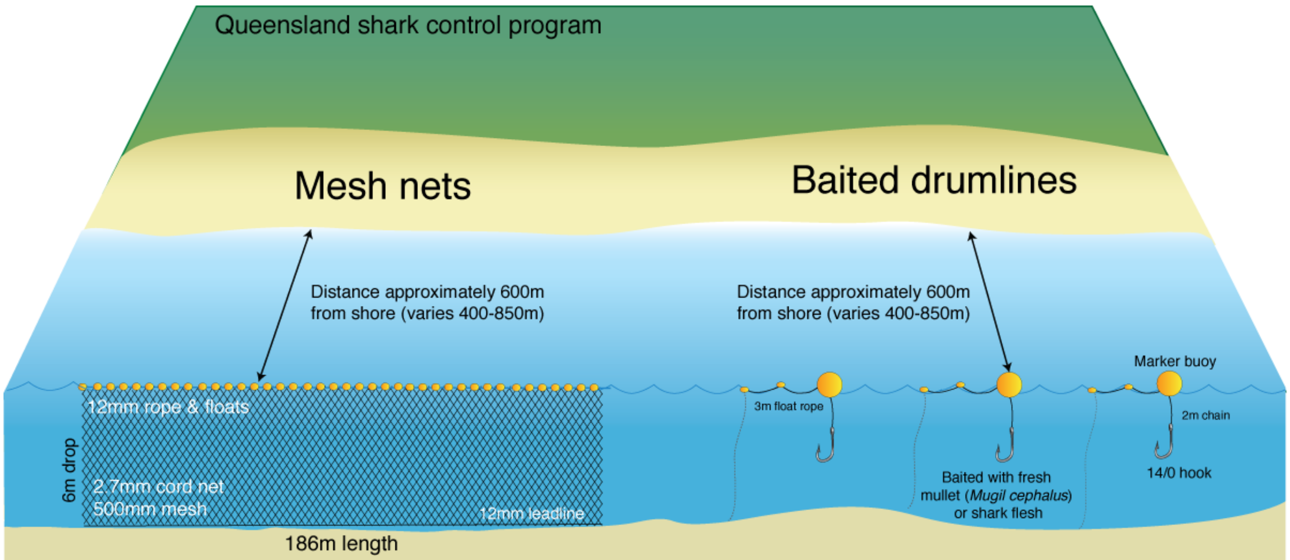
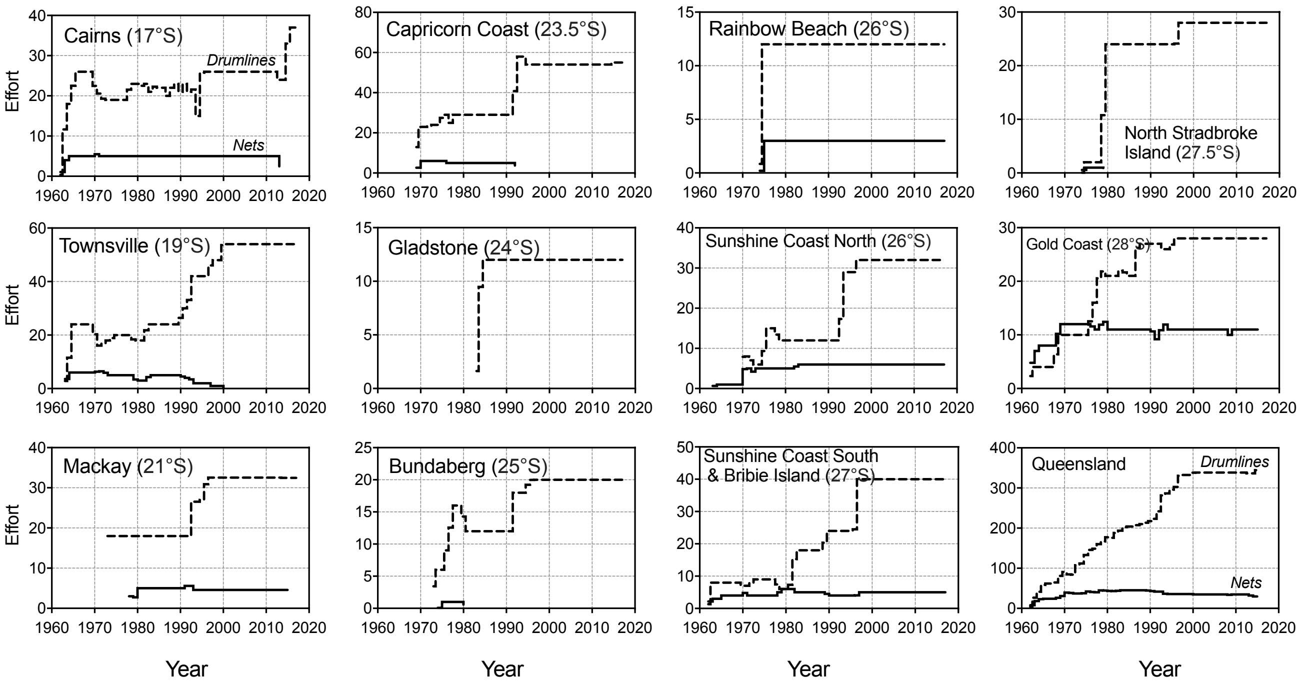
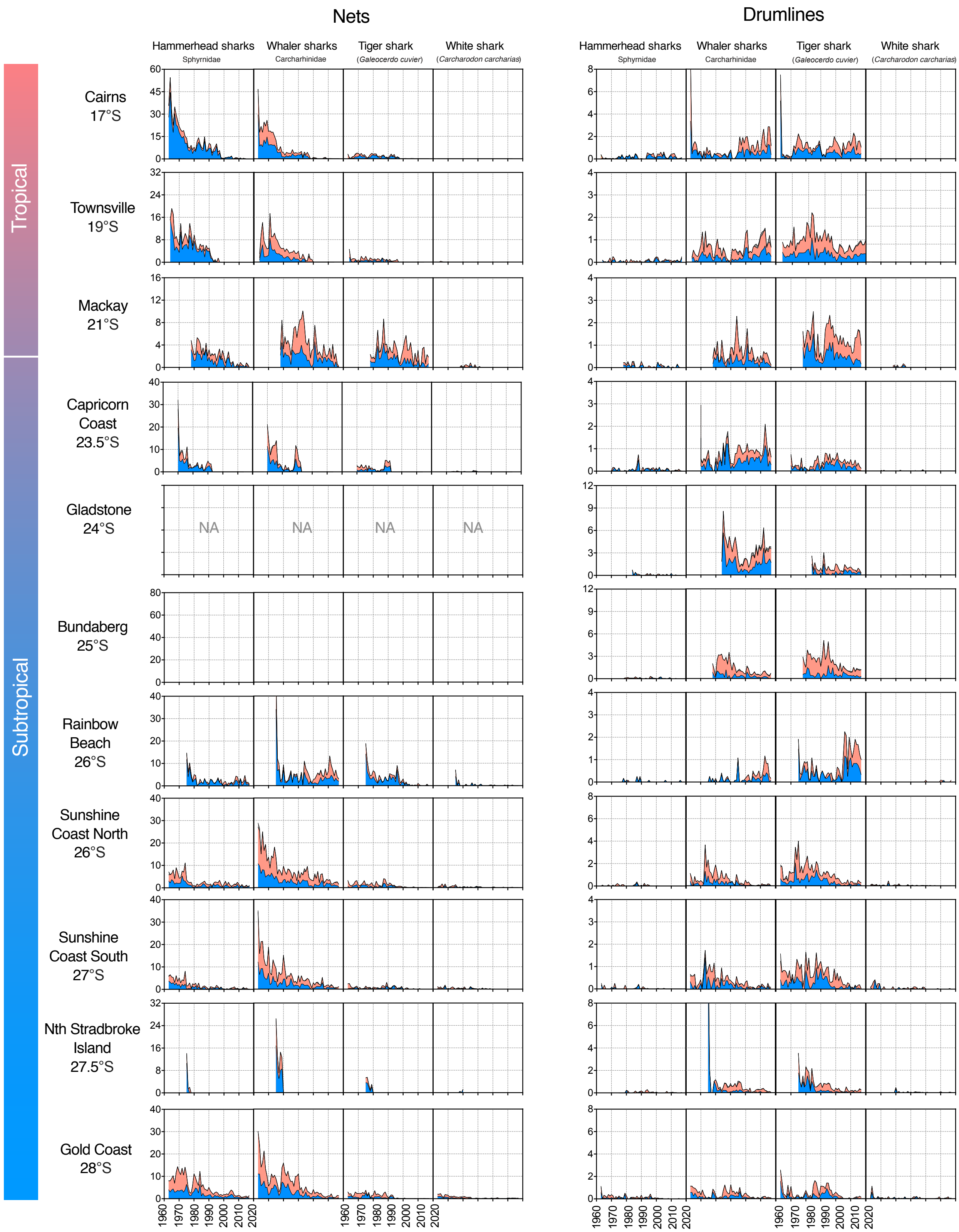


