Supplementary Information

Supplementary Methods

We collected fine-scale network data concerning fishing-related information-sharing for the gillnet skipper community in San Jose, Lambayeque, Peru (6°46' S 79°58' W). Sea turtles captured in gillnets are the marine group of primary conservation concern in San Jose; thus, information-sharing about sea turtle bycatch is one of the study's primary interests. Nevertheless, the sea turtle bycatch reduction initiative (LEDs on gillnets) may potentially add value to catch (fishing finance), as well as relating to other fishing-related information shared, such as fishery regulations, weather conditions, crew management, and vessel technology and maintenance. Thus, nine individual information-sharing networks were collected. This study aimed to investigate the social structure amongst skippers; therefore, the study's data pertain to respondent-to-respondent networks only (which also allowed for consistent respondent numbers between cross-network comparisons).

The gillnet is the most common fishing gear used in Peru's small-scale fishing fleet[1]. Several marine megafauna taxonomic groups are incidentally captured in gillnets in San Jose[2-5], of which sea turtles have been highlighted as a major conservation issue that warrants further management[2,6]. Across the inshore-midwater vessel class in San Jose, sea turtle captures per trip has been calculated at 0.71 for green turtles (*Chelonia mydas*), 0.08 for olive ridley turtles (*Lepidochelys olivacea*), and 0.02 for leatherback turtles (*Dermochelys coriacea*). Turtles released alive without visible injury comprise nearly 62% of 461 fishing trips observed from San Jose between August 2007 to March 2019. Live releases with injuries 28% of captures and 8% mortalities[6]. Gillnetting across two distinct fleets in San Jose has been defined as posing an extreme and major risk to population recovery goals of the East Pacific Regional Management Unit (RMU)[7] populations of these species[6].

Because of the threat that gillnets pose to sea turtles in Peru's northern fishing ports, our chosen study population was actively fishing San Jose skippers deploying gillnet gear year-round, including those who owned and operated their vessels and those who skippered for others. Skippers were chosen as they are in charge of the fishing gear and crew when the boat is in the water and the gears deployed, and therefore their decisions are most influential in opportunities to reduce turtle bycatch (for example, through better live release, or the use of LED lights on nets to reduce incidental captures[8]).

Five gillnet skippers and their crew are currently involved in a trial community co-management bycatch reduction scheme operating from San Jose that requires fishers to use light-emitting diodes (LEDs) on their nets a technology shown to reduce green turtle bycatch by 64% while maintaining levels of target catch in randomized control gear trials in Sechura Bay (Main text Figure 2a), located approximately 150 kilometers north of San Jose[8]. Acoustic alarms ('pingers') are also fitted to nets to reduce small cetacean bycatch[4], and a remote electronic monitoring device is under trial to improve data paucity[9].

Determining population size

During months with warmer weather (and hence better fishing conditions), the number of skippers can more than double as fishers arrive from inland areas seeking fishing work. Skippers typically operate with 1–4 crew[10]. Peruvian law defines small-scale fishing vessels as displacing a maximum of 32.6m^3 Gross Registered Tonnage (GRT), up to 15m in length, and operated predominantly manually. San Jose's small-scale gillnet vessels can be subdivided into two fleets. The first fleet comprises a class of open-welled boats known as 'chalanas', with a capacity range from 1–8 t. The second fleet comprises a predominantly larger vessel class known as 'lanchas', with small closed bridges ranging in capacity from 5–32 t[1]. The survey interviewed actively fishing gillnet skippers on both chalana and lancha vessels. Previous estimates of gillnet activity in San Jose recorded 95 gillnet vessels fishing in January–April 2004[10], and 47 gillnet vessels fishing in November 1995–April 1996[11].

The total population (n=168) was determined by triangulating data obtained from membership lists of the two main fishing groups in San Jose, lists of vessels daily launching and landing logs, and key informant interviews. We restricted the network analysis to gillnet skippers – who owned their own vessel(s) or who skippered a vessel owned by someone else, and who launched and landed their vessels from the beach at San Jose, Lambayeque, Peru (6°46' S, 79°58' W). Gillnet skippers were required to be identified as actively fishing at least once during the winter period of 1 July – 30 September 2017 using one or more of the data sources used for the analysis.

