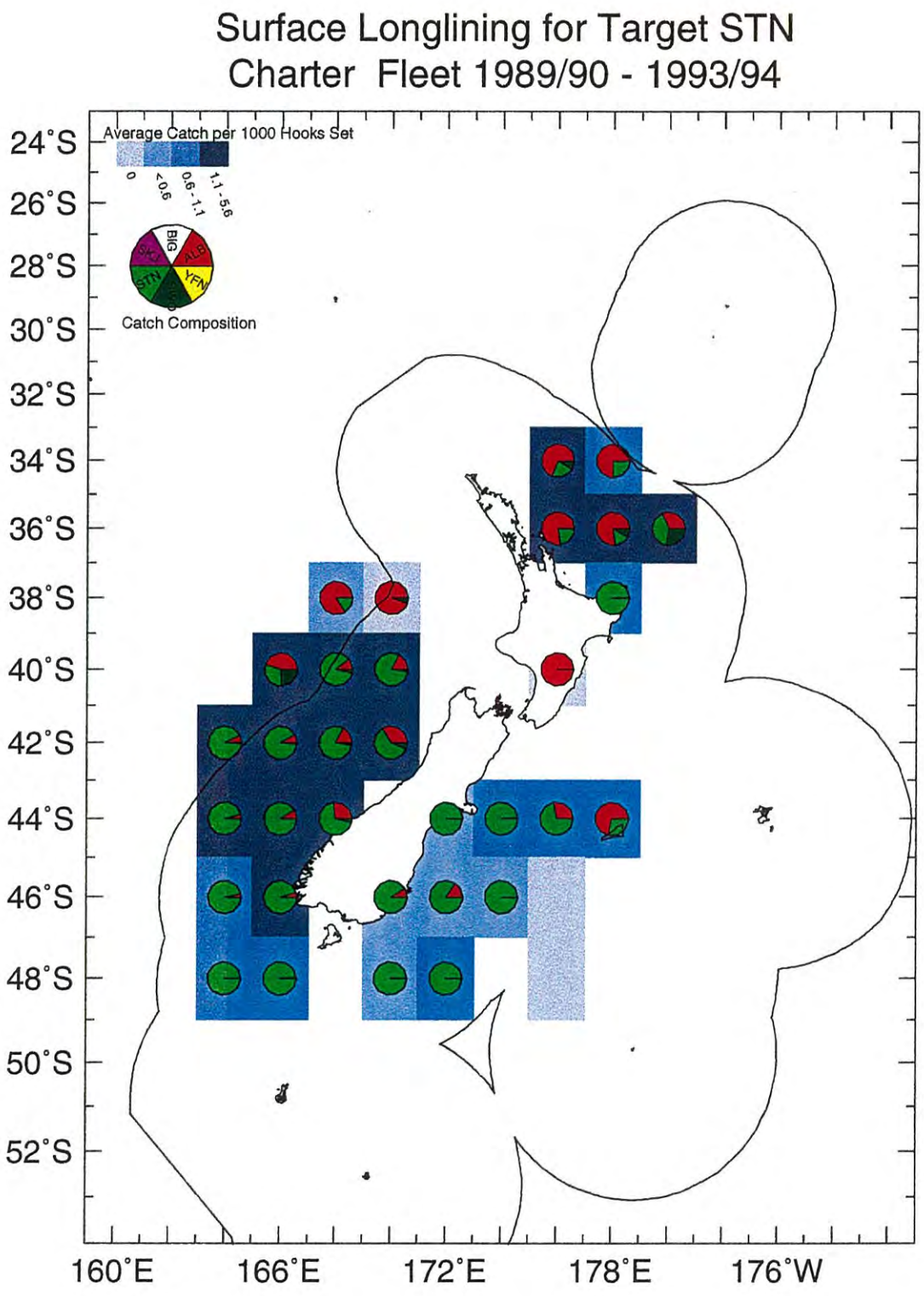
Surface Longlining for Target STN
Domestic Fleet 1989/90 - 1993/94



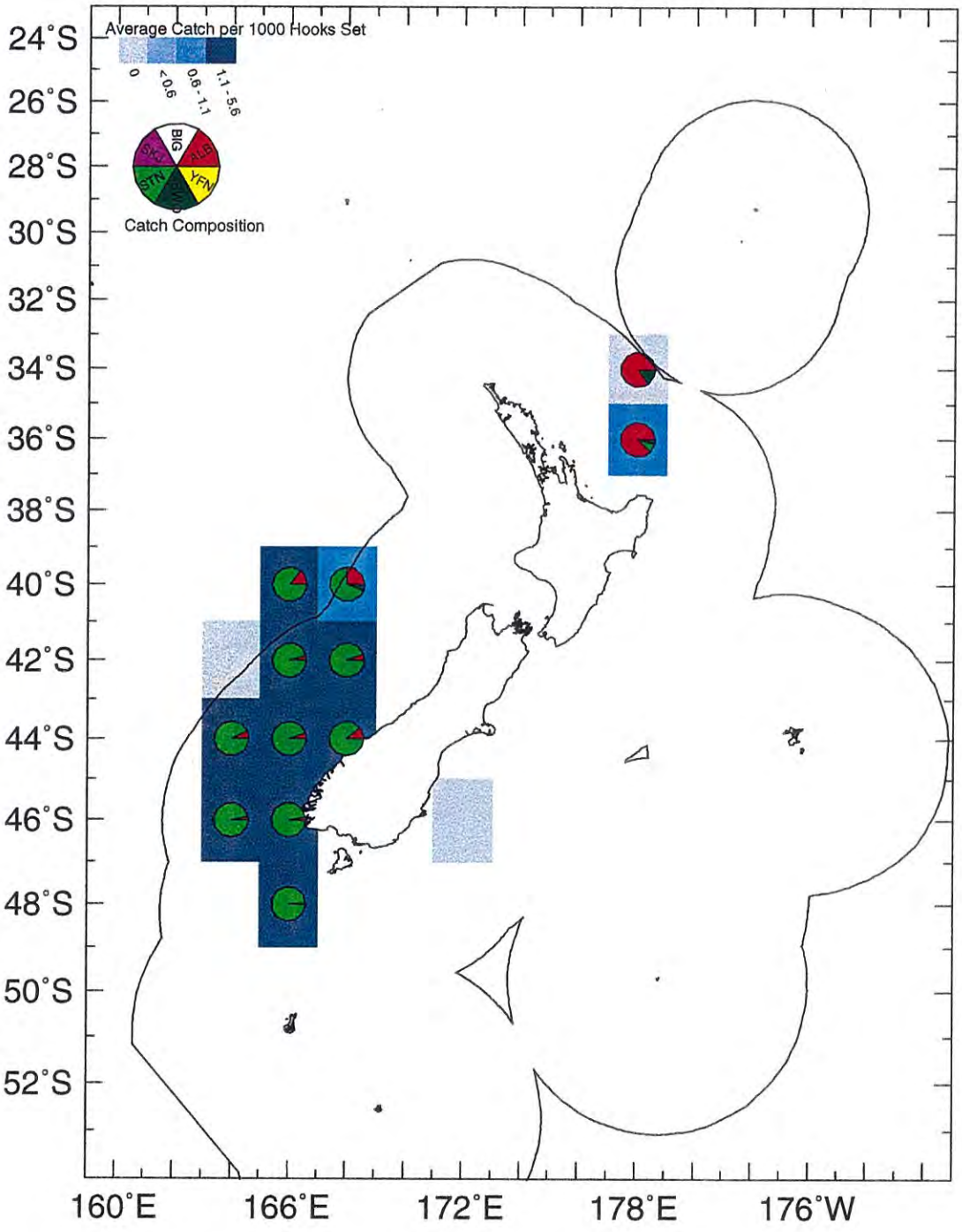
Surface Longlining for Target STN
Domestic Fleet 1994/95 - 1996/97



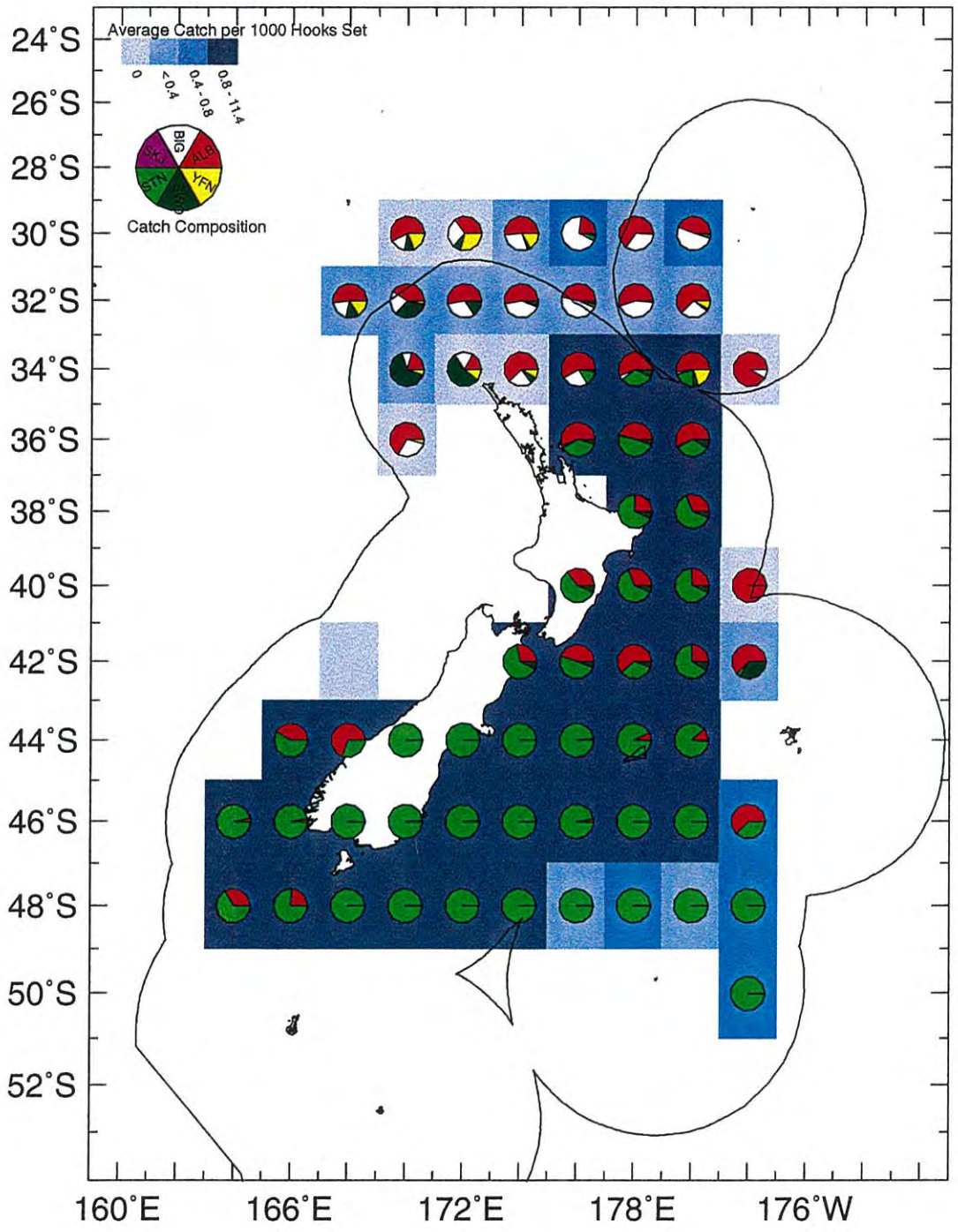

Surface Longlining for Target STN
Charter Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<0.6
0.6 - 1.1
1.1 - 5.6
BIG
ALB
YFN
SKI
STN
OTH
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

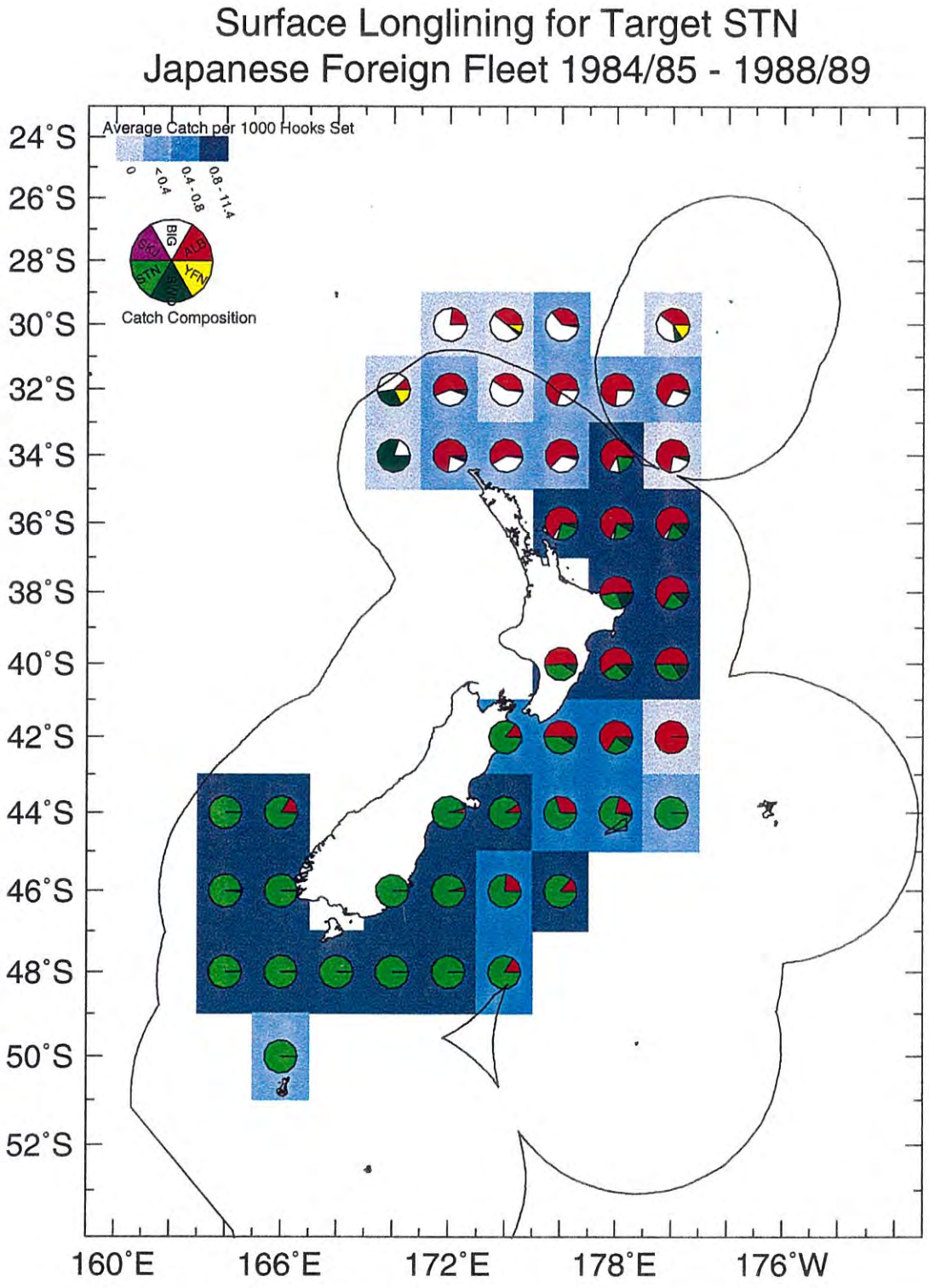

Surface Longlining for Target STN
Charter Fleet 1989/90 - 1993/94
Average Catch per 1000 Hooks Set
0
<0.6
0.6 - 1.1
1.1 - 5.6
BIG
ALB
YFN
STN
SKJ
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