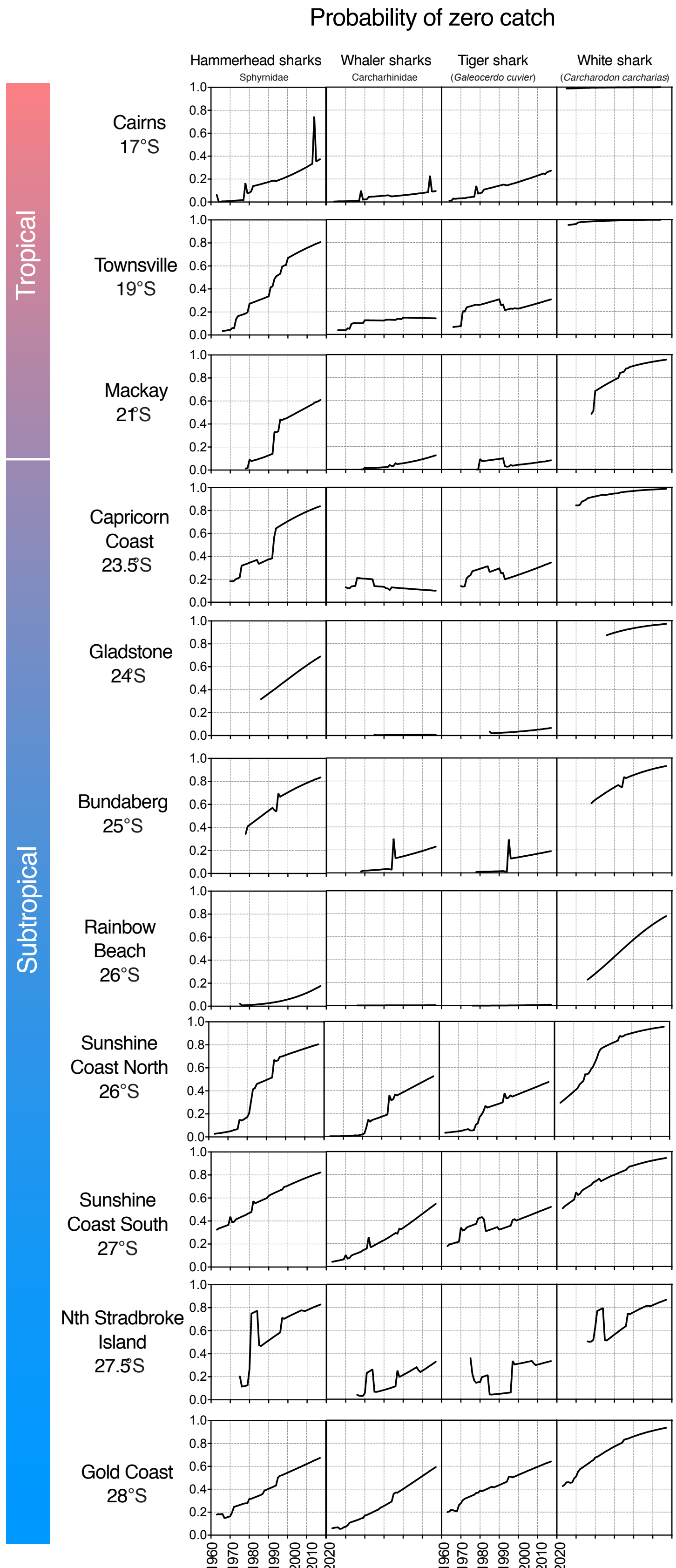
Supplementary Figure 1 Arrangement of shark nets and baited drumlines used in the Queensland Shark Control Program from 1992 onwards



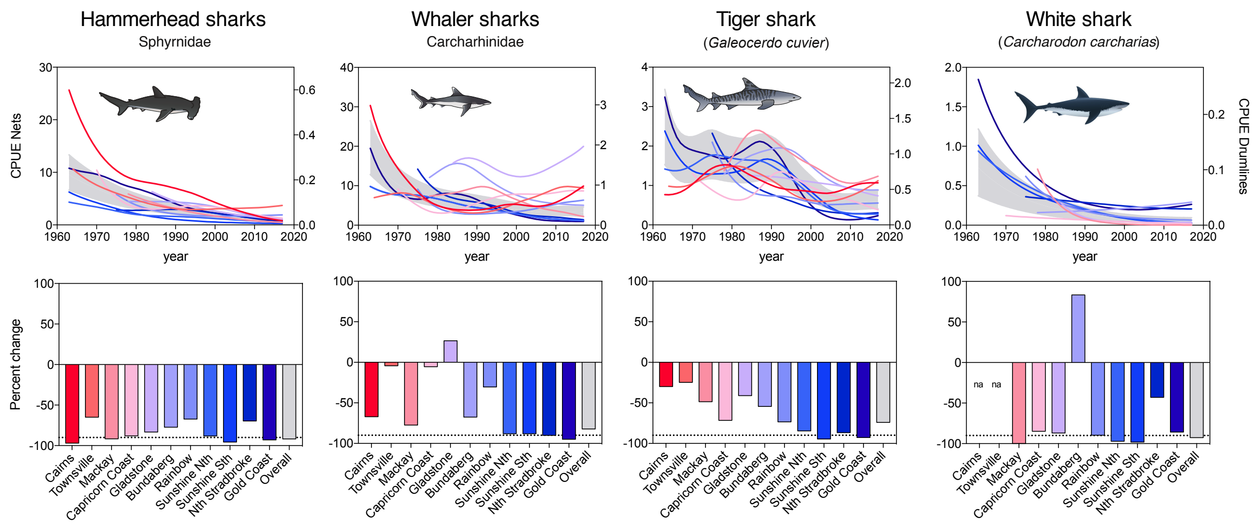
Supplementary Figure 2 Temporal trends in effort per region for number of drum lines (dashed lines) and number of nets (solid lines) between 1962 and 2017.



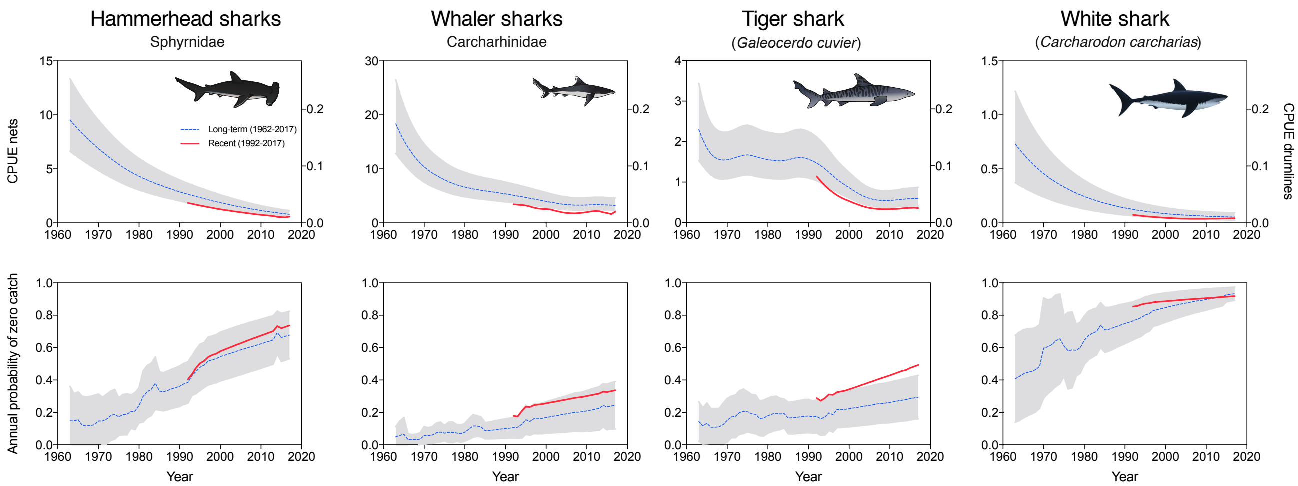
Supplementary Figure 3 Stacked area plots of changes in catch per unit effort (CPUE) for each shark group (Sphyrinidae, Carcharhinidae, tiger sharks and white sharks) for each region separate by gear type (nets, drums) and gender (red = female, blue = male)