There are two main at-sea fishing groups in San Jose (the Maritime Union of Fishermen Society, and the Artisanal Fishermen and Hydrobiological Extractors Association). Following initial introductions being made with both of the fishing groups leaders during which time we presented a description of the study and associated ethical clearance, we were granted access to the fishing groups membership lists, which contained information on gillnet skipper name, vessel name, and vessel unique identification (plate number). During our survey period, the fishers in San Jose were pushing and pulling their fishing vessels in and out of the water from the beach using large tractors that were driven by employees of a local company that specialized in providing this service. Subsequent information from San Jose in early 2019 indicates that this service is no longer being provided due to legal implications imposed by recently implemented Government legislation. Skippers were charged a fee and the tractor drivers record each vessel (using the plate number) as they are pushed each vessel out to sea and pulled each vessel back onto the beach following a fishing trip. The daily launching and landing logs were provided following a meeting with the company owner and the tractor drivers, during which we presented a description of the study and associated ethical clearance. The daily launching and landing logs were cross referenced with the list of active fishing group members and the list of actively fishing gillnet skippers was checked by several key informants during two key informant interviews held in San Jose in July 2017. Between 1 July – 30 September 2017 every actively fishing gillnet skipper (n=168) was identified and asked if they would like to partake in the interview; only three actively fishing gillnet skippers declined.

Social Network Analysis structured questionnaire

We surveyed with a fixed choice survey design, where respondents were asked to consider up to ten individuals with whom they exchange useful information about fishing and whom they considered valuable to their fishing success (see full questionnaire below). The decision to limit the number of skippers each respondent could specify was made for practical survey purposes as the network we surveyed was relatively large. The fixed-choice survey design also had the secondary benefit to help respondents understand what is required of them during the survey, as a free-choice survey design can result in subjective interpretations of the desired links[12]. While the number of out-going links was limited to ten, there was no limit on the in-degree of links in the network (i.e., there was no limit to the number of times others could nominate a skipper), which was the main focus of our analysis.

Respondents were asked to consider people from San Jose that they share useful information about fishing with; considering those that they thought may influence their fishing success. Respondents were reminded that the shared information and names will remain anonymous and will not be revealed. We highlighted that the information provided will help us understand how information that relates to fishing flows between fishers. Prior to the fixed response, respondents were asked to consider relationships that they have had with other vessel owners, captains, owner/captains (owners who also captain their vessel), other fishery leaders, fishery management officials, members of the scientific or not-for-profit community, boat launching / landing support, fish transport associations, fish sellers/market operators, their family and friends, and any other people they have fished with, or shared information with about fishing over the last 5 years.

We classified two broad categories about which we expect gillnet skippers to exchange fishing related information. These include 1) the process of fishing, and 2) the business and governance of fishing. We then disaggregated these two broad categories into nine fine-scale information-sharing types that relate to fishing, including i) turtle bycatch, ii) gillnet type and maintenance, iii) weather conditions, iv) fish location and catch sites, v) fishing activity (how many people are fishing, who is fishing, who caught what), vi) vessel technology and maintenance, vii) fishing regulations (laws and rules), viii) fishing finances (market prices, loans, fines, penalties), and ix) crew management. Fishing-related information categories were randomized before interviewing each respondent using a random number generator

Assessing cross-network correlations

The basic properties of each information-sharing network, and the nomination structure in general, will have a larger deterministic influence on the cross-network correlations. For instance, considering a network of 'any nomination in any information-sharing network', we would expect each network to hold a correlation equal to that of the number of nominations in each network (Supplementary Fig. 7). Similarly, networks with similar numbers of nominations are more likely to be more correlated with one another than those with very different numbers of nominations. Simply carrying out edge-permutations, even conservative ones controlling for the number of nominations, or degree distributions, for example, would, by definition, randomize the underlying dyadic structure (who can nominate who) and thus means all observed cross-network correlations would differ largely from expected under this null model just due to this alone. To infer the extent to which networks are more, or less, similar than expected under the general dyadic social structure, we carried out a cross-network null model: For each dyadic nomination across any of the networks, we randomized the networks that these nominations were made within. For instance, when individual X nominated individual Y for information sharing within three different networks, we allowed these three nominations to be reassigned to any of the networks, but all three still in the direction of individual X nominating individual Y within these networks. In this way, the overall dyadic nomination structure was maintained, but the networks within which these dyadic nominations took place within were randomized. Using this method (termed 'cross-network null model 1' – Main text Figure 1c), 1000 permuted networks were generated, and the distribution of the expected cross-network correlations was recalculated using this.