Surface Longlining for Target STN
Charter Fleet 1994/95 - 1996/97

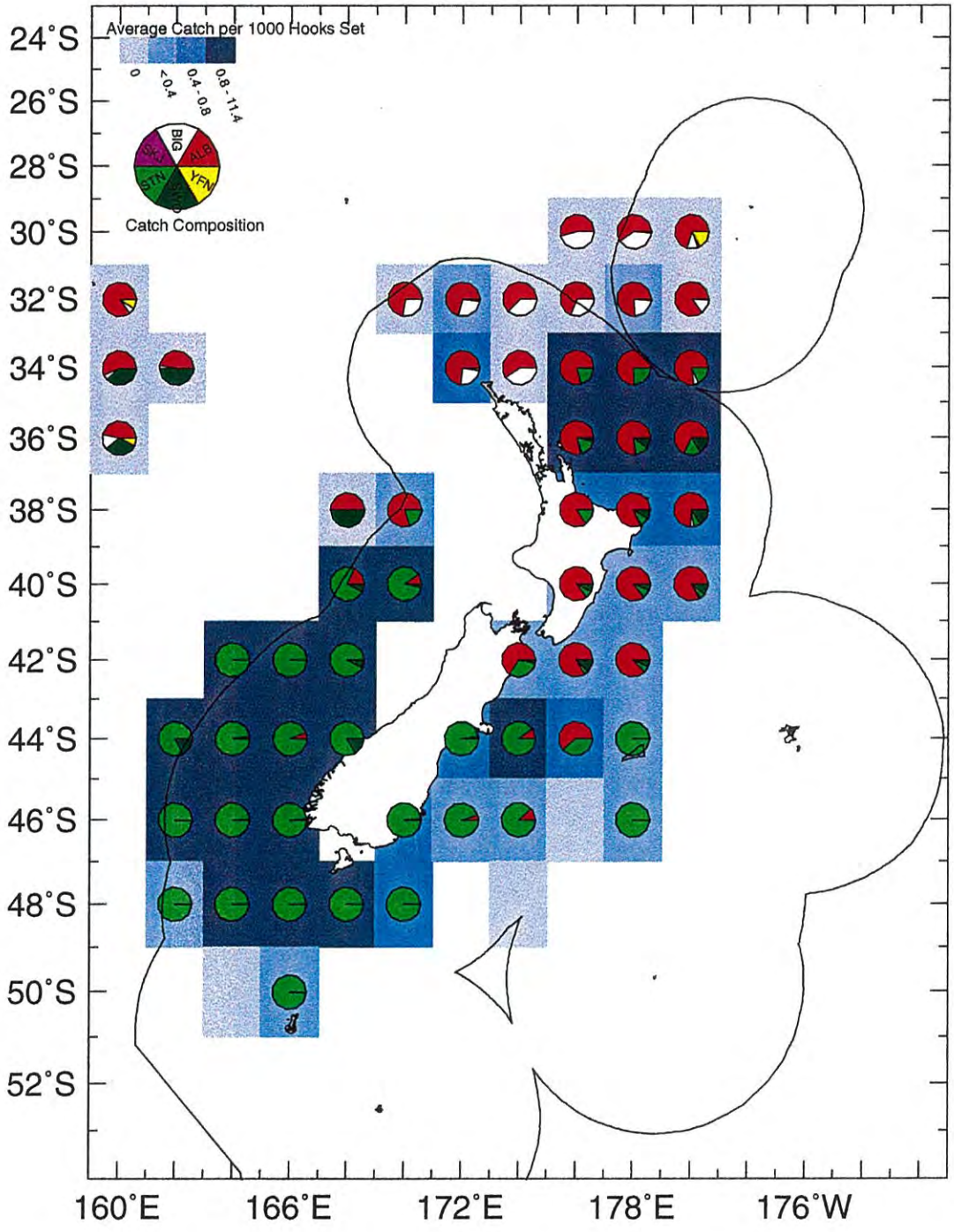


Surface Longlining for Target STN
Japanese Foreign Fleet 1979/80 - 1983/84

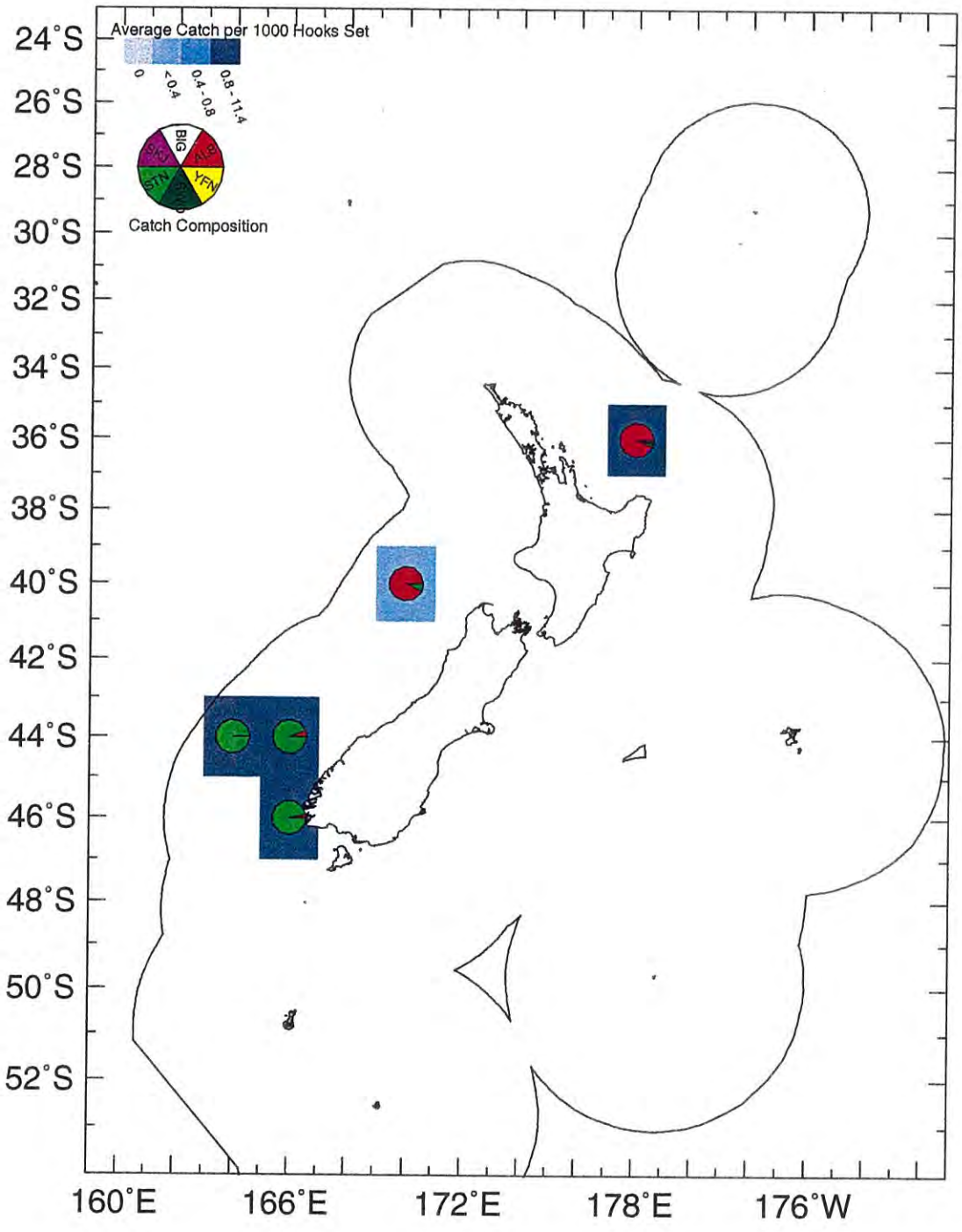



Surface Longlining for Target STN
Japanese Foreign Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<0.4
0.4 - 0.8
0.8 - 11.4
BIG
ALB
YFN
SKJ
STN
SWO
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

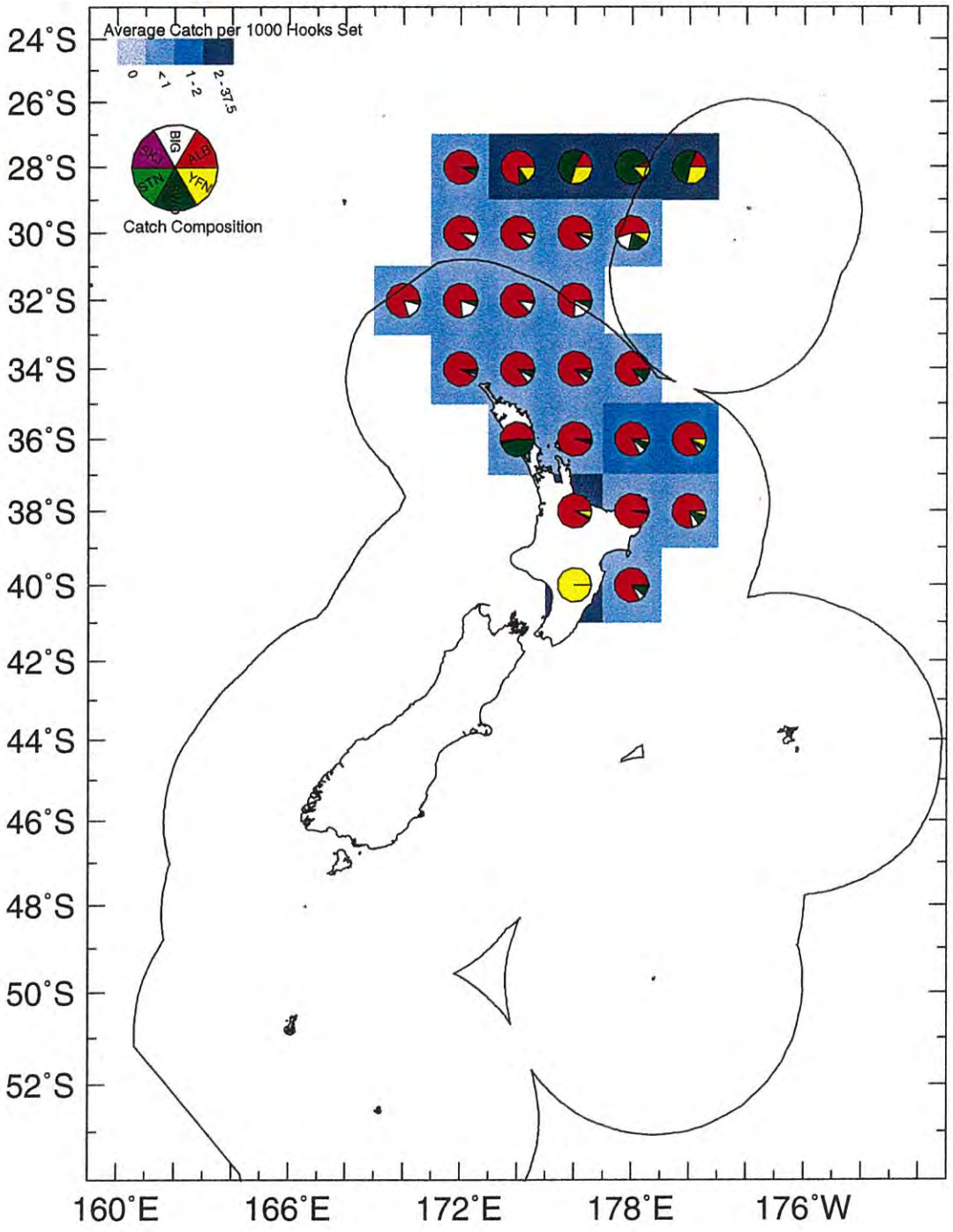
Surface Longlining for Target STN
Japanese Foreign Fleet 1989/90 - 1993/94