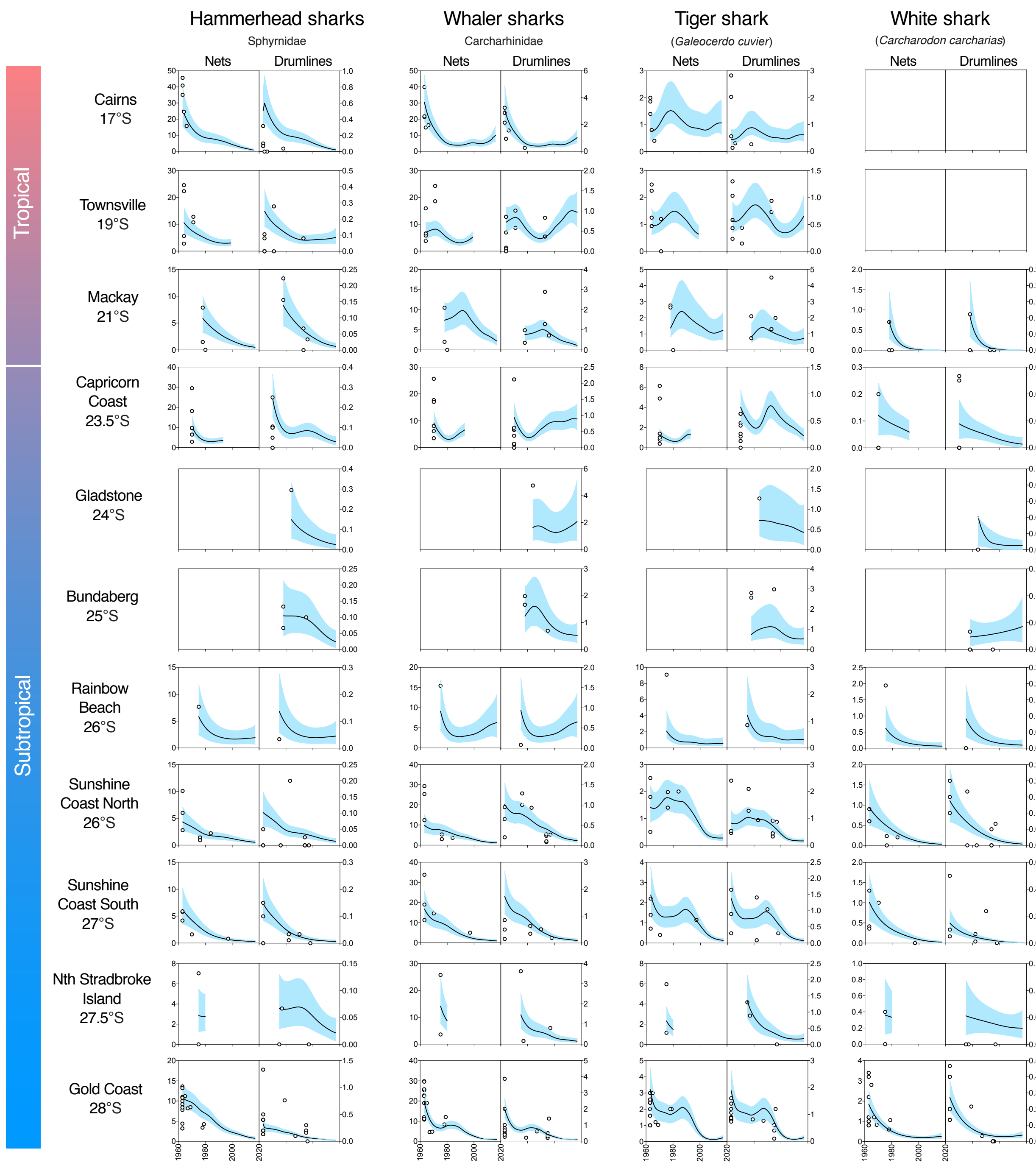
Supplementary Figure 4 Average annual zero-catch probability for each shark group (Sphyrinidae, Carcharhinidae, tiger sharks and white sharks).



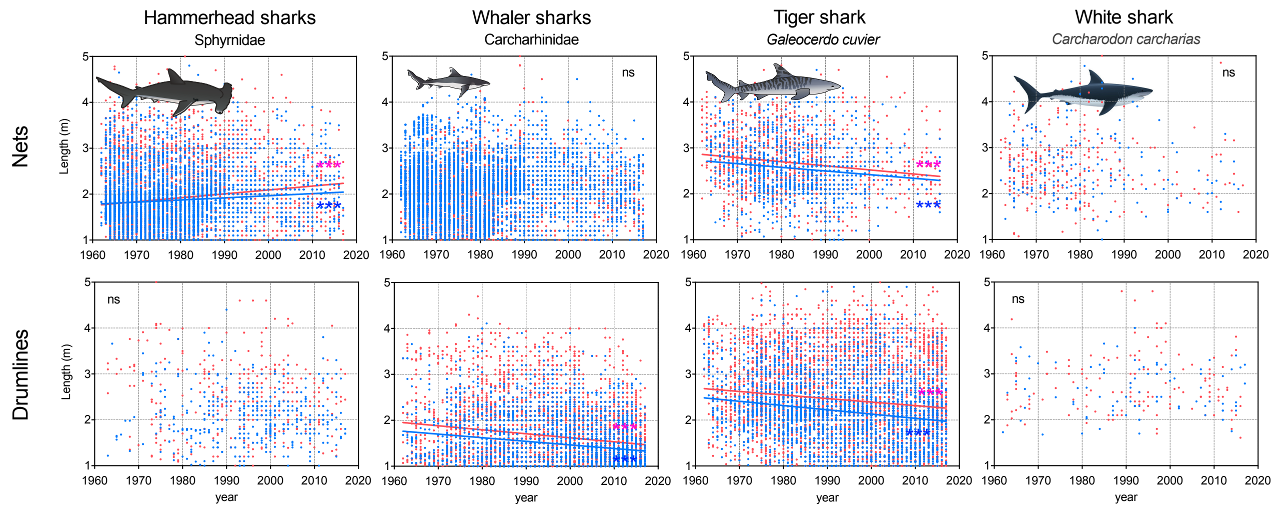
Supplementary Figure 5 Regional trends in catch per unit effort (CPUE) in nets and drumlines with fits from Bayesian negative binomial generalised additive mixed effects models (upper panels) and percent change in CPUE (lower panels) for hammerhead sharks, whaler sharks, tiger sharks and white sharks. Percent change was defined as difference between the start of the time series to the end year (2017) within each region. White sharks were not recorded in catches at Cairns and Townsville (*na*).