As an even more conservative version of a cross-network null model, we created a new version of these permutations and controlled for the number of nominations that took place overall within each network. For instance, when individual X nominated individual Y for information sharing within three different information-sharing networks, these three nominations were reassigned amongst the networks in a way that was equal to the number of nominations in each network. For example, if network A had twice as many nominations in total as network B, reassigning a nomination between individual X and individual Y would be twice as likely to be reassigned within the network A than the network B. This permutation was done by merely swapping individual network nominations between dyadic nomination pairs. This permutation is similar to a group-by-individual permutation[13] but where the rows of the matrix were set as the individual-to-individual dyadic nominations, and the columns were set as each of the information-sharing networks. Using this permutation procedure (termed cross-network null model 2 – Main text Figure 1d), we generated 1000 permuted networks (with 100 swaps between each network and a burn-in of 2000 swaps; Supplementary Fig. 8) and then calculated the distribution of the expected cross-network correlations under this null expectation.

Supplementary Results

Network summary statistics

While the current study's focus is not on the broader network of non-skipper outgoing links, our analysis showed the number of information-sharing links remained consistent between the respondent-to-respondent network and the broader network that includes non-skipper nominees. Our analysis showed that across nine different information-sharing networks evaluated, turtle bycatch remained the least discussed type of fishing information in the wider network (in 64.2% of possible nominations). Information about the weather and fishing activity were discussed the most (with 95.7% and 95% of possible links, respectively). Turtle bycatch and fishing regulations were the only two information-sharing networks that had a relative increase (both by 3%) in the amount they were discussed in the wider network, compared to the respondent-to-respondent network that contained only skippers (Supplementary Table 1b).

Structural differences between information-sharing networks

Degree assortativity

Our analysis of network degree assortativity (presented in the main text and akin to degree homophily) found that networks of sea turtle bycatch information sharing nominations show no significant assortativity in comparison to both the edge permutation null models (Main text Figure 2c). Individual gillnet skippers had a propensity to be disproportionately connected to other gillnet skippers who had nominated a similar number of people as they had (out-degree assortativity). Although none of the information-sharing networks were significantly different from the edge null models in their out-degree assortativity, the sharing of information regarding sea turtle bycatch was the only network that was slightly lower than expected, whilst all other networks were higher than expected (Supplementary Fig. 2 and Supplementary Table 2). The lack of significant differences here is probably due to the relatively low variance in out-going links in comparison to in-going links (i.e., due to the questionnaire set-up the number of nominations an individual could make was limited – see Main text, Methods), and is most likely driven by a carry-over of the strong patterns evident in the in-going nomination assortativity.

Our analysis shows that the lack of degree assortativity in the turtle bycatch context is most likely a result of more complex dyadic-level behavior patterns driving each individual's attitudes and behaviors. This is because the degree assortativity statistic itself is the level of like-to-like connectivity given the total number of links. The edge permutations (edge null model 2) also (a) directly control for the number of out-going and in-going links in each information-sharing network (Main text Figure 2d), and (b) still find that degree assortativity is not significantly different in the sea turtle network, but significantly differently in the other fishing-related information-sharing networks. These comparisons are over and above that which would be expected from the differences in the number of links, or even the degree distributions, specific to each network assessed.

Individual Centrality

As we aimed to examine the use of social network analysis for conservation-relevant systems, we did not want to use simple node-level metrics that can be inferred without building social networks (e.g., using 'degree' is simply equivalent to counting the number of nominations an individual receives and requires no knowledge of the network structure).

When considering the variance in betweenness (as an alternative measure of centrality; Supplementary Fig. 3), or the mean eccentricity of each network's nodes (rather than the variance; Supplementary Fig. 4), we found that the observed statistics from all networks (including sea turtle bycatch) were lower (and mostly strongly significantly lower) than the statistics generated from edge null model 1. This is most likely due to the random reassignment of in-going links in this permutation causing (i) the assignment of in-going links to nodes which are originally disconnected in this context and thus increasing the mean and (ii) the randomization of the in-going degree distribution increasing the betweenness variance.