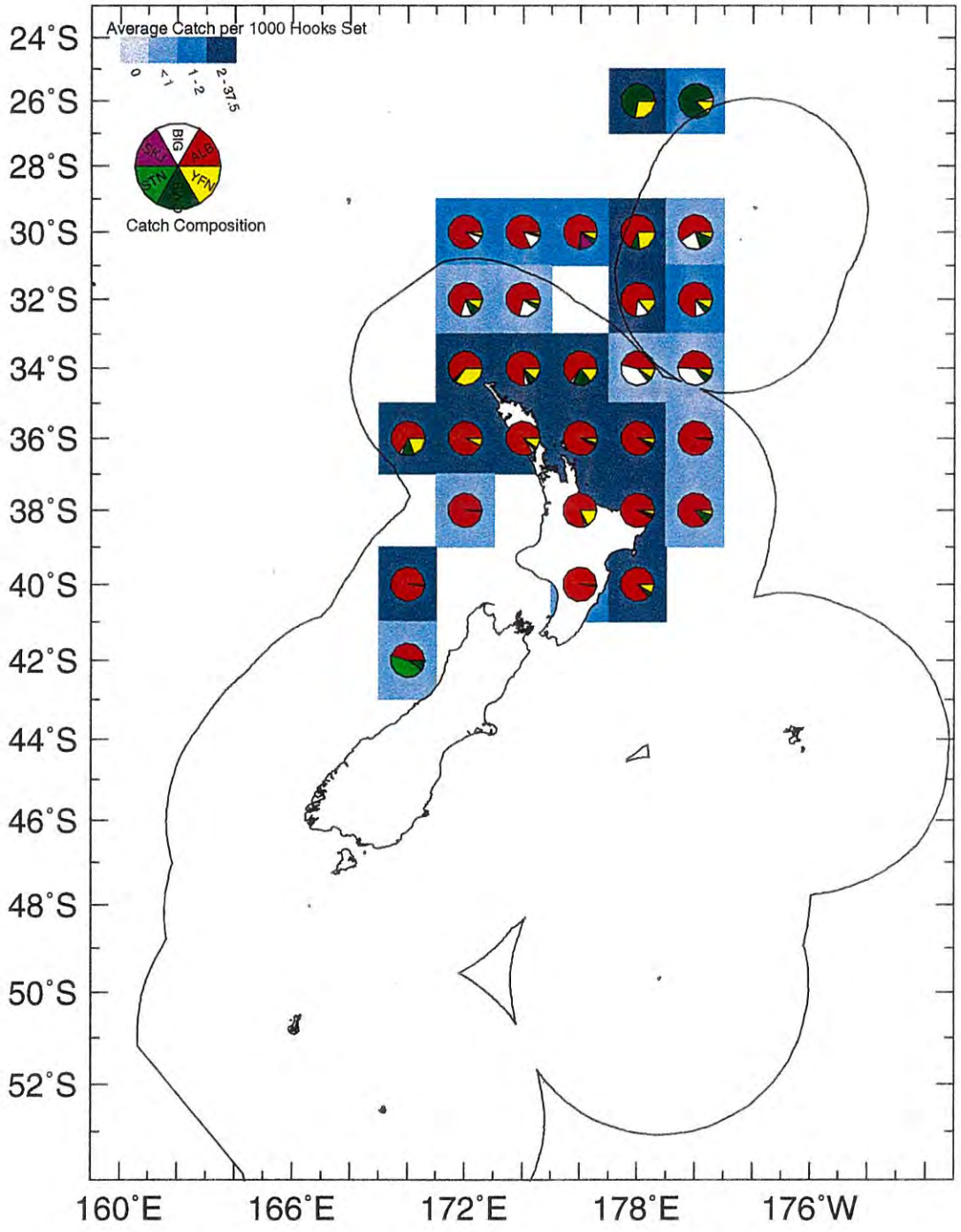
Surface Longlining for Target STN
Japanese Foreign Fleet 1994/95 - 1996/97

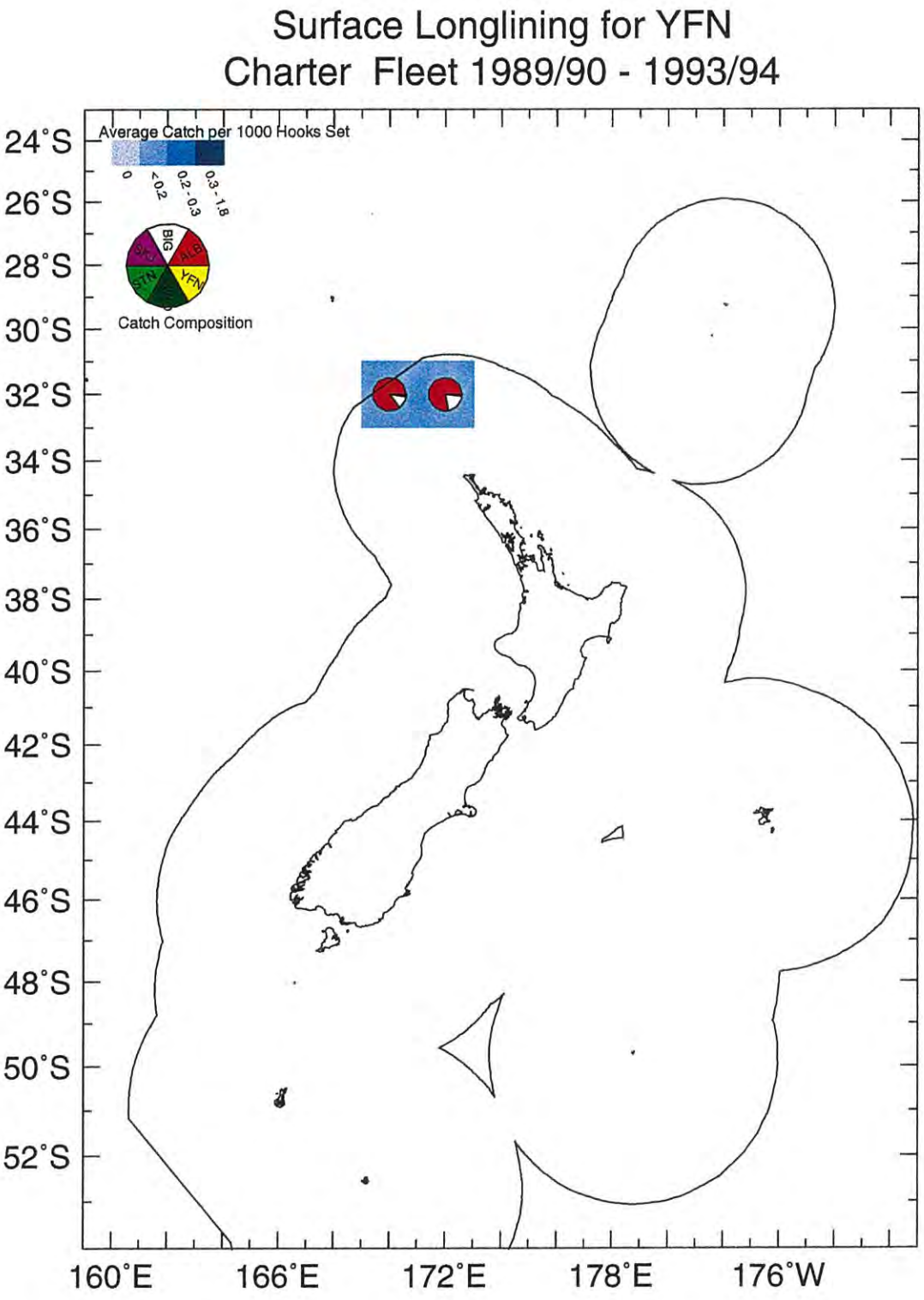


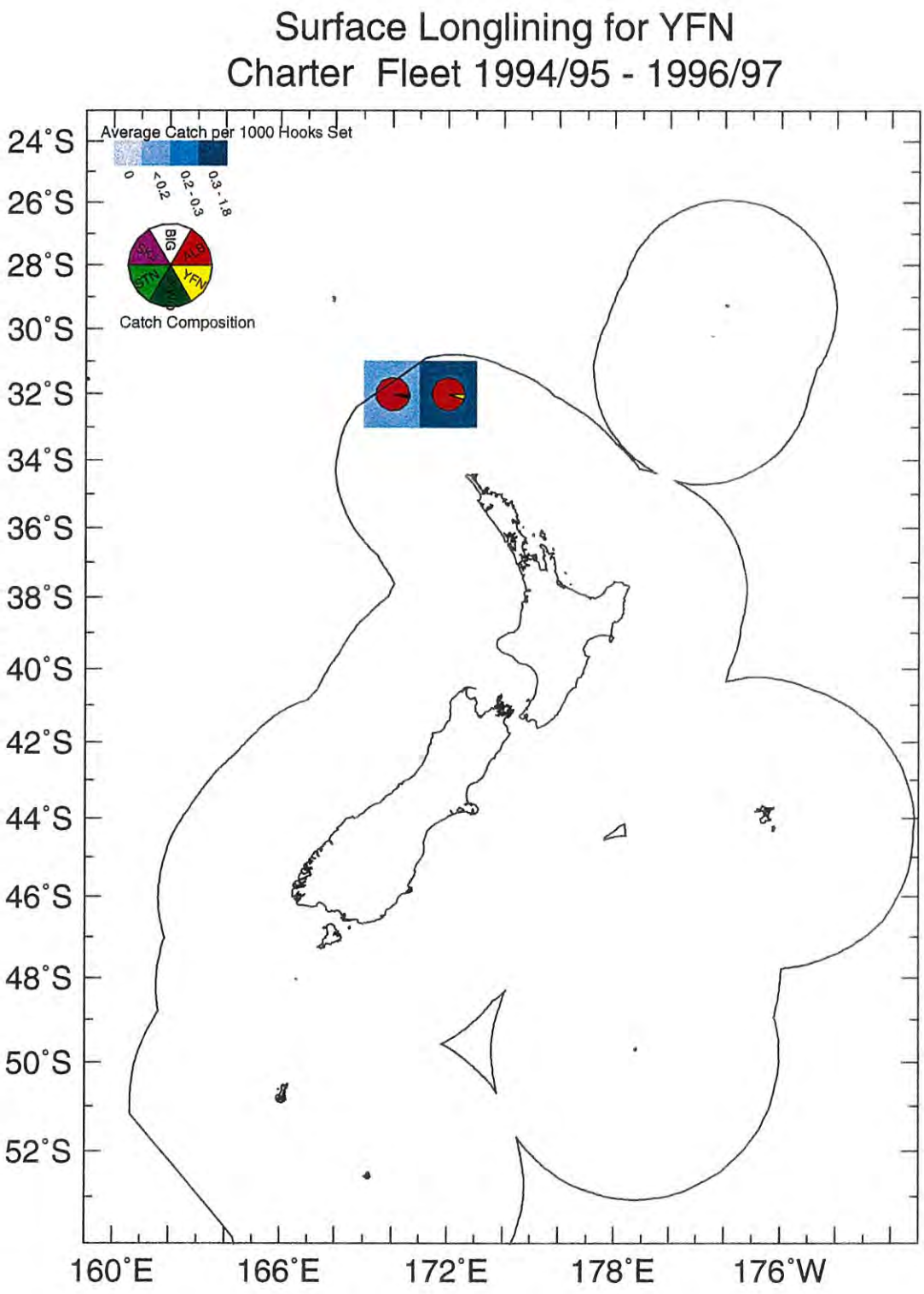
Surface Longlining for YFN
Domestic Fleet 1989/90 - 1993/94



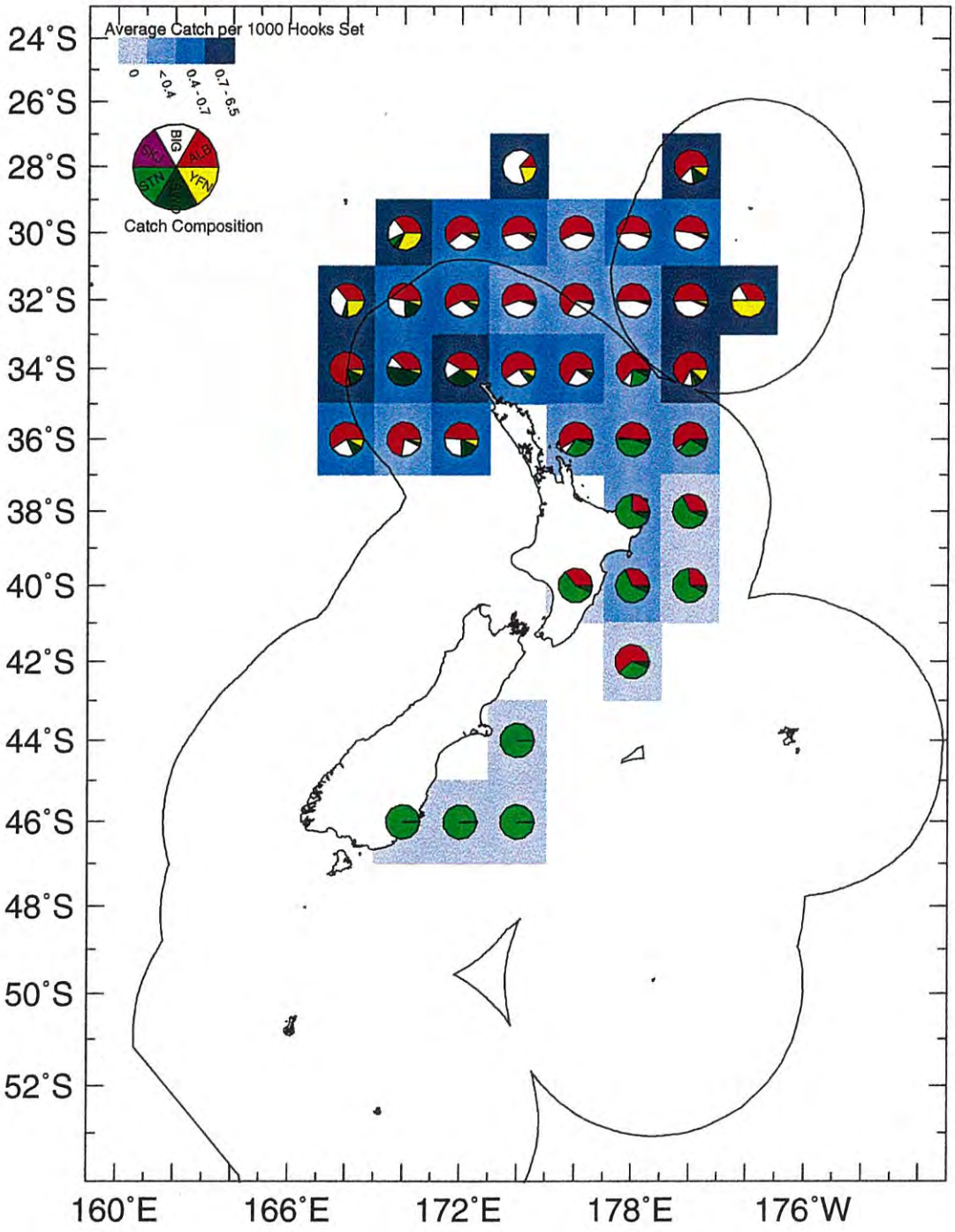
Surface Longlining for YFN
Domestic Fleet 1994/95 - 1996/97