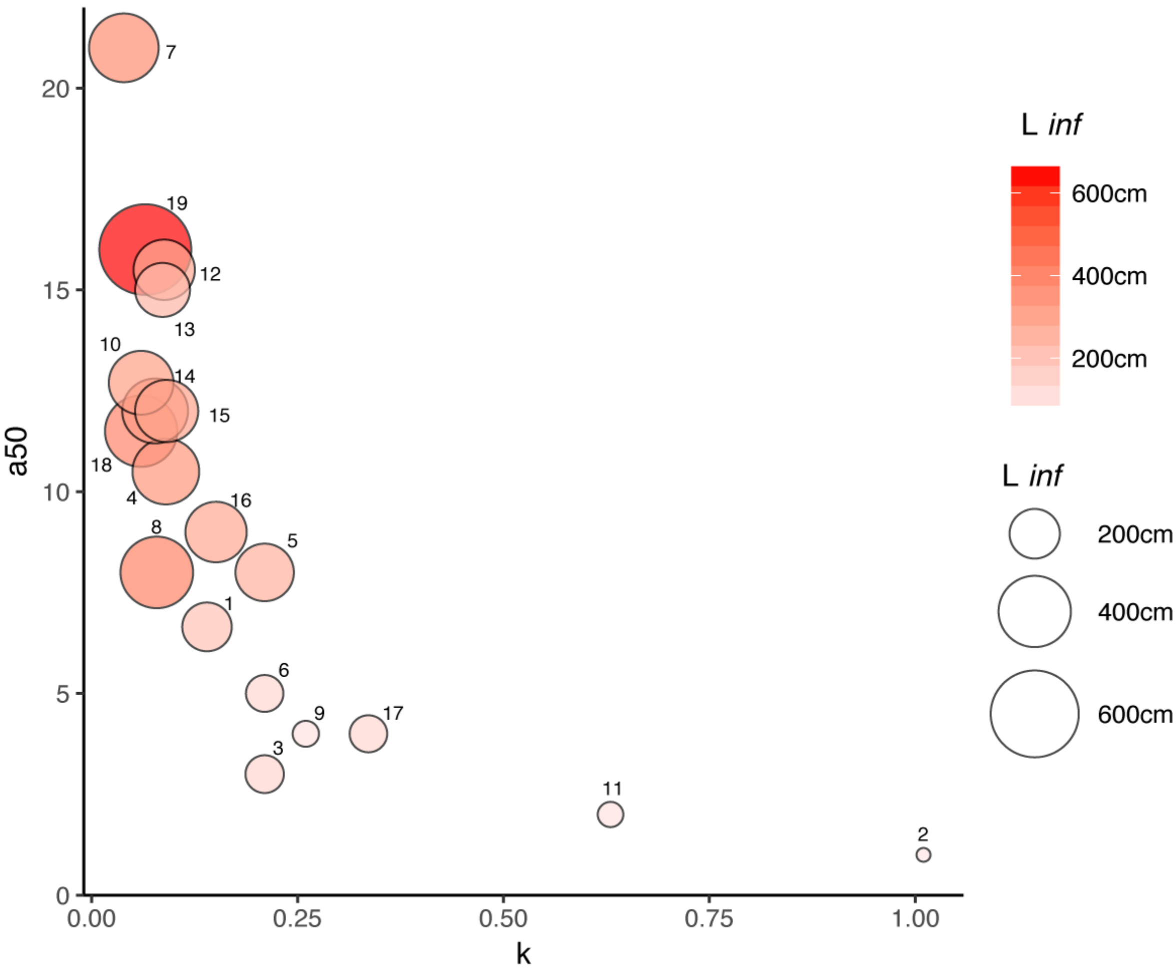
Supplementary Figure 6 Comparison of Bayesian negative binomial generalised additive mixed effects models of catch per unit effort, and annual probability of zero catch using the long-term dataset (1962 - 2017) and the recent dataset following standardisation of the program (1992 – 2017, Table S3).



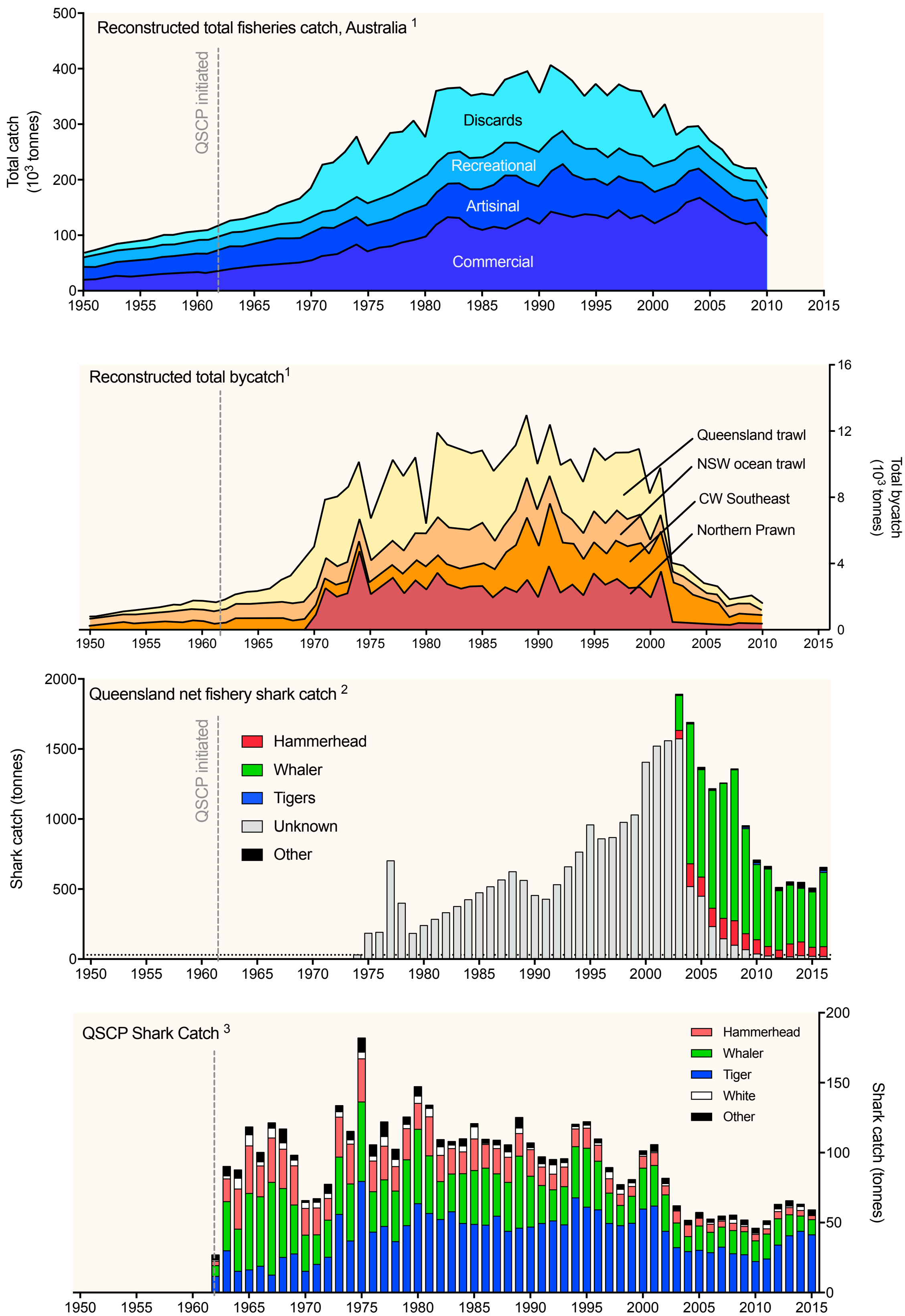
Supplementary Figure 7 Temporal trends of catch per unit effort (CPUE) per region derived from Bayesian generalised additive mixed effects models (± 95% credibility intervals) for nets and drumlines. Circles are initial CPUE (defined as the average of the first five years of operation) for each beach within regions.



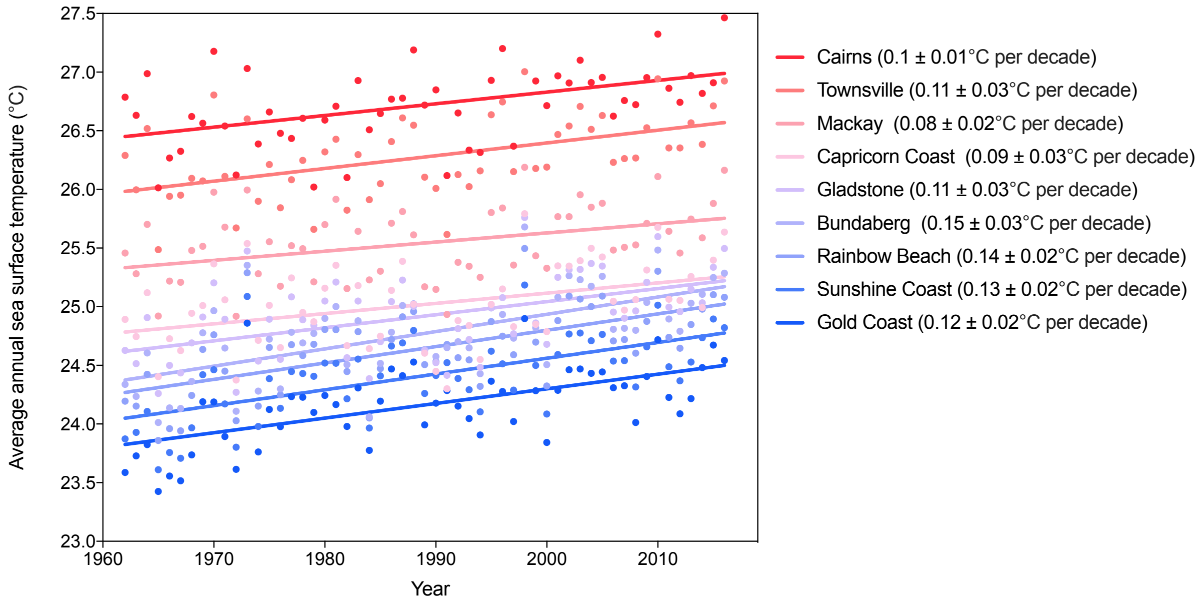
Supplementary Figure 8 Changes in length of sharks between 1962-2017 for sharks caught in drum lines and nets separated by shark groups (Sphyrinidae, Carcharhinidae, tiger sharks and white sharks) and by gender.