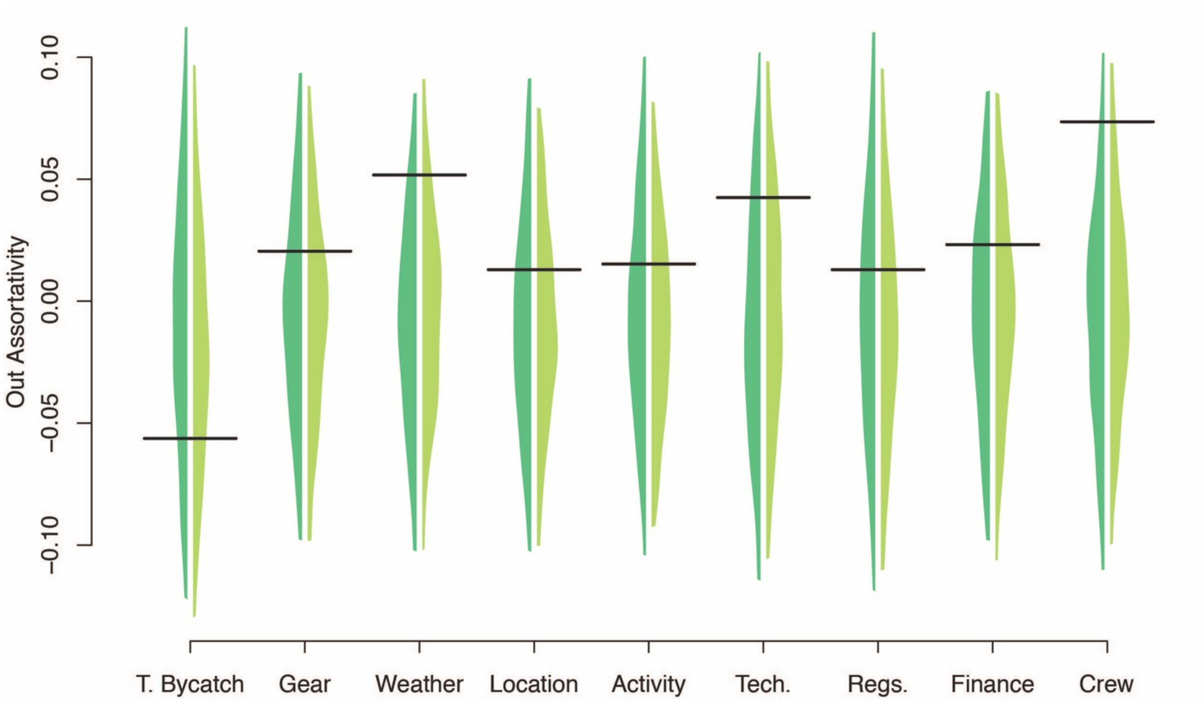
Seven of the nine information-sharing networks fell within the expected range of both the edge model permutations for node eccentricity (how far an actor is from the furthest other), with bycatch and fishing activity the only exceptions. We found that the observed variance in node eccentricity (Supplementary Fig. 5) was lower than expected for information sharing regarding sea turtle bycatch, in comparison to the null distributions (generated from the context permutations), which had higher than expected observed variance in node eccentricity. The opposite was true for fishing activity. The observed mean node eccentricity (Supplementary Fig. 6) followed a similar pattern to the variance in node eccentricity, with information sharing regarding sea turtle bycatch being the only network that was lower than expected in comparison to the null distributions. Mean node eccentricity for information sharing regarding fishing activity illustrated the greatest contrast to the sea turtle bycatch network with higher than expected observed statistics. This supplementary analysis demonstrates that the sea turtle bycatch information-sharing network holds some structural dissimilarities in mean node eccentricity, not only when being compared to the edge null models (Main Text Figure 3), but also given the underlying social structure of who is connected to who within the network.