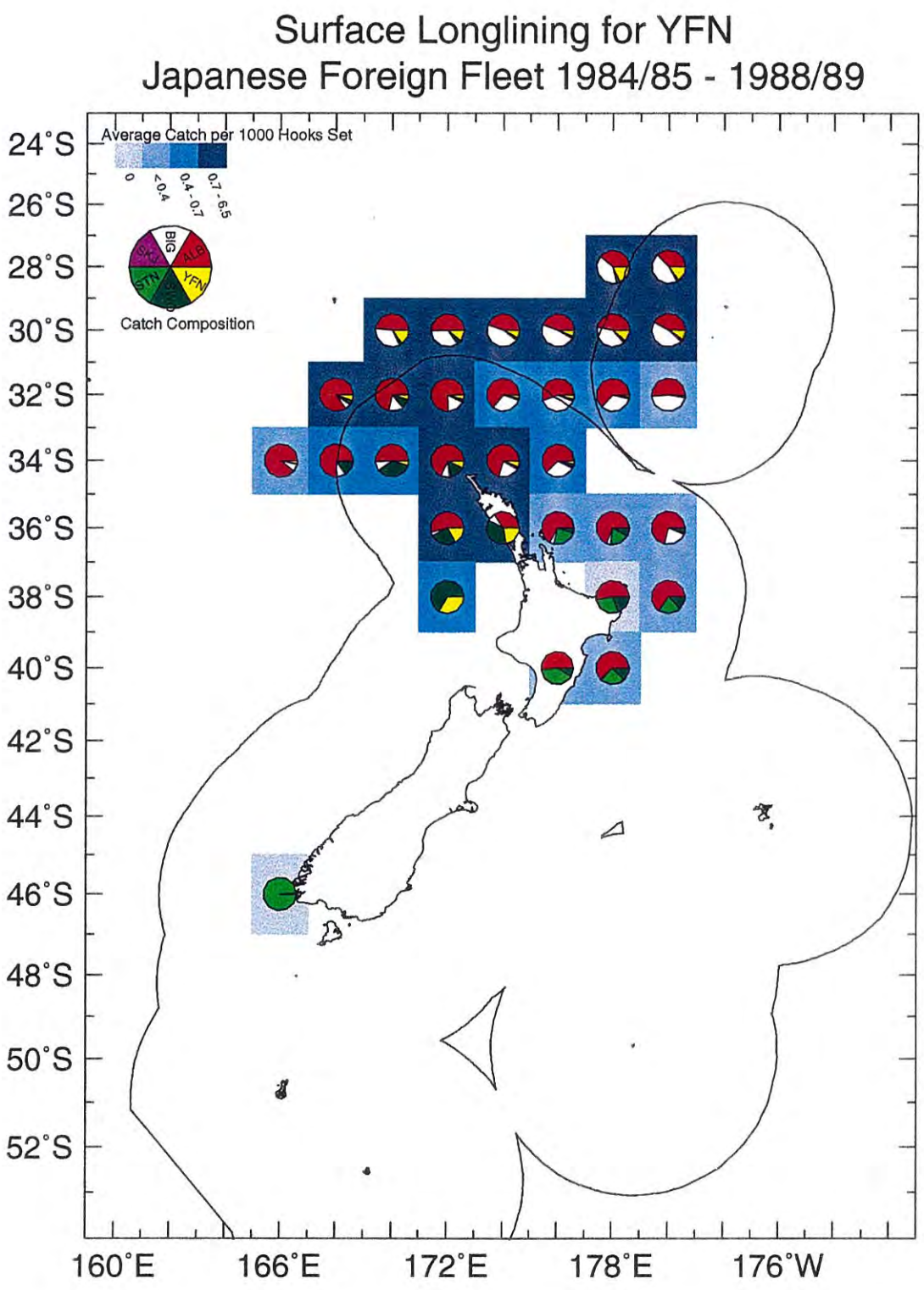


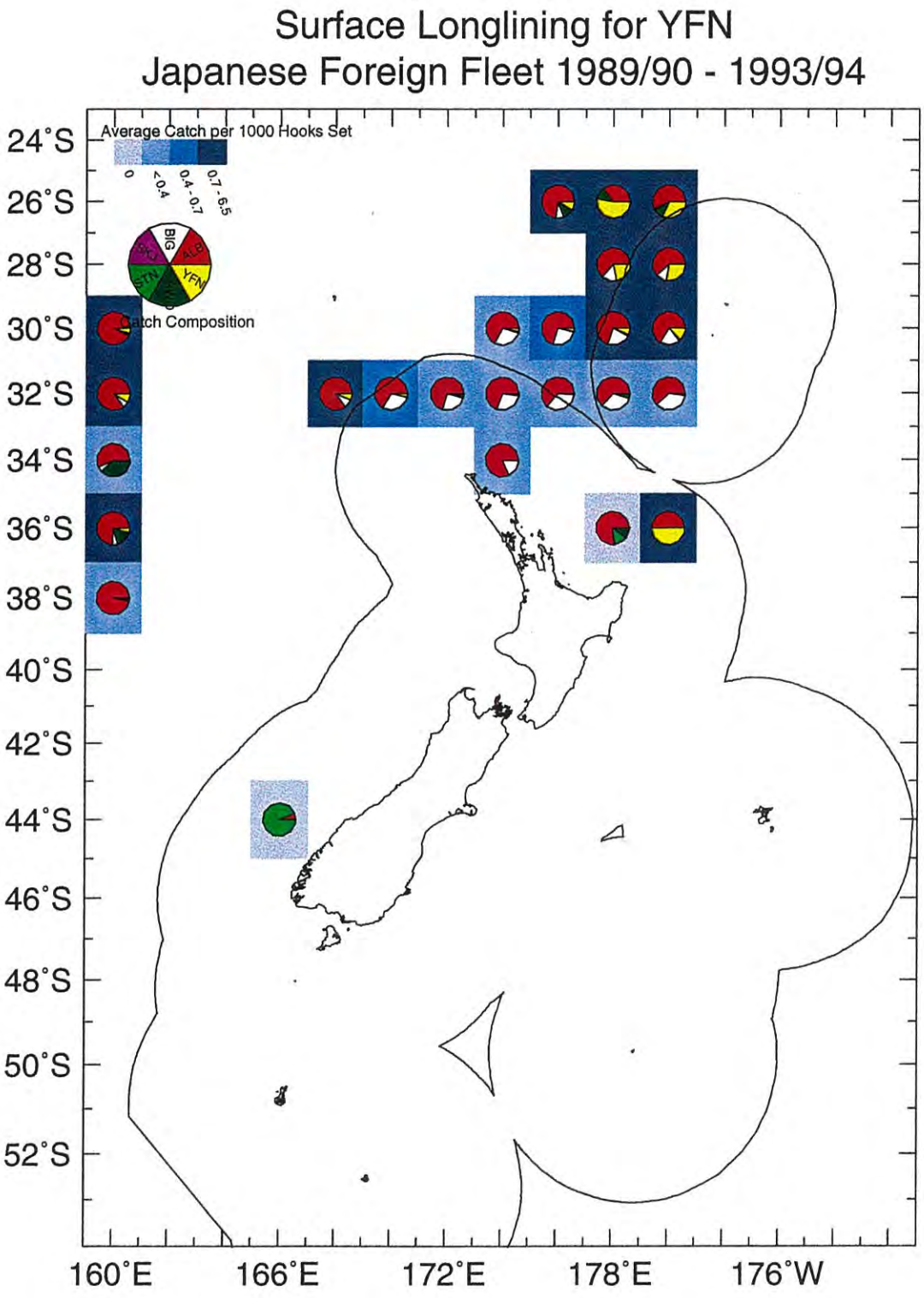

Surface Longlining for YFN
Charter Fleet 1989/90 - 1993/94
Average Catch per 1000 Hooks Set
0
<0.2
0.2-0.3
0.3-1.8
BIG
ALB
YFN
SFN
SPO
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

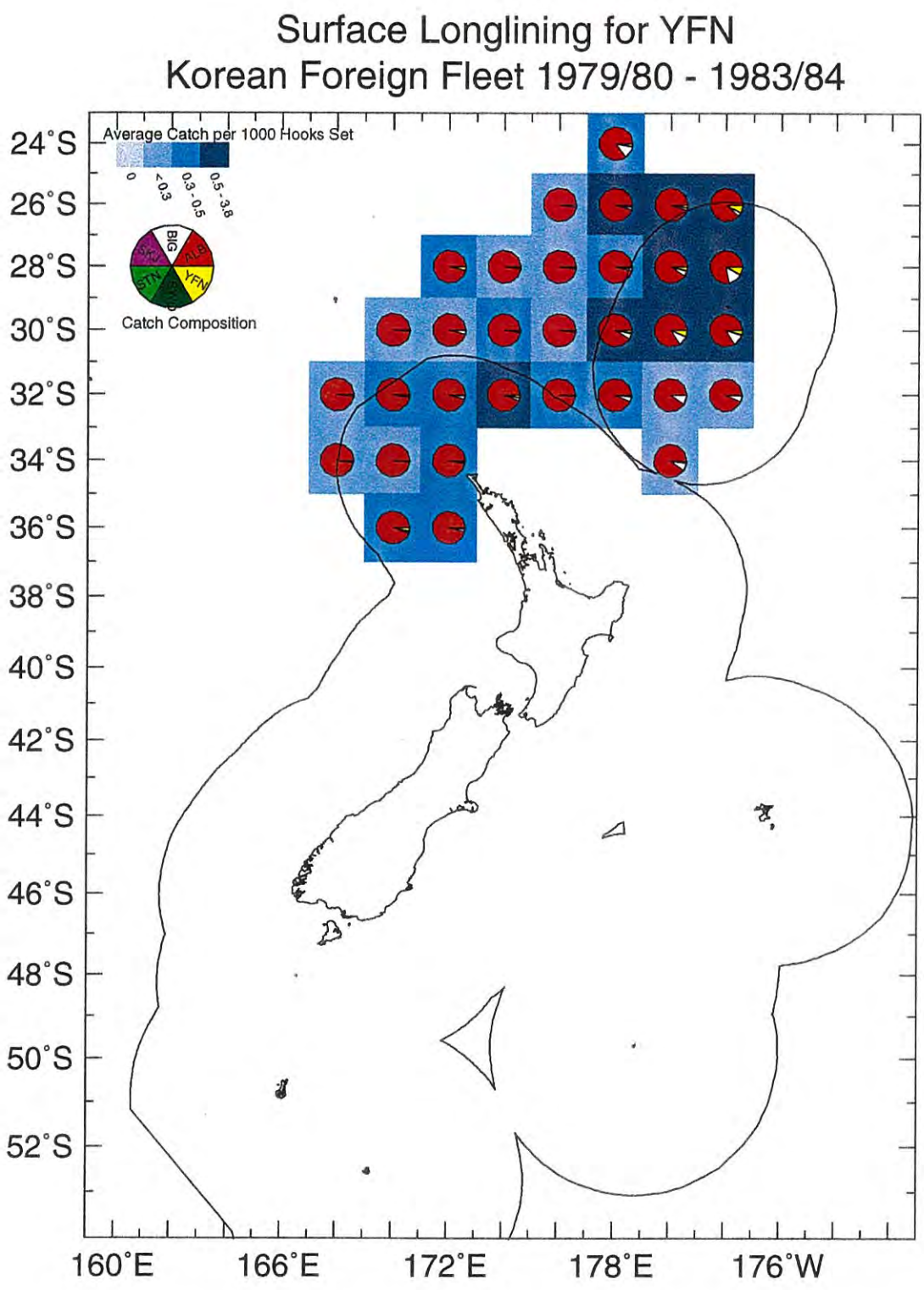

Surface Longlining for YFN
Charter Fleet 1994/95 - 1996/97
Average Catch per 1000 Hooks Set
0
<0.2
0.2 - 0.3
0.3 - 1.8
BIG
ALB
YFN
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

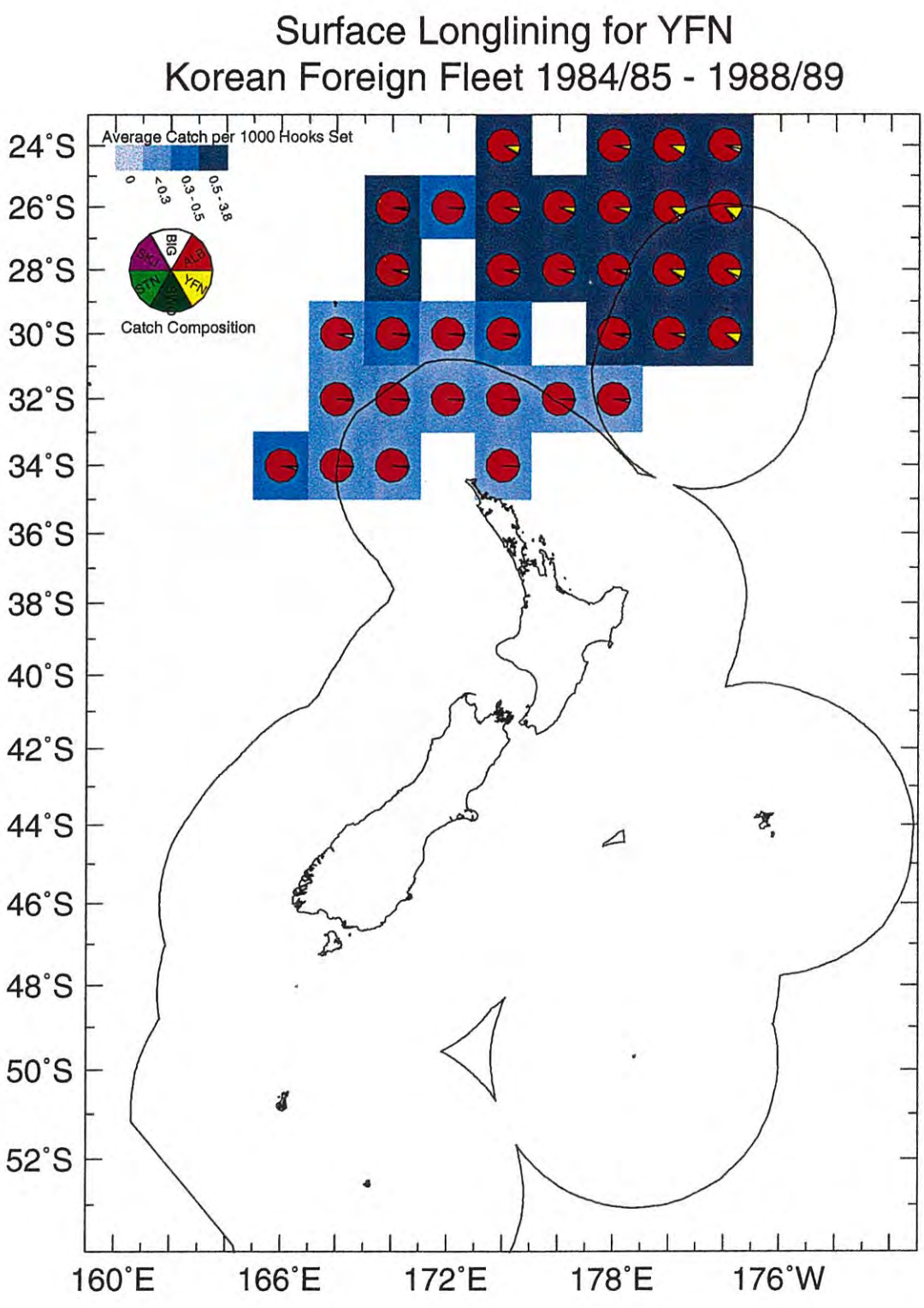
Surface Longlining for YFN
Japanese Foreign Fleet 1979/80 - 1983/84