Supplementary Figure 9 Age at maturation and maximum total size of common sharks caught in the QSCP, where k is the von Bertalanffy growth parameter for female sharks, a50 is age at 50% of maturity for female sharks, and L*inf* is the maximum total length (asymptotic length). 1) *Carcharhinus tilstoni*, 2) *Rhizoprionodon taylori*, 3) *Carcharhinus acronotus*, 4) *Carcharhinus leucas*, 5) *Carcharhinus limbatus*, 6) *Carcharhinus fitzroyensis*, 7) *Carcharhinus obscurus*, 8) *Sphyrna mokarran*, 9) *Carcharhinus macloti*, 10) *Negaprion acutidens*, 11) *Rhizoprionodon acutus*, 12) *Carcharhinus amboinensis*, 13) *Carcharhinus plumbeus*, 14) *Sphyrna lewini*, 15) *Carcharhinus falciformis*, 16) *Carcharhinus brevipinna*, 17) *Carcharhinus sorrah*, 18) *Galeocerdo cuvier*, 19) *Carcharodon carcharias*. Data from references [1-3].



Supplementary Figure 10 Historical regional fisheries in Australia 1950-2015. Dashed grey line is 1962 when the QSCP was initiated. Sources: [1] = [4], [2] = QFish (http://qfish.fisheries.qld.gov.au/), [3] = present study



Supplementary Figure 11 Linear increases in sea surface temperatures 1962 – 2016 within regions (data extracted from the Hadley Centre Sea Ice and Sea Surface Temperature data set [HadISST] for 1 degree grid cells and averaged across years). Warming trends across all regions were significant at $p < 0.005$.

Supplementary Table 1 Species of sharks caught in the Queensland Shark Control Program (QSCP) between 1962 and 2017. Maximum total length and trophic level reported from [5], and % is proportion of total catch (1962-2017). * prior to 1992, hammerheads and whalers were not identified to species level. † Protected species under the Queensland Nature Conservation Act 1992

Group	Species	Max length (cm)	Trophic level	%	IUCN Red list status
Hammerhead	Hammerhead shark *	na	na	20.4 %	na
	Eusphyra blochii	186	4.2	< 0.1%	Endangered
	Sphyrna lewini	430	4.1	1.5 %	Endangered
	Sphyrna mokarran	610	4.3	0.6 %	Endangered
Tiger Shark	*Galeocerdo cuvier*	750	4.5	26.3 %	Near Threatened
White Shark	*Carcharodon carcharias* †	541	4.5	1.6 %	Vulnerable
Whalers	Whalers *	na	na	23.4 %	na
	Carcharhinus albimarginatus	300	4.2	< 0.1%	Vulnerable
	Carcharhinus altimus	300	4.5	< 0.1%	Data Deficient
	Carcharhinus	255	4.1	0.1 %	Near Threatened
	Carcharhinus amblyrhychos	255	4.1	0.6 %	Near Threatened
	Carcharhinus amboinensis	280	4.3	0.6 %	Data Deficient
	Carcharhinus brachyurus	325	4.5	0.2 %	Near Threatened
	Carcharhinus brevipinna	300	4.2	2.3 %	Near Threatened
	Carcharhinus cautus	150	4.3	< 0.1 %	Data Deficient
	Carcharhinus dussumieri	96	3.9	0.5 %	Near Threatened
	Carcharhinus falciformis	350	4.5	0.1 %	Near Threatened
	Carcharhinus fitzroyensis	135	4.1	< 0.1%	Least Concern
	Carcharhinus leucas	360	4.3	5.9 %	Near Threatened
	Carcharhinus limbatus	275	4.4	0.2 %	Near Threatened
	Carcharhinus macloti	110	4.2	< 0.1 %	Near Threatened
	Carcharhinus melanopterus	200	3.9	8.2 %	Near Threatened
	Carcharhinus obscurus	420	4.3	0.6 %	Vulnerable
	Carcharhinus plumbeus	180	4.5	0.5 %	Vulnerable
	Carcharhinus sorrah	160	4.2	0.7 %	Near Threatened
	Carcharhinus tilstoni	200	4.2	< 8.2 %	Least Concern
	Glyphis glyphis †	175	4.2	< 0.1 %	Endangered
	Loxodon macrorhinus	98	4.0	< 0.1 %	Least Concern
	Negaprion acutidens	380	4.1	0.4 %	Vulnerable
	Prionace glauca	400	4.5	0.1%	Near Threatened
	Rhizoprionodon acutus	175	4.3	0.1 %	Least Concern
	Rhizoprionodon taylori	69	4.5	< 0.1%	Least Concern
	Triaenodon obesus	213	4.2	0.1 %	Near Threatened
Other	*Brachaelurus waddi*	122	3.9	< 0.1 %	Least Concern

	Alopias vulpinus	549	4.5	< 0.1 %	Vulnerable
	Nebrius ferrugineus	320	4.1	1.9 %	Vulnerable
	Chiloscyllium punctatum	132	4.1	< 0.1%	Near Threatened
	Hemipristis elongata	240	4.3	< 0.1%	Vulnerable
	Hemigaleus australiensis	110	4.4	< 0.1 %	Least Concern
	Eucrossorhinus dasypogon	366	4.0	< 0.1 %	Least Concern
	Isurus sp.	445	4.5	0.3 %	Vulnerable
	Carcharias taurus †	330	4.5	0.5 %	Vulnerable
	Stegastoma fasciatum	354	3.1	1.3 %	Unknown
	Galeorhinus galeus	193	4.3	0.1 %	Vulnerable
	Mustelus antarcticus	157	4.5	< 0.1 %	Least Concern

Supplementary Table 2 Results from Bayesian mixed effects models of long-term changes in CPUE for major groups 1962 – 2017. Values are mean estimates with 95% CIs in brackets.

Sphyrinidae (hammerhead sharks) [1962-2017]

Random effects	Variance (global model)	Variance (regional model)
Dispersion parameter	0.6 (0.54 – 0.67)	0.52 (0.46 – 0.59)
Temporal variance	0.001 (0.001-0.008)	0.22 (0.1 – 0.68)
Regional variance	0.19 (0.08 – 0.58)	0.05 (0.02 – 0.12)
Site variance	0.17 (0.11 – 0.29)	0.18 (0.12 – 0.29)

Fixed effects	Variance (global model)	Variance (regional model)
intercept	-2.61 (-2.28 – -2.94)	-2.69 (-2.34 – -3.05)
gear	3.63 (3.53 – 3.74)	1.05 (0.7 – 1.42)

Carcharhinidae (whaler sharks) [1962-2017]

Random effects	Variance (global model)	Variance (regional model)
Dispersion parameter	0.72 (0.68 – 0.78)	0.51 (0.47 – 0.55)
Temporal variance	0.01 (0.001 – 0.07)	0.06 (0.02 – 0.42)
Regional variance	0.1 (0.03 – 0.55)	0.15 (0.09 – 0.29)
Site variance	0.24 (0.16 – 0.38)	0.18 (0.12 – 0.28)

Fixed effects	Variance (global model)	Variance (regional model)
intercept	-0.34 (-0.63 - 0.01)	-0.51 (-0.20 – 0.76)
gear	2.06 (1.97 – 2.15)	1.76 (1.51 – 2.08)

Tiger sharks (*Galeocerdo cuvier*) [1962-2017]

Random effects	Variance – global model	Variance – regional model
Dispersion parameter	0.56 (0.51 – 0.61)	0.44 (0.4 – 0.49)
Temporal variance	0.07 (0.03 – 0.21)	0.001 (0.001 – 0.29)
Regional variance	0.12 (0.03 – 0.6)	0.18 (0.11 – 0.32)
Site variance	0.39 (0.27 – 0.58)	0.39 (0.27 – 0.59)

Fixed effects	Variance – global model	Variance – regional model
intercept	-0.36 (-0.01 – -0.68)	-0.6 (-0.81 – -0.28)
gear	0.47 (0.37– 0.55)	-0.06 (-0.28 – 0.27)

White sharks (*Carcharodon carcharias*) [1962-2017]

Random effects	Variance – global model	Variance – regional model
Dispersion parameter	0.85 (0.63 – 1.16)	0.79 (0.58 – 1.09)
Temporal variance	0.001 (0.001 – 0.02)	0.36 (0.14 – 1.34)
Regional variance	0.4 (0.15 – 1.6)	0.01 (0.001 – 0.05)
Site variance	0.09 (0.04 – 0.23)	0.09 (0.04 – 0.22)

Fixed effects	Variance – global model	Variance – regional model
intercept	-3.79 (-3.3 – -4.39)	-3.85 (-3.33 – 4.41)
gear	1.9 (1.7 – 2.1)	-1.93 (-1.41 – -2.5)

Supplementary Table 3 Results from Bayesian mixed effects models of long-term changes in CPUE for major groups 1992 – 2017. Values are mean estimates with 95% CIs in brackets.