Cross-network correlations of dyadic links

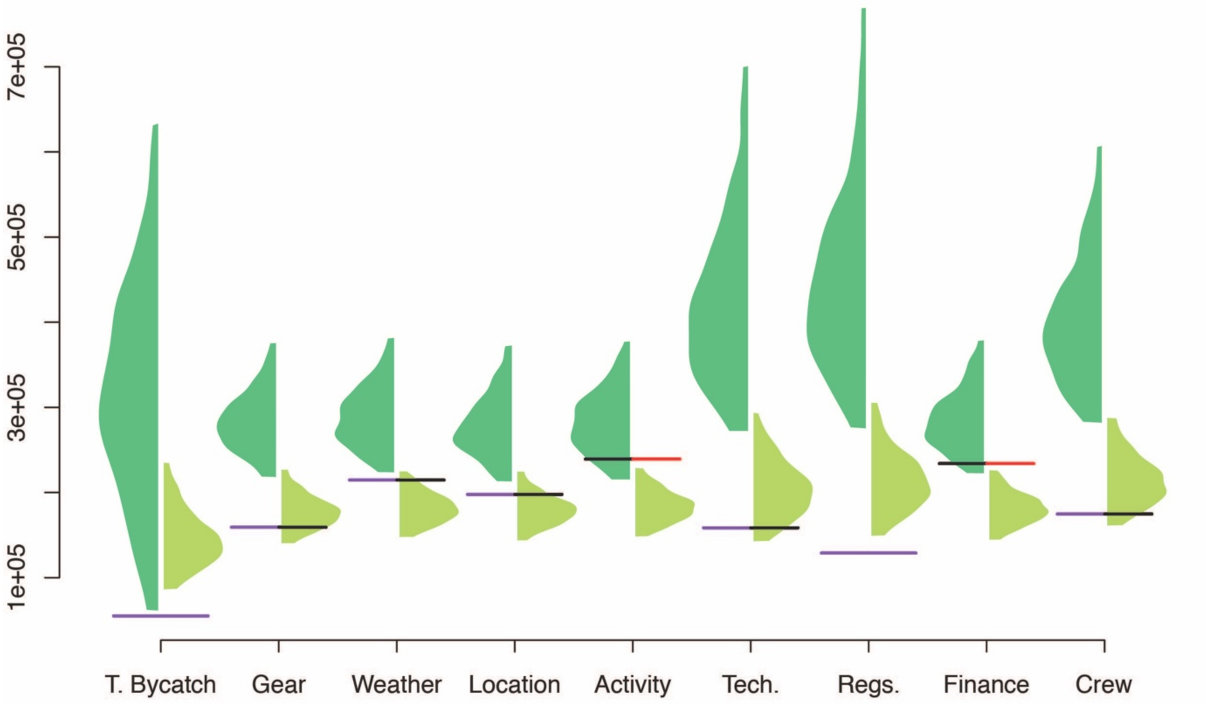
Along with focussing on the ability of each fishing-related information-sharing network to predict to sea turtle bycatch information-sharing links, we also considered the correlation between all networks and how these differed from the correlations expected under the cross-network permutation null models (Supplementary Fig. 9). We found that the dyadic directed links within the 'technology' information-sharing network was more correlated with all the other networks than expected under the general social structure of the network. This suggests that the technology information-sharing network was particularly predictive of fishing activity in general.

As expected, when comparing the correlations to those generated from edge-permutations (rather than cross-network permutations), the observed statistics were vastly different even though these permutations were controlling for the number of nominations, degree distributions etc. due to randomizing the underlying dyadic social structure (in terms of who can nominate who) (Supplementary Fig. 10).