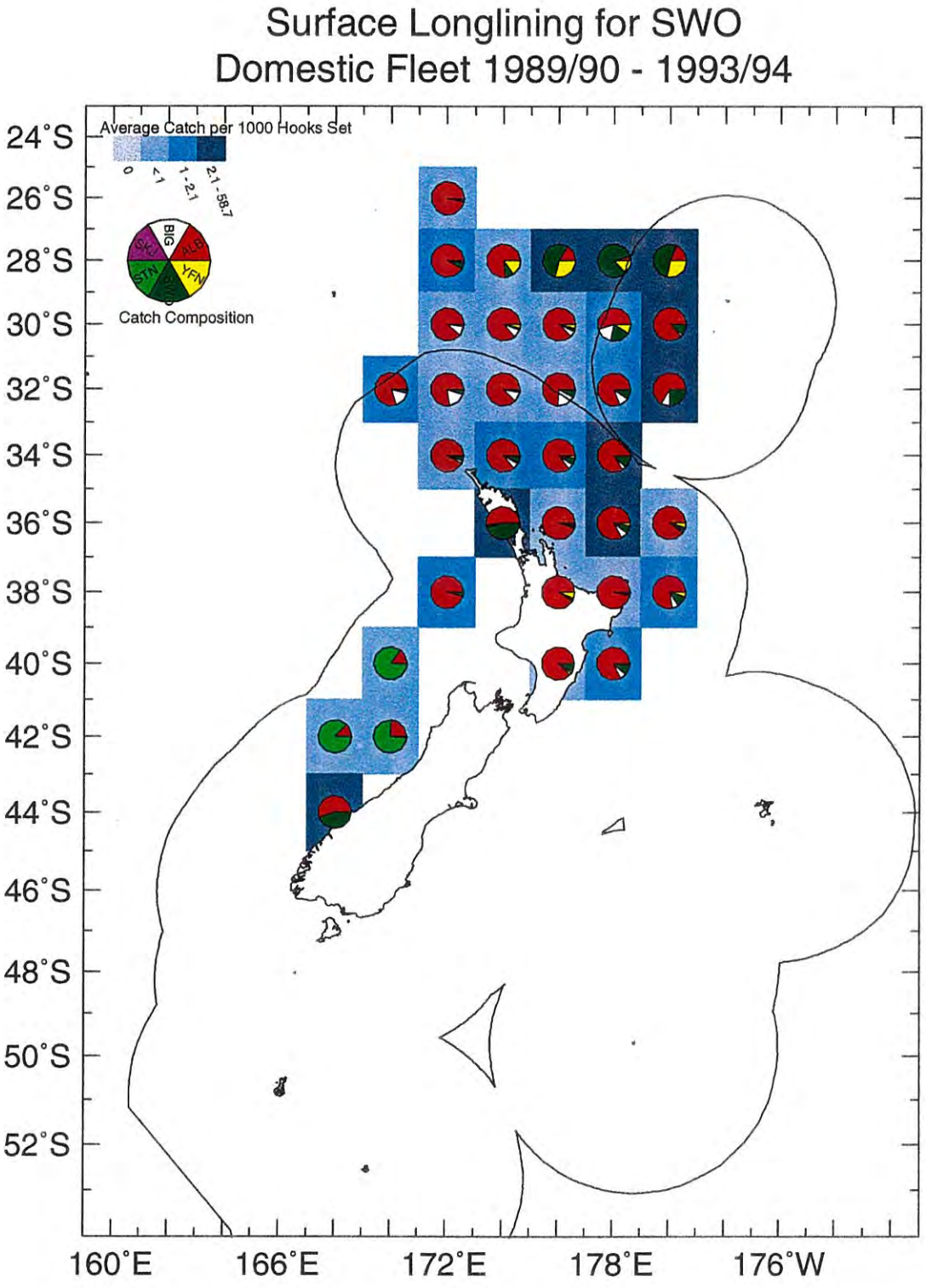



Surface Longlining for YFN
Japanese Foreign Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<0.4
0.4 - 0.7
0.7 - 6.5
BIG
ALB
YFN
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

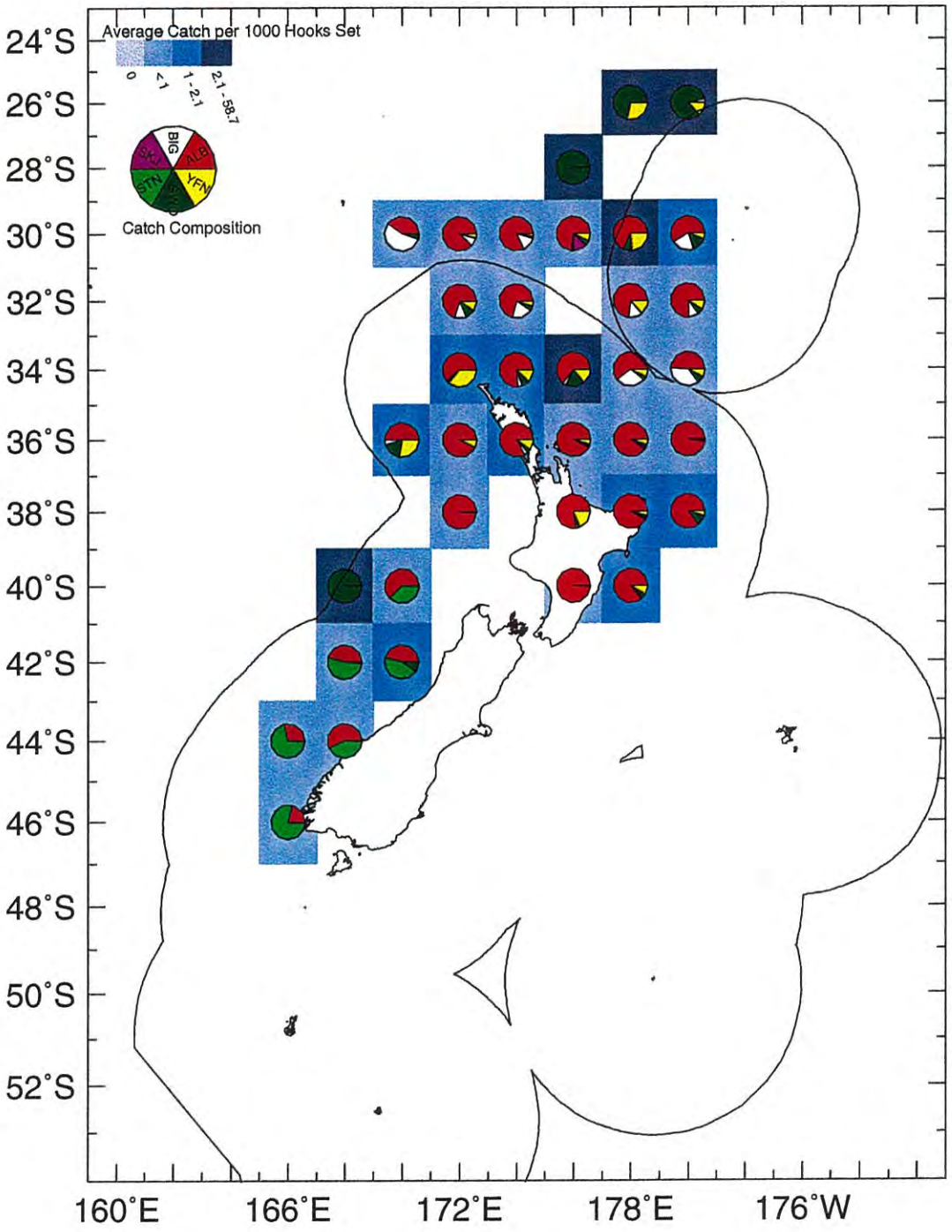

Surface Longlining for YFN
Japanese Foreign Fleet 1989/90 - 1993/94
Average Catch per 1000 Hooks Set
0
<0.4
0.4 - 0.7
0.7 - 6.5
BIG
ALB
YFN
SKJ
BTN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

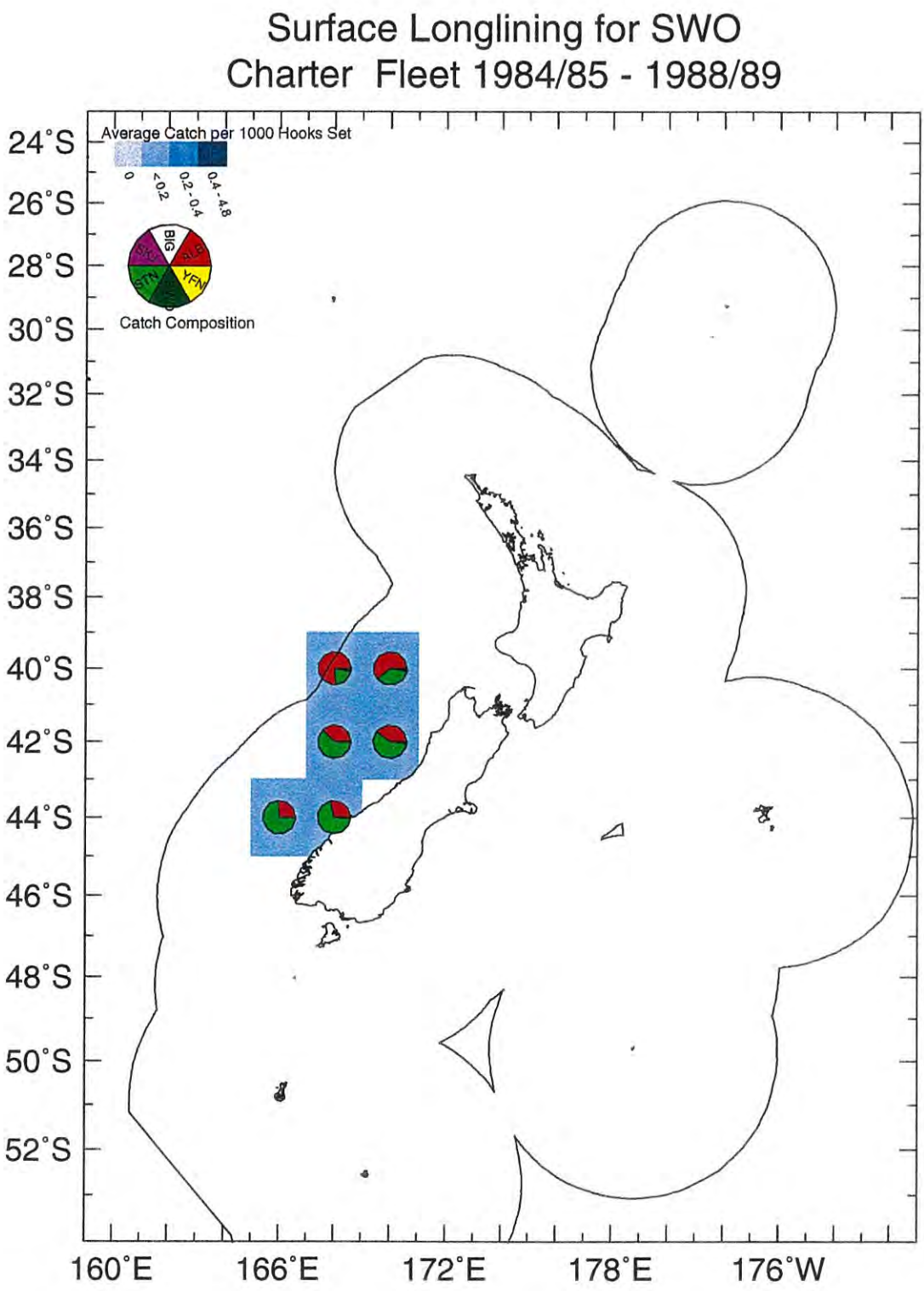

Surface Longlining for YFN
Korean Foreign Fleet 1979/80 - 1983/84
Average Catch per 1000 Hooks Set
0
<0.3
0.3-0.5
0.5-3.8
BIG
ALB
YFN
STN
SKJ
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W


Surface Longlining for YFN
Korean Foreign Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<0.3
0.3 - 0.5
0.5 - 3.8
BIG
ALB
YFN
SKJ
STR
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

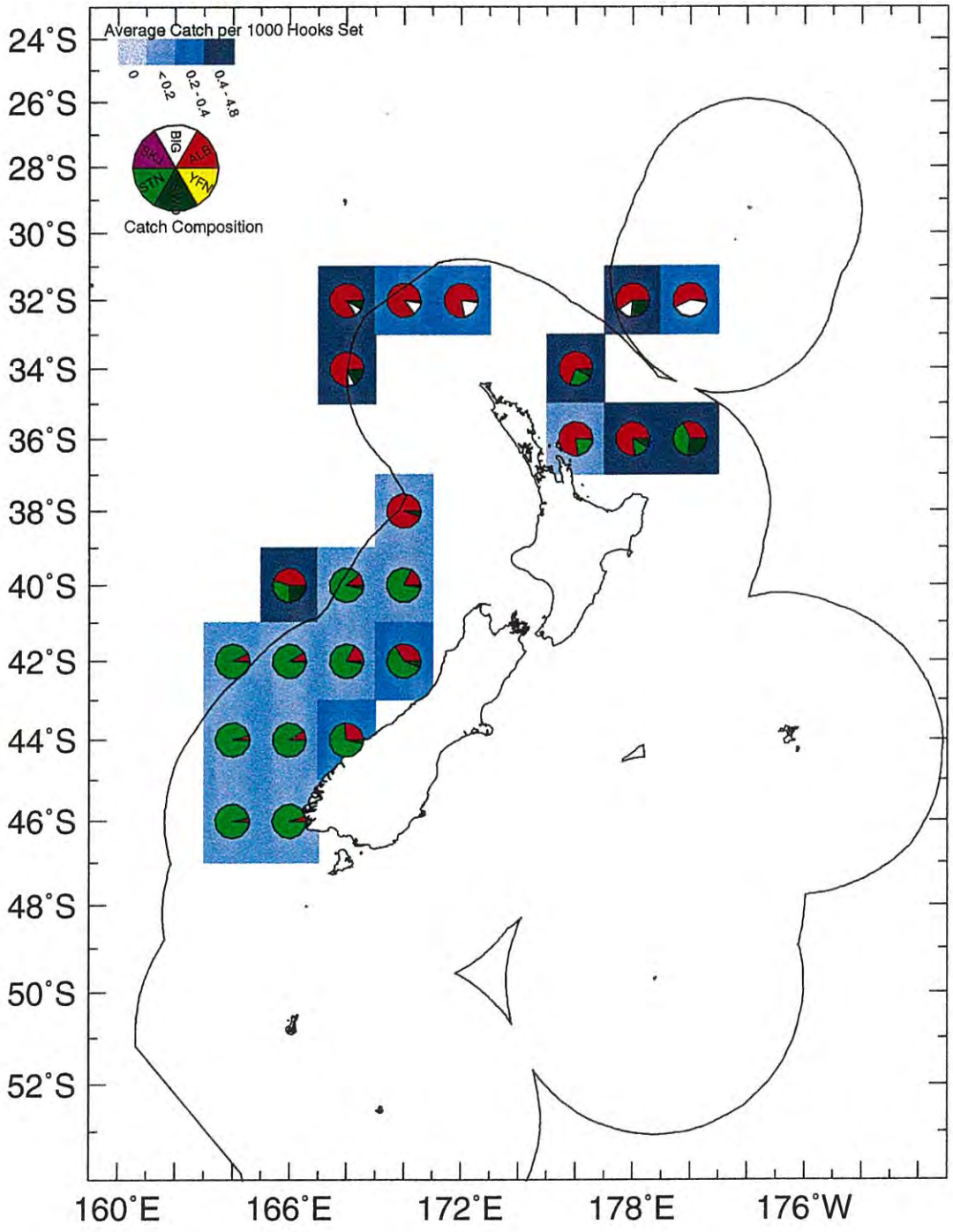

Surface Longlining for SWO
Domestic Fleet 1989/90 - 1993/94
Average Catch per 1000 Hooks Set
0
<1
1-21
21-58.7
BIG
ALB
YFN
STN
SKJ
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