Sphyrinidae (hammerhead sharks) [1992-2017]

Random effects	Variance (global model)	Variance (regional model)
Dispersion parameter	0.77 (0.7 – 0.86)	0.74 (0.66 – 0.83)
Temporal variance	0.01 (0.01-0.07)	0.01 (0.01 – 0.07)
Regional variance	0.45 (0.29 – 0.82)	0.44 (0.28 – 0.81)
Site variance	0.48 (0.37 – 0.65)	0.48 (0.37 – 0.65)

Fixed effects	Variance (global model)	Variance (regional model)
intercept	-2.94 (-3.32 – -2.59)	-2.97 (-3.34 – -2.62)
gear	2.91 (2.72 – 3.11)	0.06 (-0.44 – 0.31)

Carcharhinidae (whaler sharks) [1992-2017]

Random effects	Variance (global model)	Variance (regional model)
Dispersion parameter	0.71 (0.67 – 0.75)	0.62 (0.58 – 0.67)
Temporal variance	0.14 (0.07 – 0.31)	0.06 (0.02 – 0.21)
Regional variance	0.45 (0.27 – 0.91)	0.5 (0.3 – 0.95)
Site variance	0.62 (0.51 – 0.77)	0.58 (0.48 – 0.73)

Fixed effects	Variance (global model)	Variance (regional model)
intercept	-0.62 (-0.99 – -0.21)	-0.67 (-1.06 – -0.24)
gear	1.42 (1.27 – 1.57)	0.88 (0.48 – 1.32)

Tiger sharks (*Galeocerdo cuvier*) [1992-2017]

Random effects	Variance – global model	Variance – regional model
Dispersion parameter	0.62 (0.58 – 0.67)	0.53 (0.49 – 0.58)
Temporal variance	0.08 (0.05 – 0.17)	0.16 (0.11 – 0.24)
Regional variance	0.54 (0.34 – 1.05)	0.64 (0.41 – 1.16)
Site variance	0.68 (0.57 – 0.85)	0.7 (0.58 – 0.87)

Fixed effects	Variance – global model	Variance – regional model
intercept	-0.69 (-1.12 – -0.23)	-0.77 (-1.26 – -0.26)
gear	-0.09 (-0.24 – 0.06)	-0.74 (-1.23 – -0.22)

White sharks (*Carcharodon carcharias*) [1992-2017]

Random effects	Variance – global model	Variance – regional model
Dispersion parameter	0.66 (0.41 – 1.17)	0.65 (0.4 – 1.2)
Temporal variance	0.03 (0.01– 0.14)	0.01 (0.01 – 0.09)
Regional variance	1.06 (0.64 – 2.21)	1.34 (0.8 – 2.87)
Site variance	0.35 (0.2 – 0.71)	0.32 (0.17 – 0.68)

Fixed effects	Variance – global model	Variance – regional model
intercept	-4.52 (-5.5 – -3.66)	-4.85 (-6.12 – -3.8)
gear	1.31 (0.92 – 1.7)	-3.54 (-4.85 – -2.45)

Supplementary Table 4 Results of linear mixed effects models for changes in size through time among shark groups. Model simplification from full model (year * gear * sex) was based on Akaike Information Criterion (AIC).

Sphyrinidae [1962-2017]

	SS	**MSS**	**DF**	**DenDF**	**F**	**P**
year	24.153	24.153	1	8220.4	53.281	<0.001
gear	15.95	15.95	1	4823.2	35.186	<0.0001
sex	36.121	36.121	1	9691.6	79.683	<0.0001
gear:sex	10.629	10.629	1	9630.2	23.448	<0.0001

Carcharhinidae [1962-2017]

	SS	**MSS**	**DF**	**DenDF**	**F**	**P**
year	15.2172	15.2172	1	17343	45.868	<0.0001
sex	1.9214	1.9214	1	20008	5.792	<0.0001
gear	4.9642	4.9642	1	17770	14.963	<0.0001
year:gear	5.1763	5.1763	1	17706	15.602	<0.0001
year:sex	1.7281	1.7281	1	20008	5.209	<0.05

Tiger sharks (*Galeocerdo cuvier*) [1962-2017]

	SS	**MSS**	**DF**	**DenDF**	**F**	**P**
year	147.688	147.688	1	10342.6	245.949	<0.0001
gear	59.739	59.739	1	7193.8	99.484	<0.0001
sex	65.014	65.014	1	12508.2	108.27	<0.0001
gear:sex	7.713	7.713	1	12517.7	12.844	<0.0001

White sharks (*Carcharodon carcharias*) [1962-2017]

	SS	**MSS**	**DF**	**DenDF**	**F**	**P**
gear	45.028	45.028	1	9108.2	133.67	<0.0001

Scalloped hammerhead (*Sphyrna lewini*) [1995-2017]

	SS	**MSS**	**DF**	**DenDF**	**F**	**P**
year	3.2317	3.2317	1	662.06	11.58	<0.0001
sex	0.5766	0.5766	1	671.06	2.066	>0.1
gear	1.6952	1.6952	1	374.34	6.074	<0.05
sex:gear	1.8956	1.8956	1	668.42	6.792	<0.001

Great hammerhead (*Sphyrna mokarran*) [1995-2017]

	SS	**MSS**	**DF**	**DenDF**	**F**	**P**
year	4.2379	4.2379	1	292.79	14.8909	<0.0001
sex	1.9552	1.9552	1	292.21	6.8701	<0.001
gear	1.9552	1.9552	1	292.21	6.8701	<0.001
year:sex	4.641	4.641	1	290.48	16.3073	<0.0001
year:gear	0.2414	0.2414	1	289.81	0.8482	>0.1
sex:gear	1.9552	1.9552	1	292.21	6.8701	<0.001
year:sex:gear	1.9537	1.9537	1	292.2	6.8648	<0.001

Supplementary Table 5 Results of binomial probability general linear models for changes in maturity through time among shark groups

Binomial GLM Scalloped hammerhead (*Sphyrna lewini*) [1995-2017]

	Estimate	**SE**	**z value**	**P**
year	-0.07602	0.01618	-4.698	<0.001

Binomial GLM Great hammerhead (*Sphyrna mokkaran*) [1995-2017]

	Estimate	**SE**	**z value**	**P**
year	-0.04563	0.02257	-2.021	<0.05

Binomial GLM Tiger shark (*Galeocerdo cuvier*) [1995-2017]

	Estimate	SE	z value	P
year	-0.031625	0.005666	- 5.581	<0.0001

Supplementary Table 6 Alternative hypothesis to account for the long-term decline in shark populations in the QSCP data