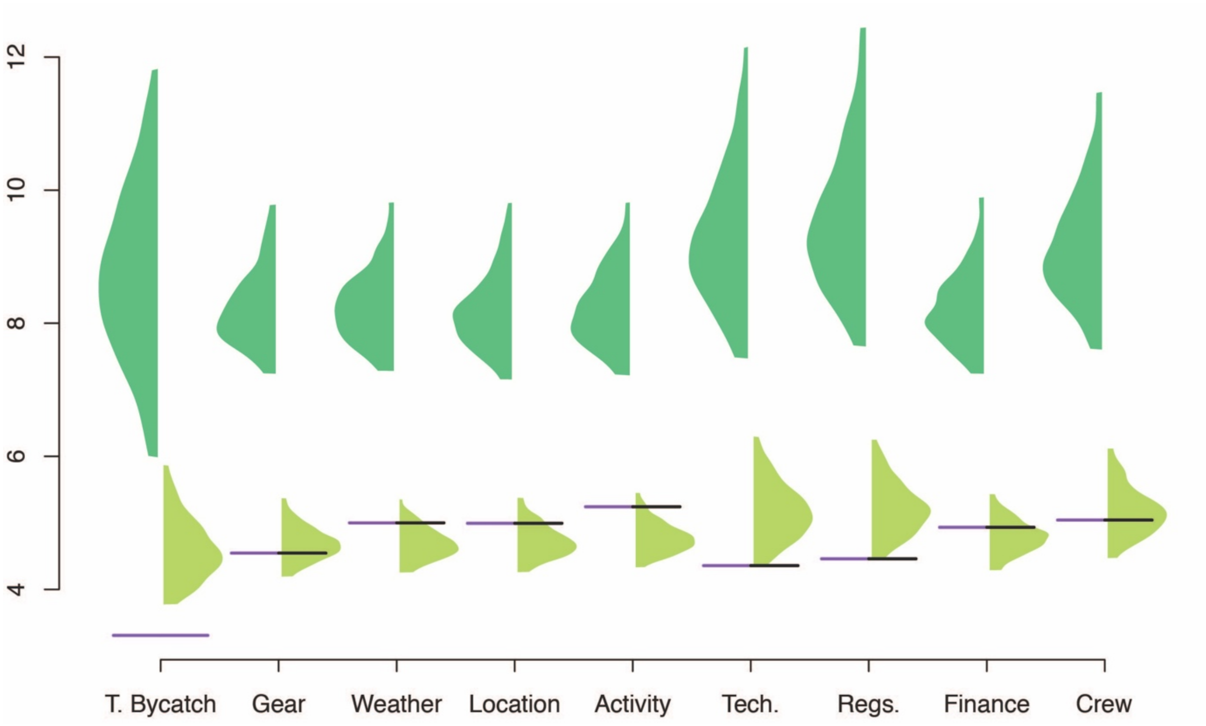
Supplementary Figure 1. Illustrative network of the structure of information sharing across fishing-related information-sharing networks. The nodes show each of the skippers and the adjoining lines show which dyads shared information in at least one network, and nominations within the focal network (as indicated by heading) is highlighted as a directed red arrow here (arrow points to the one that was nominated). Node size and shading shows the number of nominations each individual received for the focal network (largest and most red = most nominations, small and grey = no nominations). Layout was set as a spring layout of edges within each focal network (to minimize overlap).