Surface Longlining for SWO
Domestic Fleet 1994/95 - 1996/97

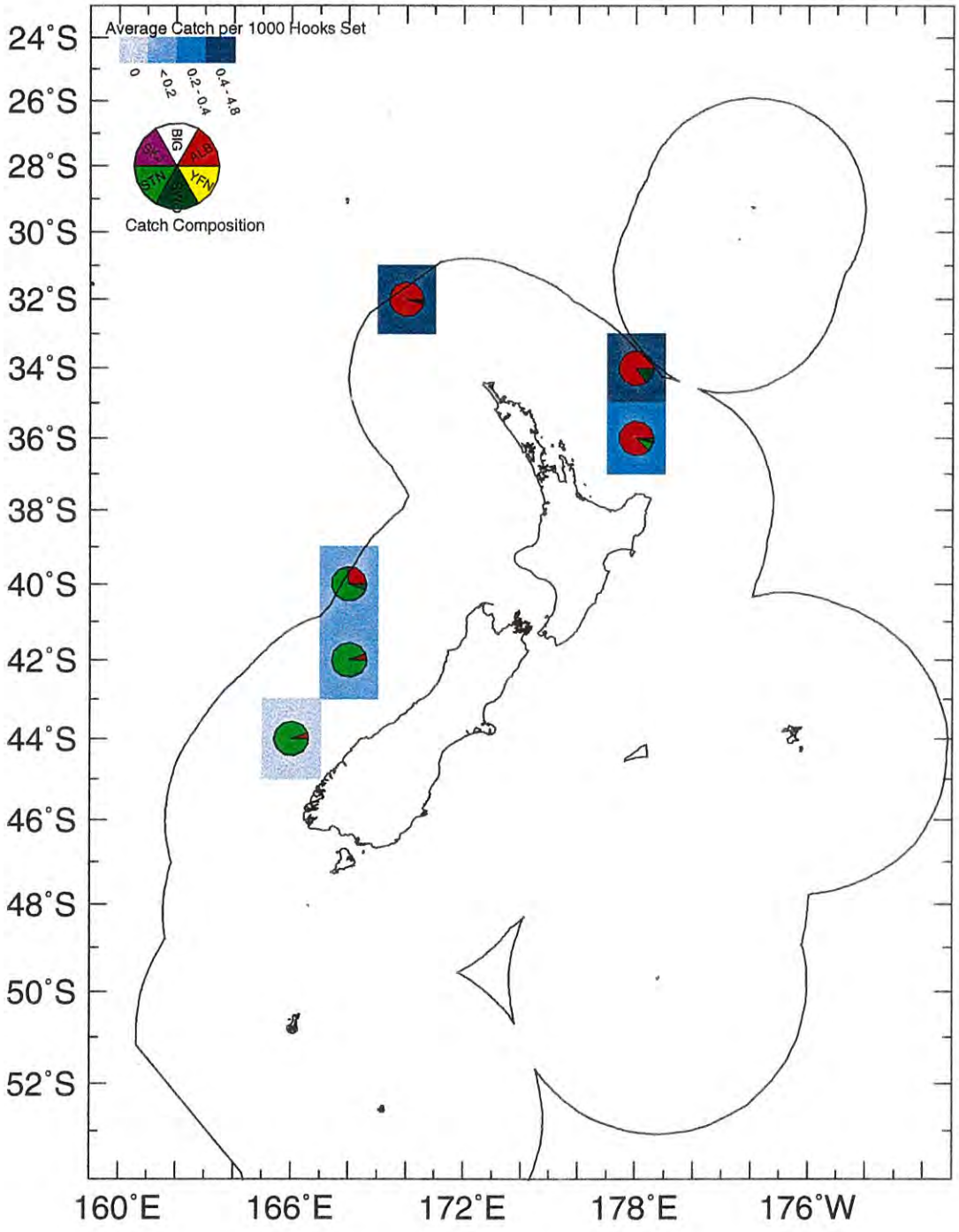



Surface Longlining for SWO
Charter Fleet 1984/85 - 1988/89
Average Catch per 1000 Hooks Set
0
<0.2
0.2 - 0.4
0.4 - 4.8
BIG
ALB
YFN
STN
SKJ
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

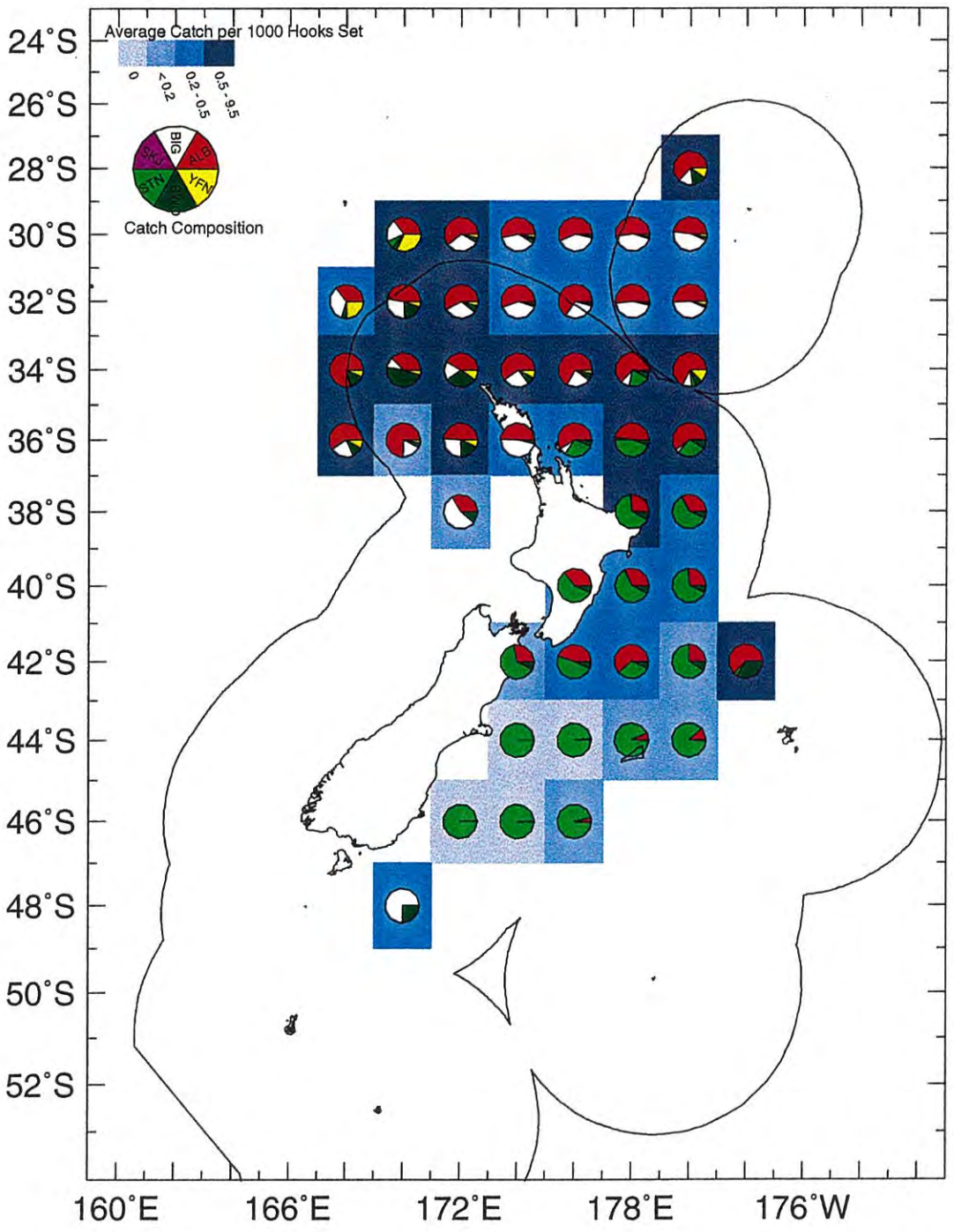
Surface Longlining for SWO
Charter Fleet 1989/90 - 1993/94



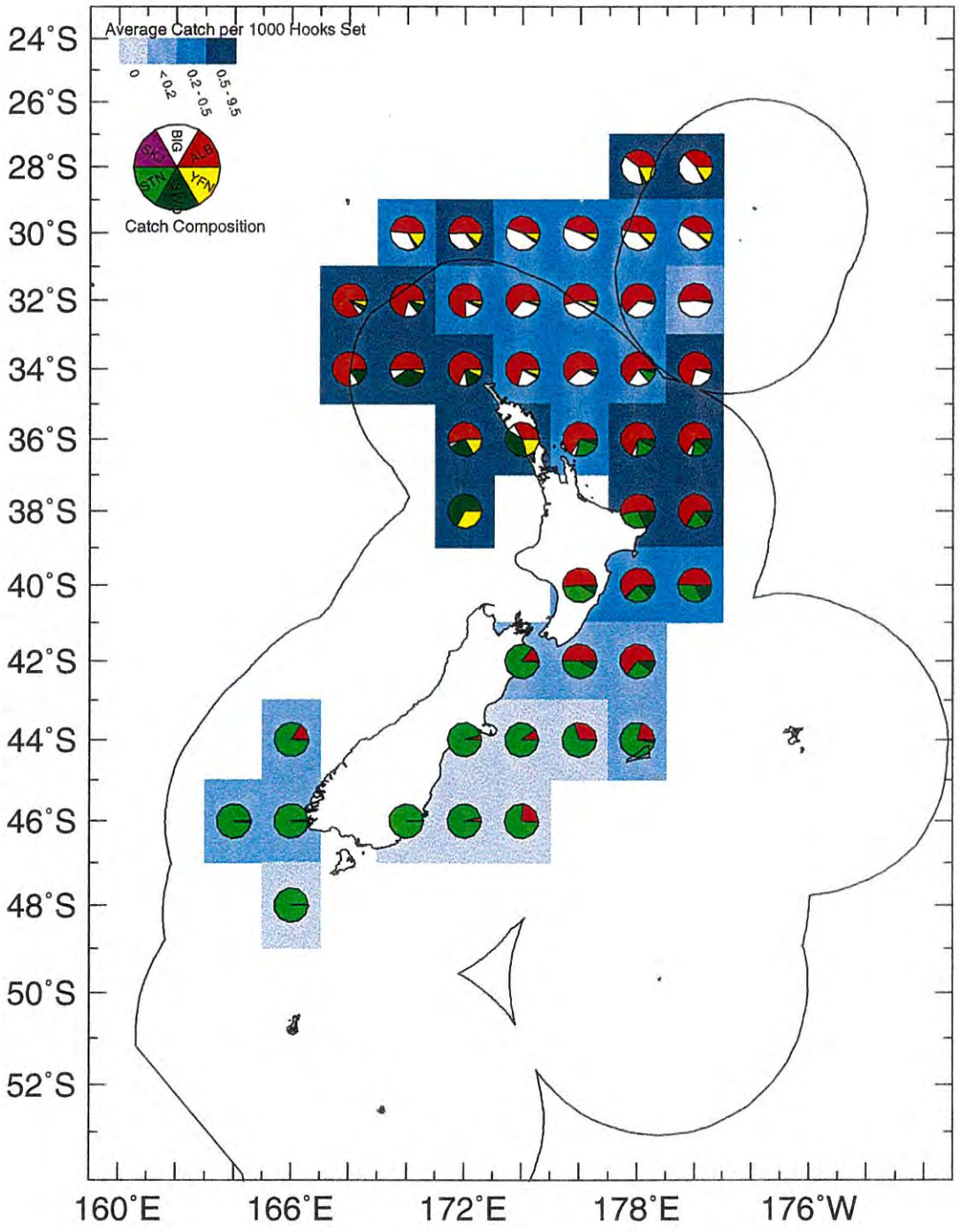
Surface Longlining for SWO
Charter Fleet 1994/95 - 1996/97