Hypothesis 1: Environmental changes (increasing SST) are responsible for long-term declines in shark populations
Theoretically, shifts in environmental conditions (rainfall and temperature) could affect shark abundance and distribution over decadal scales. On the Queensland coastline, rainfall and river flow variability are strongly influenced by El Nino Southern Oscillation events and the Pacific Decadal Oscillation, resulting in periodic wet seasons and dry seasons. Analysis of 20th century patterns of rainfall indicate that there appears to be no overall trend toward wetter or drier conditions[19], precluding long-term changes in rainfall as a driver of declining shark populations. Analysis of long-term trends of sea surface temperature (SST) over the past five decades (Figure S11) indicates that all QSCP regions have experienced a significant warming trend of between 0.08 to 0.14°C per decade. While long-term increases of temperatures in the past decades occur at a time when shark population are in decline, SST is unlikely to be a primary driver of shark declines, as declines in shark populations were non-linear, and declined rapidly in the 1960's to 1970's (Figure 2) under relatively slow linear increases in temperature (Figure S11). Concurrent warming patterns in SST could theoretically result in changes in latitudinal distribution shifts (e.g. [20]), yet it seems unlikely that relatively minor changes in SST (~0.1 °C per decade) would account for such substantial non-linear declines in shark populations. Warming SST in high latitudes regions could theoretically drive distribution shifts, resulting in more incursions of tiger sharks that prefer tropical and warm-temperate oceans[5]. Yet, the strongest declines in tiger shark CPUE were recorded at high latitude regions (Fig S5). While environmental fluctuations can influence the distribution and habitat use of coastal sharks[21], it seems unlikely that long-term shifts in the environment are responsible for rapid declines in coastal shark populations.
Hypothesis 2: Long-term changes in prey abundance have resulted in declines in shark populations
Seasonal abundances and habitat use of apex sharks can be linked to both water temperature and availability of prey[22,23]. However, there is no clear evidence of declines in prey coinciding with the rapid declines in CPUE in the 1960's and 1970's (Figure 2). Large apex sharks exhibit a high degree of omnivory: tiger sharks feed on sharks, rays, bony fishes, marine mammals, tortoises, seabirds, sea snakes, squids, gastropods, crustaceans, including carrion, garbage, cans, and pieces of metal[5], white sharks feed on a bony fishes, sharks, rays, seals, dolphins and porpoises, sea birds, carrion, squid, octopi and crabs[5], great hammerhead sharks feed on stingrays and other batoids, groupers and sea catfishes, but also small bony fishes, crabs, squid, other sharks, rays, and lobsters [5]. Further, large apex sharks often exhibit facultative scavenging behaviour, often feeding on weak and diseased individuals rather than actively hunting prey[23,24]. Given such a high degree of omnivory and facultative scavenging, it seems unlikely that declines in prey items or shifts in food-web structure would account for such substantial and rapid declines in shark populations (Figure 2). Furthermore, declines in shark populations in the 1960's and 1970's were spatially consistent across the Queensland coastline (Figure

S5), and occurred during a time when coastal human population growth was comparatively minor compared to current human population size.

Hypothesis 3. Sharks are learning to avoid nets and drums

An alternative explanation may be that declines in CPUE within beaches result from sharks "*…learning that nets and drumlines placed in their local areas represent an obstacle and actively avoid(ing) them* [25]". While it has been broadly speculated that sharks are capable of some degree of learning (see [26] for a concise review), it seems improbable that avoidance behaviour can account for the rapid declines observed across multiple taxa across the length of the Queensland coastline (Fig S5). Such learned avoidance of QSCP program locations is particularly unlikely in sharks that exhibit widespread movement patterns at regional scales (e.g. *Galeocerdo cuvier* and *Carcharodon carcharias*, Fig 5). The QSCP uses two methods of shark control: nets that passively trap a broad range of shark species, and baited drumlines that actively target large sharks[27]. While some degree of operant conditioning could occur from baited hooks[26], high rates of bait scavenging in shark control programs (~60% of hooks within a single day of deployment[28]) implies that sharks are attracted to, and are actively targeting baited drumlines. Contractors notes from the early years of the QSCP (Sunshine Coast, 1963) suggest that drumline installations actively attract sharks to beaches where gear is installed rather than displace them:

> "*… thirty five feet of shark were taken on one drumline when hooks were shackled back to back at the end of the trace. An 11 foot whaler had swallowed both hooks and was attacked by a 13 foot tiger which also became hooked. Both were attacked by other sharks and another 11 foot whaler took one of the free hooks*" [29]

There are several lines of evidence that argue against net avoidance: i) declines in catches in shark netting programs occur even when nets have been set randomly within a beach and on different days[30], ii) nets may be set in turbid coast water, where sharks are unable to visually avoid entanglement, and iii) learned behaviour is unlikely to be intergenerational, as sharks would die without transferring the knowledge that nets are dangerous (Wallett 1983, cited in [31]). The evidence from the QSCP argues against the hypothesis of learned avoidance, in that sharks and bycatch trapped in nets actively attracts larger sharks decades after the gear was first installed:

> "*On 3 June 1975 two tiger sharks and three whaler sharks were caught at Bundaberg and all were found in close proximity to a meshed and severely mauled dugong*" [32]

> "*On 7 November 1977 a 5.1 m white pointer shark was caught at the Gold Coast while attacking a meshed dolphin. The stomach of the shark contained the caudal third of the dolphin*" [32]

> "*On 11 June 1985 seven tiger sharks and one white pointer shark were caught at Mackay and all were found in close proximity to a meshed dolphin*" [32]

Hypothesis 4. Sharks are actively avoiding coastal regions with high human activity

As shark control programs are set adjacent to major metropolitan areas that have grown rapidly and become increasingly degraded and noisy in recent years, large apex sharks may be actively avoiding such busy coastal regions. Indeed, such displacement in response to increased boat traffic has been observed in a broad range of cetaceans[33,34] and large predatory fish[35]. However, acoustic tagging studies of mesopredator sharks (*Triaenodon obesus* and *Carcharhinus amblyrhynchos*) showed no strong evidence of a link between spatial habitat use and intensity of human activities[35]. Conversely, large apex sharks with generalist diets may be attracted to coastal habitats while scavenging for food sources, and port areas are recognised as having a higher risk of shark attacks[36]. Such evidence is supported by studies that indicate that large apex sharks (specifically *G. cuvier*) may be attracted to coastal areas by increased levels of maritime traffic [37,38]. The use of baited drumlines are designed to attract sharks to control programs, and studies have documented the change movement patterns and behaviour of sharks in response to baiting and feeding [39-41].

While increased urbanisation of the Queensland coastline is likely to have affected coastal ecosystems and food-webs, the rapid declines in shark catches in the early decades of the QSCP (1960's and 1970's) occurred at a time when coastal development was low, prior to recent coastal migration and substantial tourism development in the 1990's and onwards [42-44]. Further, a review of current and historical distributions of marine mammal populations in Moreton Bay suggests that Queensland coastal ecosystems support a remarkably diverse and abundant marine mammal fauna, despite substantial population increases and coastal development over the past 50 years [45].

Supplementary Table 7 Summary of commercial and recreational fisheries for sharks operating in Queensland and adjacent jurisdictions. Lack of detailed data on species identification and shark numbers within historical fisheries records makes it difficult to assess the impacts of commercial and recreational fisheries on shark populations. We collated local and adjacent fisheries to determine (where possible) species composition of shark catches and historical estimates of fisheries intensification over the past 50 years to contrast with data collected from the QSCP.

Commercial fisheries

Queensland shark fisheries

The majority of commercial shark product caught in Queensland, accounting for ~94% of all sharks, comes from the East Coast Inshore Fin Fish Fishery (ECIFFF)[46]. Shark fisheries had been operating for some years on some parts of the East Coast, but numbers of the shark catches were only recorded from 1974–75 onwards. Catches of sharks may have been very small prior to the mid-1970s, when many gillnet fishers using heavy nets were practically able to fish only rivers and estuaries[1]. Major shifts in net technology occurred in the 1970s, with the take-up of lightweight untarred nylon nets which allowed gillnet fishers to fish further from shore on the Queensland East Coast and actively target sharks[1] (Figure S11). The increase of shark catch from 1994 – 2003 from 319 to 1252 tonnes (Figure S10) raised concern from fishery and marine park managers[46,47]. Since 2003 the catch of sharks has fallen (Figure S10) primarily due to shark-specific measures implemented by fishery managers including restriction of license retention, possession limits and fishery-wide catch limits, along with a maximum size limit of 150 cm to protect large breeding females. While historical data on species composition is unavailable prior to 2003 (Figure S10), fisheries observer data indicates that blacktips (*Carcharhinus tilstoni*) and scalloped hammerheads (*S. lewini*) dominated commercial catches (32% and 18% respectively), while great hammerheads (*S. mokarran*) and neonate tiger sharks (*G. cuvier*) were less frequent (2.9% and 0.2% respectively)[46]. Based on the average catch of sharks from 1990 to 2005 (793 tonnes per year), the estimated catch of scalloped hammerheads (*S. lewini*) was 143 tonnes per year[47]. Later fishery observer surveys between 2006 and 2009 indicate that while whaler sharks (Carcharhinidae) formed 94.5% of catch by abundance, scalloped (*S. lewini*) and great (*S. mokarran*) hammerheads were the third and fourth most targeted species by biomass (9.7 and 6.8% respectively)[48]. Estimates of historical shark finning are largely unknown. Around 5.3 to 5.8 tonnes per year in the late 1990's was derived from shark landings in Queensland, although this is likely to be an underestimate[49].