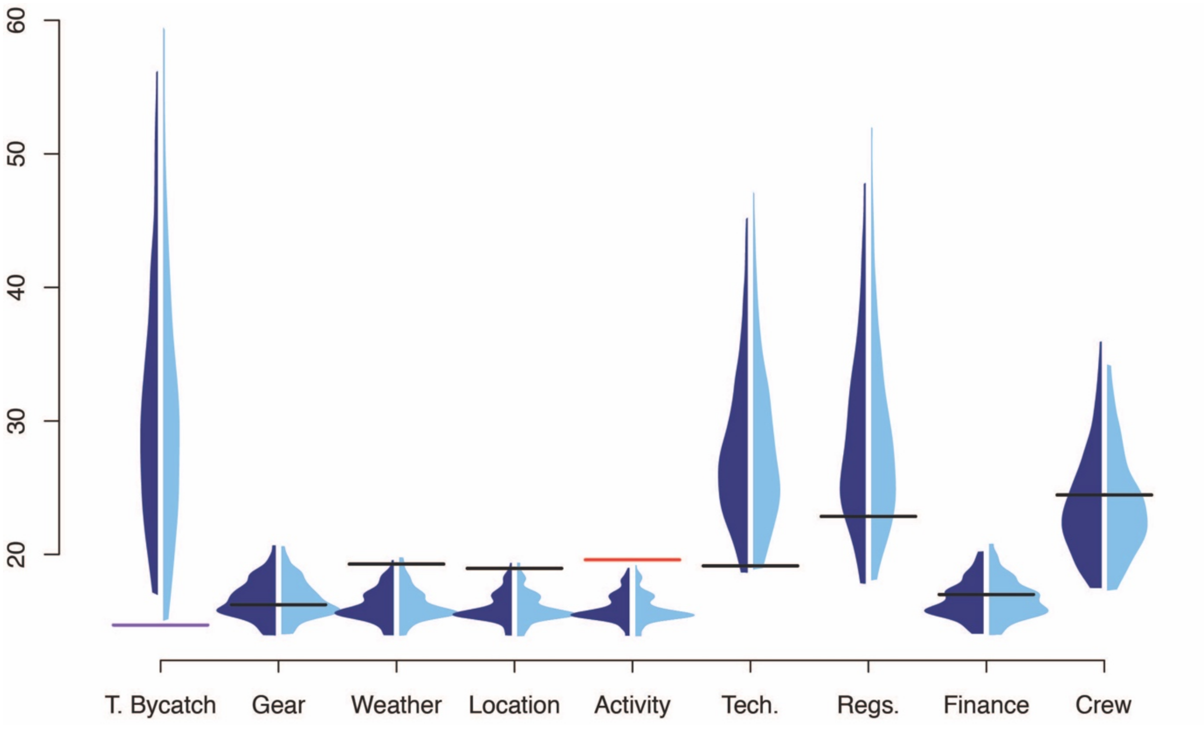
Supplementary Figure 2. The observed assortativity coefficient for outgoing links in comparison to the null distributions for the different information-sharing networks. Horizontal lines show the observed values from the actual networks (red = observed values are above the permutations, black = observed values are within the range of the permutations, purple = observed values are below the permutations). Polygon distributions show those generated by permutations (dark green = outgoing edge permutation that maintains the no. of nominations each individual makes, light green = edge swap that maintains the no. of nominations each individual makes and also the number of times each individual was nominated). Outgoing links also show the same pattern seen in figure 1 (i.e., the turtle bycatch network is the only information network measured which is not positively homophilous) but with no significant difference. For details on fishing-related information-sharing networks refer to Table 1 in the main text.



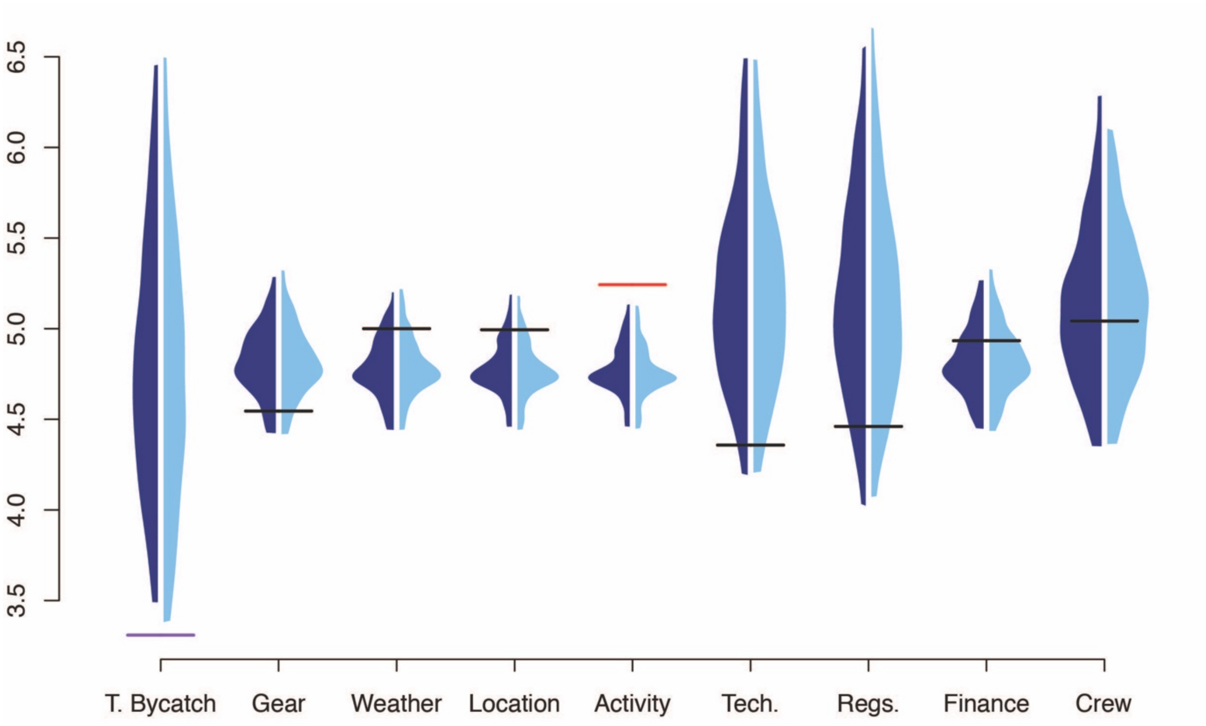
Supplementary Figure 3. The observed variance in node betweenness in comparison to the null distributions for the different information-sharing networks. Horizontal lines show the observed values from the actual networks (red = observed values are above the permutations, black = observed values are within the range of the permutations, purple = observed values are below the permutations). Polygon distributions show those generated by permutations (dark green = outgoing edge permutation that maintains the no. of nominations each individual makes, light green = edge swap that maintains the no. of nominations each individual makes and also the number of times each individual was nominated). Here a similar pattern to the degree assortativity (homophily) coefficient is also seen. For details on fishing-related information-sharing networks refer to Table 1 in the main text.