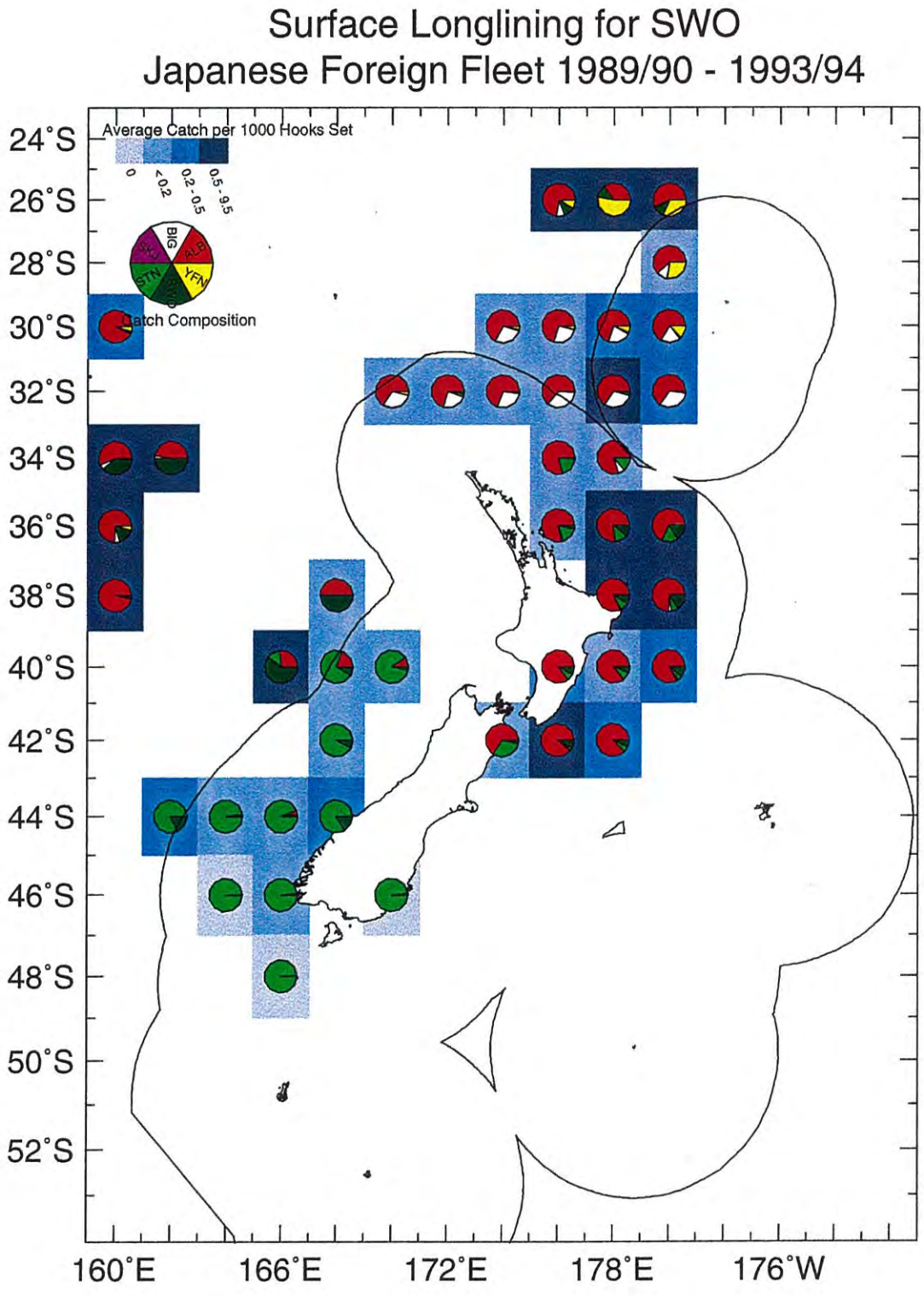


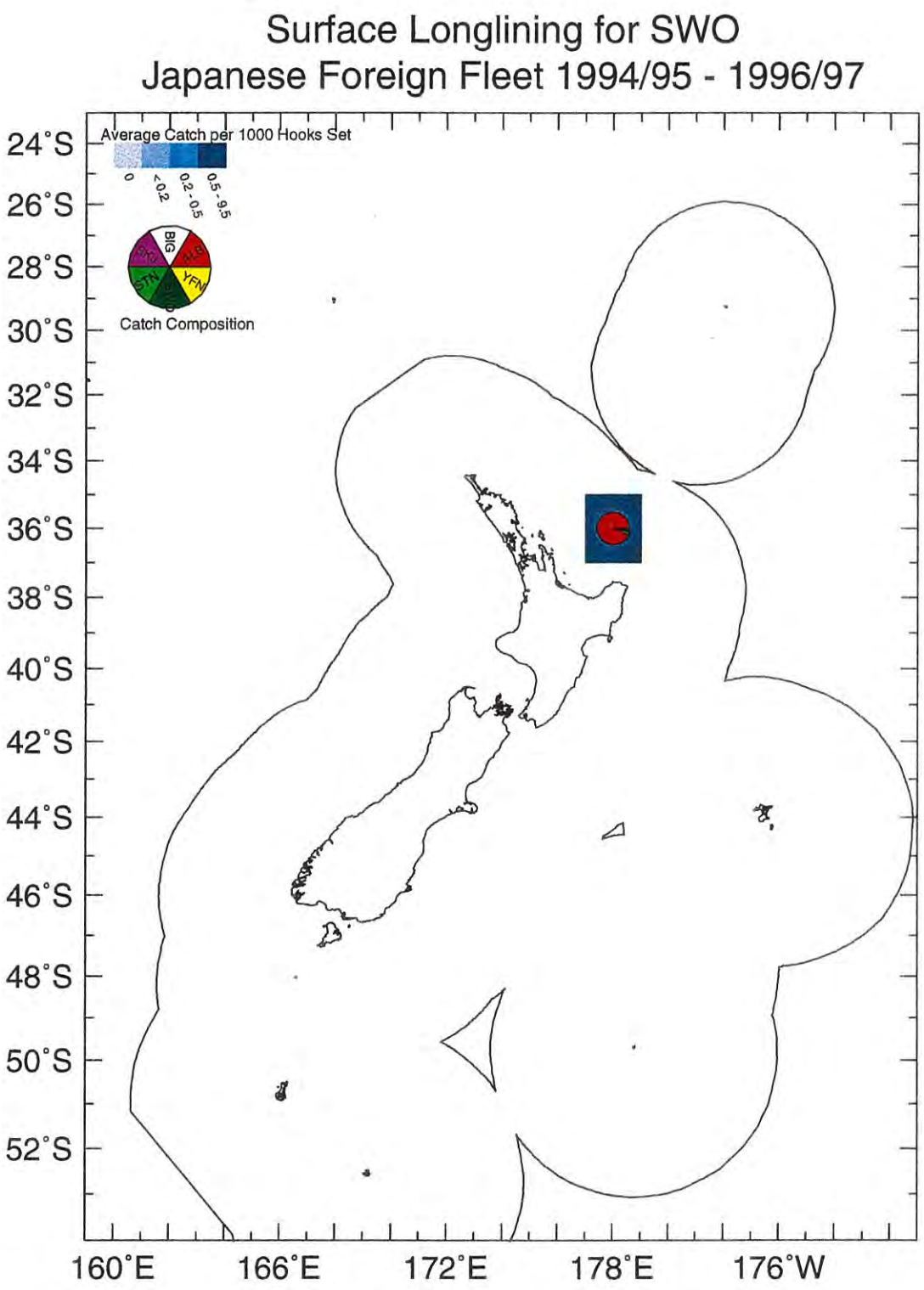
Surface Longlining for SWO
Japanese Foreign Fleet 1979/80 - 1983/84



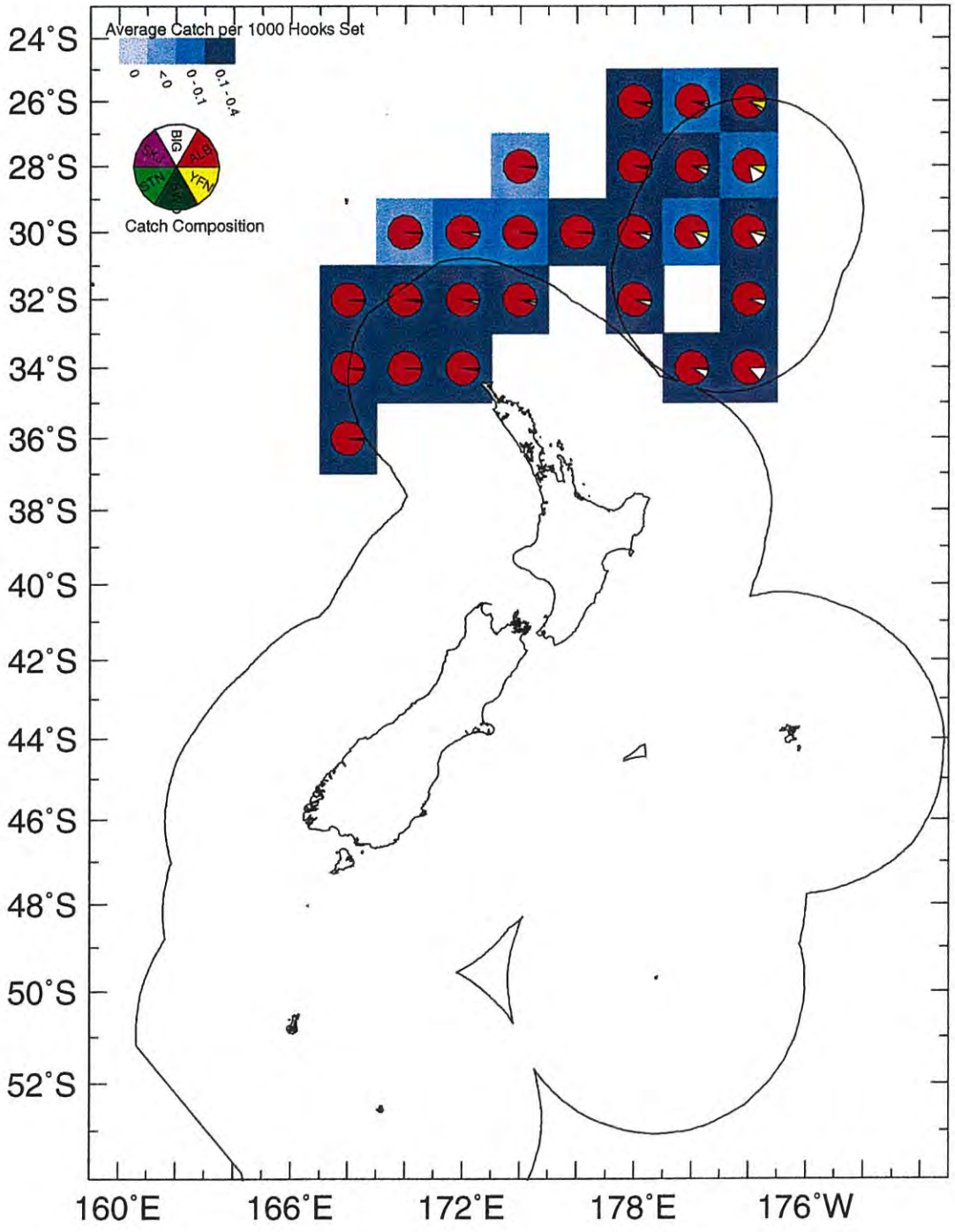
Surface Longlining for SWO
Japanese Foreign Fleet 1984/85 - 1988/89



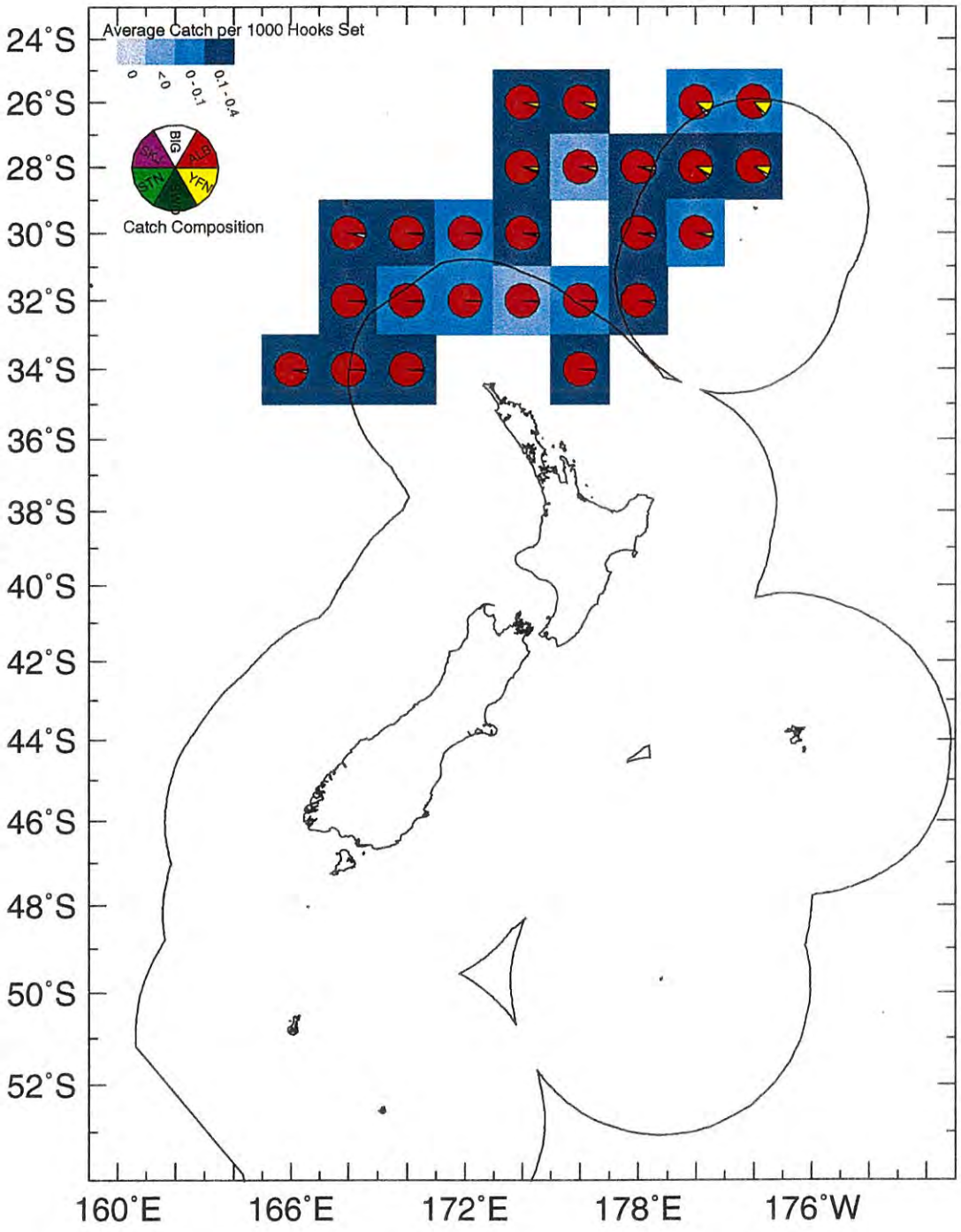

Surface Longlining for SWO
Japanese Foreign Fleet 1989/90 - 1993/94
Average Catch per 1000 Hooks Set
0
<0.2
0.2 - 0.5
0.5 - 9.5
BIG
ALB
YFN
STN
SWO
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W


Surface Longlining for SWO
Japanese Foreign Fleet 1994/95 - 1996/97
Average Catch per 1000 Hooks Set
0
<0.2
0.2 - 0.5
0.5 - 9.5
BIG
ALB
YFN
SKJ
STN
Catch Composition
24°S
26°S
28°S
30°S
32°S
34°S
36°S
38°S
40°S
42°S
44°S
46°S
48°S
50°S
52°S
160°E
166°E
172°E
178°E
176°W