The East Coast Otter Trawl Fishery (ECOTF) targets a range of prawns, scallops, bugs and squid species across on the eastern Queensland coastline[50]. In terms of the volume of product caught, the fishery is the largest in Queensland, operating across estuaries, coastal and oceanic waters, and encompassing approximately 57% of the Great Barrier Reef Marine Park[51]. Recent bycatch records indicate interactions with scalloped hammerheads (*S. lewini*) [50]. Prior to the introduction of bycatch reduction devices and mitigation measures in 2005, given the size of the fishery, substantial unreported numbers of sharks may have been caught as bycatch. As with nearly all fisheries, historical catch data and effort data from the onset of the QSCP are unavailable, although reconstructed fisheries estimates indicates increasing rates of bycatch in the 1970's [4] prior to a reduction in the early 2000's with the onset of bycatch reduction (Figure S10).

East coast Australian fisheries

The Eastern tuna and billfish (ETBF) fishery operates using longline and minor line (including hand line, troll, rod and reel) fishing gear. It is unlikely that the fishery has strong impact on coastal sharks, as the shark catch in the fishery has historically been dominated by blue shark (*Prionace glauca*), oceanic white tip (*Carcharhinus longimanus*), and shortfin mako (*Isurus oxyrinchus*) that are uncommon in the QSCP[52], although tiger sharks (*G. cuvier*) and hammerheads (*S. lewini* and *S. mokkaran*) were historically finned along with a range of whaler sharks (Carcharhinidae)[49]. Logbook data from 1995 - 1996 indicates that sharks represent a significant portion (6.4 - 13.6%) of the catch in the ETBF, with 33 – 53% of sharks retained or finned, although this may be an underestimate due to under-reporting of catch[49]. Australian and Japanese longline fisheries targeting tunas and billfish in the Australian Exclusive Economic Zone (EEZ) have been ongoing since the 1960's. These fisheries are unlikely to impact coastal shark populations as they target pelagic sharks (primarily *Prionace glauca,* ~85% of total catch) that are uncommon in coastal Queensland waters and the QSCP catch[53]. Further, other line fisheries that operate in eastern Australian coastal regions are highly selective, and catch of non-target shark bycatch is relatively infrequent[54].

The Ocean Trap and Line fishery (OTLF) is a multi-method, multi species fishery targeting demersal and pelagic fish along the entire New South Wales coast in coastal and open ocean waters. The fishery targets sandbar sharks (*Carcharhinus plumbeus*, ~33% of total catch), dusky whaler (15.2%) and spinner sharks (10.6%) that occur within the QSCP long-term catch as 'whalers' (Carcharhinidae)[55,56]. While tiger and hammerhead sharks are a comparatively minor component of the OTLF shark catch (5.9% and 3.7% respectively), specific targeting of large individuals for shark finning prior to a prohibition in 2011 may have historically impacted upon shark populations. Long-term records since 1974 show that total catch rates have remained stable over the 30-year period, with reported shark catches from 1990 onwards showing a decline in shark catch[57].

Regional SE Pacific shark fisheries

At a regional scale, shark fisheries in the Pacific were generally low until the late 1970's, and intensification of targeted fisheries for shark finning increased in the 1980's[56,58]. Prior to the introduction of pelagic long-line and industrial fisheries in the mid 1980's – mid 1990's, shark fisheries in the SW Pacific region were mostly small-scale artisanal fisheries relying on traditional fisheries methods[58-61]. While it is plausible that some declines occurred during oceanic excursions within the region (Figure 5), it seems unlikely that regional Pacific shark fisheries have a substantial impact on the observed declines, particularly in the early years of the program.

Recreational fisheries

The extent to which recreational fisheries have impacted upon coastal shark populations is unclear. Commercial production is reported by weight, while recreational fisheries is typically reported in terms of numbers, rendering comparisons among sectors difficult[62]. While Queensland's human population in the 1960's and 1970's was relatively stable, increases large shark fishing for white sharks occurred in the 1950's following popularisation of "shark hunting" and big game fishing[63]. Recreational spearfishing for grey nurse sharks (*Carcharias taurus*) on the eastern Australian coastline in the 1950's and 1960's resulted in near extirpation of local populations.

Current recreational fisheries largely target smaller species with an average weight of just 15kg[64], although some sport fishing does target large oceanic and pelagic sharks that overlap with QSCP catches. Leigh[1] argues that the impact of recreational fisheries on Queensland's shark populations is comparatively minor, as most (88.6%) of sharks caught are released. Considering that common fishing gear is designed to catch sharks <1m (~0.25kg to 6kg in weight), the average retained recreational catch of sharks is estimated to be ~12-75 tonnes[1]. Fisheries independent estimates of recreational fishing indicate that whalers (Carcharhinidae) form 86.8% of the catch in the Great Barrier Marine Park, with hammerheads (*S. lewini* and *S. mokkaran*) forming 7.8% of catch, which is broadly similar to the composition of shark catches in the ECIFFF[62].

Shark catches from sport fishermen off New South Wales between 1959-1979 indicates that most of the catch (>50%[65]) was composed of the pelagic shortfin mako (*Isurus oxyrinchus*) and blue sharks (*Prionace glauca*). Coastal sharks including tiger, and hammerhead sharks were historically targeted in lower numbers (<20% of total catch[65]). White sharks were rare in the 1979-1982 landings (0.4%) but accounted for 7% of all landings in 1959-1979, suggesting early population decline[65]. Shark catches from sport fishermen from Queensland in the late 1990's indicates that recreational catch is also primarily composed of the pelagic shortfin mako (*Isurus oxyrinchus*, 41%), with tiger (17.4%), whaler (16.7%), hammerhead (13%) blue sharks (12%), and that 80-100% of sharks were released, with the exception of tiger sharks, where larger individuals were kept for weighing[66]. On the Great Barrier Reef, line fisherman mostly target smaller reef sharks (*Carcharhinus melanopterus* and *Carcharhinus amblyrhynchos*, 56% catch), with large apex sharks such as tigers (1.5%) and hammerhead (7.8%) comparatively rare[62].

NSW Shark meshing program

The New South Wales (NSW) government has operated a shark netting program since 1937 in Sydney (33.8°S), and since 1949 in Newcastle (32.9°S) and Wollongong (34.4°S). Continuous data from the early years of the program is not available, and analysis is limited to decadal trends[67]. Records of catches between 1950 – 2010 indicated three main shark taxa: hammerhead sharks (*Sphyrna* spp.), whaler sharks (*Carcharhinus* spp.) and Australian angel sharks (*Squatina australis*)[67]. Catch rates of sharks in the NSW program are substantially lower than that of the QSCP. Similar to the QSCP, catches of large white sharks (Carcharodon carcharias) and tiger sharks (Galeocerdo cuvier) declined over time, although the magnitude of the decline was substantially less than the QSCP[67]. Tiger sharks were stable across the first 60 years of data, however a significant decline was observed in the last 20 years, and cyclical peaks in catch that were observed in catch rates ceased after 40 years of catch. Catch rates of white sharks *(C. carcharias)* in shark meshing programs is low (~six white sharks per year) but significantly reduced from the 1950's[67]. While the shark meshing program is located a substantial distance from the southernmost beaches of the QSCP (~700km), migration of tiger[10] and white sharks[8] between tropical and subtropical waters (Figure 5) implies that shark catches in the NSW shark meshing programs may be contributing to the declines observed in the Queensland Shark Control Program".

Supplementary Table 8. Summary of movement studies for 13 shark species that included movements of individuals within South East Queensland and have also been recorded in the QSCP. *S = satellite tags; A = acoustic tags; R = archival (non-transmitting) tags; T =conventional external tags (mark-recapture); P = conventional external tags (photo-ID re-sighting). §Total number of individuals tagged. Figures in parentheses refer to number of tagged individuals that were recaptured or re-sighted with conventional external tags.

Species	**Method***	**Number §**	**D_{max}**	**Source**
Carcharodon carcharias	S	25	3665	[6]
Carcharodon carcharias	S, R, T	405 (1)	3298	[7]
Carcharodon carcharias	S, A	10	2484	[8]
Carcharhinus leucas	A	114	1985	[9]
Galeocerdo cuvier	S	18	1832	[10]
Galeocerdo cuvier	S, A, P	34	1442	[11]
Galeocerdo cuvier	S	10	1259	[12]
Carcharias taurus	S, A	15	1550	[13]
Carcharias taurus	P	931 (386)	1260	[14]
Carcharias taurus	A	21	1050	[15]
Carcharias taurus	T, P	24 (14)	681	[16]
Carcharhinus sorrah	T	436 (7)	683	[17]
Carcharhinus tilstoni	T	957 (35)	309	[18]
Carcharhinus brevipinna	T	643 (46)	169	[17]
Carcharhinus amblyrhynchos	A	9	134	[17]
Carcharhinus amboinensis	T	410 (33)	123	[17]
Rhizoprionodon taylori	T	967 (5)	53	[17]

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