Surface Longlining for SWO
Korean Foreign Fleet 1979/80 - 1983/84



Surface Longlining for SWO
Korean Foreign Fleet 1984/85 - 1988/89



APPENDIX VI: Biological parameters derived from fish caught by longliners

A. Size composition (cm)

Albacore

	males	females	unsexed	total
number	682	663	14484	15829
minimum	53	57	45	45
maximum	108	107	118	118
mean	86.2	85.6	80.3	80.8
CV.	13.3	11.8	13.6	13.6
median	88	89	79	79

Bigeye tuna

	males	females	unsexed	total
number	305	382	155	842
minimum	78	84	80	78
maximum	183	190	183	190
mean	132.5	130.7	124.4	130.2
CV.	14.0	13.0	14.5	13.8
median	132	131	120	130

Southern bluefin tuna

	males	females	unsexed	total
number	6528	5695	235	12458
minimum	87	67	85	67
maximum	215	197	198	215
mean	153.1	150.4	147.7	151.8
CV.	15.9	14.5	19.7	15.4
median	154	152	156	153

Yellowfin tuna

	males	females	unsexed	total
number	281	356	69	706
minimum	75	90	66	66
maximum	160	142	125	160
mean	115.1	114.7	90.4	112.5
CV.	9.1	8.5	19.8	11.7
median	113	113	90	112

Swordfish

	males	females	unsexed	total
number	205	634	188	1027
minimum	107	78	42	42
maximum	289	280	264	289
mean	172.0	185.8	162.6	178.8
CV.	18.0	20.0	22.4	15.4
median	177	188	161.5	177

B. Sex ratio

Albacore

Year	Male	Female	Total	M:F
1987	20	7	27	2.9
1988	7	9	16	0.8
1989	32	22	54	1.5
1990	38	42	80	0.9
1991	546	351	897	1.6
1992	166	148	314	1.1
1993	141	129	270	1.1
1994	41	36	77	1.1
1995	20	24	44	0.8
1996	302	307	609	1.0
1997	29	35	64	0.8
Total	1342	1110	2452	1.2

Bigeye tuna

Year	Male	Female	Total	M:F
1987	0	0	0	n–a
1988	2	3	5	0.7
1989	1	2	3	0.5
1990	21	29	50	0.7
1991	113	146	259	0.8
1992	7	42	49	0.2
1993	17	21	38	0.8
1994	36	35	71	1.0
1995	38	31	69	1.2
1996	17	15	32	1.1
1997	29	40	69	0.7
Total	281	364	645	0.8

Southern bluefin tuna

Year	Male	Female	Total	M:F
1987	56	34	90	1.6
1988	71	64	135	1.1
1989	95	88	183	1.1
1990	535	544	1079	1.0
1991	273	248	521	1.1
1992	261	232	493	1.1
1993	799	700	1499	1.1
1994	1545	1304	2849	1.2
1995	1306	1146	2452	1.1
1996	112	93	205	1.2
1997	1506	1270	2776	1.2
Total	6559	5723	12282	1.1

Yellowfin tuna

Year	Male	Female	Total	M:F
1987	0	0	0	n–a
1988	0	0	0	n–a
1989	0	0	0	n–a
1990	9	6	15	1.5
1991	0	2	2	0.0
1992	0	0	0	n–a
1993	0	0	0	n–a
1994	17	15	32	1.1
1995	72	106	178	0.7
1996	59	85	144	0.7
1997	90	112	202	0.8
Total	247	326	573	0.8

Swordfish

Year	Male	Female	Total	M:F
1987	0	8	8	0.0
1988	15	68	83	0.2
1989	11	74	85	0.1
1990	13	307	320	0.0
1991	64	102	166	0.6
1992	46	95	141	0.5
1993	51	137	188	0.4
1994	18	64	82	0.3
1995	9	11	20	0.8
1996	9	29	38	0.3
1997	90	351	441	0.3
Total	326	1246	1572	0.3

Summary Statistics

Null hypothesis: sex ratio independent of years

Species	G statistic	d.f	stat. sig.
ALB	32.447	10	$P < 0.005$
BIG	26.103	9	$P < 0.005$
SBT	11.350	10	n.s..
YFN	2.230	3	n.s.
SWO	127.539	9	$P < 0.005$

Null hypothesis: sex ratio = 1:1

Species	X^2	d.f	stat. sig.
ALB	10.976	1	$P < 0.005$
BIG	5.340	1	n.s
SBT	28.452	1	$P < 0.005$
YFN	5.446	1	n.s
SWO	269.211	1	$P < 0.005$

C. Length – relationships

The following table summarises the parameters and their standard errors for the following equation:

$$\ln(\text{weight}) = b_0 + b_1 * \text{length}$$

where weight is in kg and length is in cm. Length is fork length for tunas and body length for swordfish.

Species	Sex	n	b_0	SE_{b0}	b_1	SE_{b1}	R^2
ALB	male	736	-0.822	0.039	0.038	0.000	0.908
	female	703	-0.864	0.043	0.039	0.000	0.895
	both	1439	-0.837	0.029	0.038	0.000	0.902
BIG	male	127	0.829	0.077	0.023	0.001	0.931
	female	147	1.084	0.076	0.021	0.001	0.904
	both	274	0.954	0.054	0.022	0.000	0.918
SBT	male	5723	1.069	0.010	0.021	0.000	0.950
	female	4974	1.045	0.011	0.021	0.000	0.938
	both	10697	1.061	0.007	0.021	0.000	0.945
YFN	male	105	0.294	0.105	0.026	0.001	0.881
	female	133	0.365	0.072	0.025	0.001	0.922
	both	238	0.292	0.058	0.026	0.001	0.912
SWO	male	245	1.141	0.067	0.018	0.000	0.892
	female	879	1.141	0.037	0.018	0.000	0.901
	both	1124	1.153	0.031	0.018	0.000	0.902

APPENDIX VII: Trends in the bigeye tuna fishery in the New Zealand EEZ

Trends in the Bigeye Tuna Fishery in the New Zealand EEZ

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Abstract

Longline fishing effort has declined steadily within the New Zealand Exclusive Economic Zone coincident with a contraction of the southern bluefin tuna (SBT) fishing season and the reduction in Japanese longline vessels taking up SBT licences. by these Total longline effort targeting bigeye tuna is less than 1 million hooks per year (average 968 000 per year for the last five years). Since the 1995/96 fishing year no foreign licensed longline effort has been conducted and domestic vessels account for over half the effort in 1996/97 and all effort in 1995/96. The total bigeye catch in the EEZ (both target and bycatch) has declined from the peak catch of 758 tonnes in 1986 to 105 tonnes in the 1996/97 fishing year.

Relative abundance of bigeye in the EEZ has been modelled using an effort weighted negative binomial response model. The relative year effect in CPUE shows a marked undulating decline over the period 1980–97. Nominal and standardised CPUE exhibit similar trends relative to the start of the time series in 1980 with low relative abundance in 1981–83 followed by an increase to about 80% (standardised) of the 1980 level during 1984–86. Since 1986 the relative abundance of bigeye in the New Zealand EEZ has further declined to about 20% of the 1980 level. The relative abundance of bigeye reached its lowest level (15% of 1980 level) in 1995, increasing in the last two years to reach 28% in 1997. The decline in relative abundance of bigeye in the New Zealand EEZ is consistent with a stock wide decline across the entire Pacific Ocean basin but appears more marked than in the main longline areas fished by Japanese and Taiwanese distant water fleets.

1. Introduction

Bigeye tuna caught in the EEZ are part of a single Pacific stock ranging from about 40° N to 40° S across the entire Pacific Ocean basin. In the New Zealand EEZ bigeye are caught primarily north of 37° S, mainly during December—May. Bigeye are an important target species for longline fleets operating in the EEZ accounting for about 16% of all tuna longline target sets and with landings valued at about $1.6 million in 1996.

Recent concern over the status of the Pacific bigeye tuna stock has been raised (Anon 1998) following the rapid expansion of purse seine effort directed at free floating objects (logs and fish aggregating devices) and associated catches of juvenile

yellowfin and bigeye tunas. Bigeye catches, particularly by purse seine, have recently increased and in 1997 were about 181 000 tonnes for the stock as a whole. In the eastern tropical Pacific purse seine catches now exceed those by longline (51 000 cf. 46 000 tonnes in 1997) while in the western and central Pacific longline catches exceed purse seine (28 000 cf. 56 000 tonnes in 1997). The increase in purse seine catches is attributed to the practise of setting on floating objects. While this fishing practise is largely confined to the eastern Pacific, USA purse seiners appear to be increasingly using this technique in the western Pacific.

Anon (1998) reports that longline CPUE models using Taiwanese and Japanese data show declines over the last several decades, although the magnitude of the decline varies depending on model assumptions. In this paper we investigate the trend in relative abundance at the southern edge of the bigeye distribution, where one might suspect such changes could be of greater magnitude. We have used longline catch and effort data from Japanese and New Zealand vessels targeting bigeye within the EEZ since 1980 and the generalised linear model (GLM) approach of Richardson *et al* 1998 to estimate yearly abundance indices for bigeye tuna.

2. Method

Catch and effort data for longline sets targeting bigeye tuna and bycatch (given as number of fish and number of hooks), longline set position, date, start and finish times, sea surface temperature, cloud cover, vessel specifications and other fisheries related data were obtained from the Ministry of Fisheries for the period 1980–1997. These data were checked and groomed by NIWA

The distribution of fishing since 1980 is shown in Figure 1 in three year blocks. The bigeye fishing area is reasonably discrete (operating largely in Fishery Management Areas 1, 9, and 10) and has not been sub-divided.

The spatial distribution of CPUE for each year is shown in Figure 2 and a histogram of CPUE over all years is given in Figure 3. Histograms of effort for each year and fleet are plotted in Figure 4.

An effort-weighted negative binomial generalised linear CPUE response model was used for this fishery (see Richardson *et al* 1998). The construction of the main effects GLM used the S function step to select predictor terms. These terms were tested with the usual F statistic (see Appendix 2).

Predictor variables tested for inclusion in the model were:

1. Factors
   - *year*
   - *month:* February to August
   - *fleet:* Foreign (Japanese or charter), Domestic (NZ owner operator)

2. Covariates
   - *moon phase*
   - *sea surface temperature (SST)*

- *latitude*
- *longitude*

Covariates were treated as Hermite polynomials up to order 4. The order of the polynomial was chosen by step.

3. Results

Figure 5 plots fitted year factor levels and means (unstandardised) for the fitted model. Tables of these data are given in Appendix 1. There is no strong evidence in any of the usual residual plots of inadequacy in the negative binomial models (see Figure 6). Tables of residual deviance are given in Appendix 2.

The final model is given (in S notation) as

$$\text{CPUE} \sim \text{year} + \text{month} + \text{longitude} + \text{poly(latitude,4)} + \text{poly(SST,4)}. \qquad (3.1)$$

Between 1980 and 1997, there are only small differences between the estimated coefficients and the nominal (mean) CPUE values (see Figure 5).. Nominal and standardised CPUE exhibit similar trends with low relative abundance in 1981–83 compared with 1980 followed by an increase to about 80% (standardised) of the 1980 level during 1984–86. Since 1986 the relative abundance of bigeye in the New Zealand EEZ has further declined to about 20% of the 1980 level. The relative abundance of bigeye reached its lowest level (15% of 1980 level) in 1995, increasing in the last two years to reach 28% in 1997.

Confidence intervals for year coefficients

The standard error for the year coefficient on the scale of the response variable, $\exp(\hat{y})$, is calculated as

$$\text{var}\left[(\exp(\hat{y})\right] = \exp(2\hat{y})e^{v}(e^{v} - 1) \qquad (3.2)$$

with v the appropriate diagonal element of the covariance matrix, and $\hat{y}$ the value of the year linear predictor estimated during the fitting procedure. This equation assumes the residuals are normally distributed which will only be approximate for the negative binomial models used here. To check these results, bootstrap means and confidence intervals have also been computed under the assumption that the negative binomial shape parameter is not changed by bootstrap sampling. Little difference between the results from the two methods is observed (compare Figure 5a and 5b).

Spatial Effects in CPUE Models

Spatial Distribution of CPUE for Main Effects Models

As noted in Richardson *et al* 1998, the model fitted here includes polynomial terms in latitude and longitude which estimate the spatial distribution of fish and fishing activity. However, it is assumed that the profiles in latitude and longitude do not change over time and that the spatial distribution is separable (i.e., can be written as the product of single variable functions of latitude and longitude). As can be seen from the CPUE contours in Figure 2, these assumptions are only approximate, and work is under way to improve them.

4. Fisheries Indicators

Total Catch and Effort

Total catch in the EEZ has steadily declined, as has total longline effort, from a peak of 759 tonnes in 1986 to 105 t in the 1996/97 fishing year. Much of the decline is due to declines in Japanese longline fishing. No foreign licensed fishing has been undertaken since 1995 and all longline effort since 1995/96 within the EEZ has been by domestic owner-operated or Japanese longliners on charter to a New Zealand company. Domestic longline effort for bigeye is less than 1 million hooks annually.

The total catch and effort targeting bigeye is given by fleet for the period 1980 to 1997 (in calendar years) in Appendix 3. The targeted effort and associated catch of bigeye is also summarised in Appendix 1 for all fleets combined. The actual bigeye catch and effort since 1995 has been slightly higher than indicated in Appendices1 and 3 since, with the reduction of foreign fishing, a substantial proportion of longline fishing operations are now reported on CELR forms. At the time of writing, the CELR data were still being groomed for incorporation in future CPUE analyses.

CPUE

Declines in CPUE have been reported for the Pacific-wide bigeye stock that appear to have been underway for several decades (Anon, 1998). The trends seen in bigeye CPUE in the New Zealand EEZ are certainly consistent with declines seen elsewhere. Recent attempts to standardise bigeye CPUE are limited to the work of Miyabe and Takeuchi (1998) who provide age specific CPUE (for fish aged 3–6 years old) based on Japanese longline data. Their data suggest declines of the order of 50% over the period 1965–95 for these ages. Sun and Yeh (1998) show larger declines (about 75%) in CPUE for Taiwan's distant water fleet over the period 1967–96. However, Taiwan's small boat fleet based in some Pacific Island EEZs show either no trend or a slight increase in CPUE over the period 1988–97. These latter data may not reflect actual abundance since such vessels are highly mobile and have not been consistently fishing the same area over this period.

Bigeye CPUE in the New Zealand EEZ over the period 1980–97 has shown a downward trend since 1980, reaching its lowest level at about 15% of 1980 levels in 1995. Thereafter CPUE has generally increased to about 20–30% of what it was in 1980. Since both nominal and standardised CPUE show similar behaviour, the