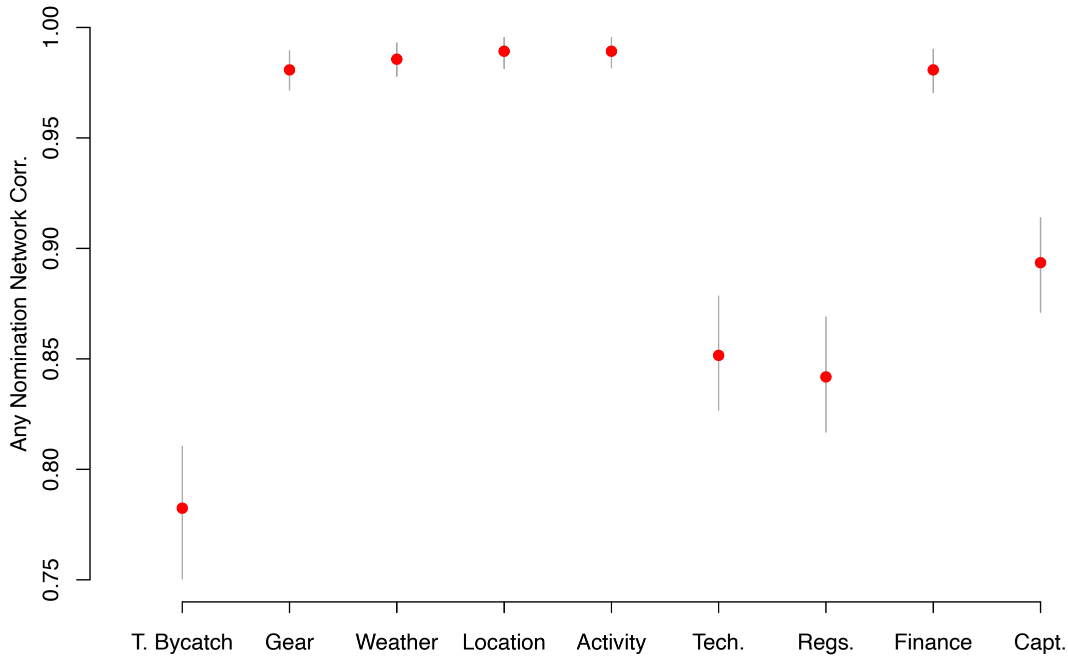
Supplementary Figure 4. The observed mean node eccentricity in comparison to the null distributions for the different information-sharing networks. Horizontal lines show the observed values from the actual networks (red = observed values are above the permutations, black = observed values are within the range of the permutations, purple = observed values are below the permutations). Polygon distributions show those generated by permutations (dark green = outgoing edge permutation that maintains the no. of nominations each individual makes, light green = edge swap that maintains the no. of nominations each individual makes and also the number of times each individual was nominated). Here a similar pattern to the degree assortativity (homophily) coefficient is also seen. For details on fishing-related information-sharing networks refer to Table 1 in the main text.



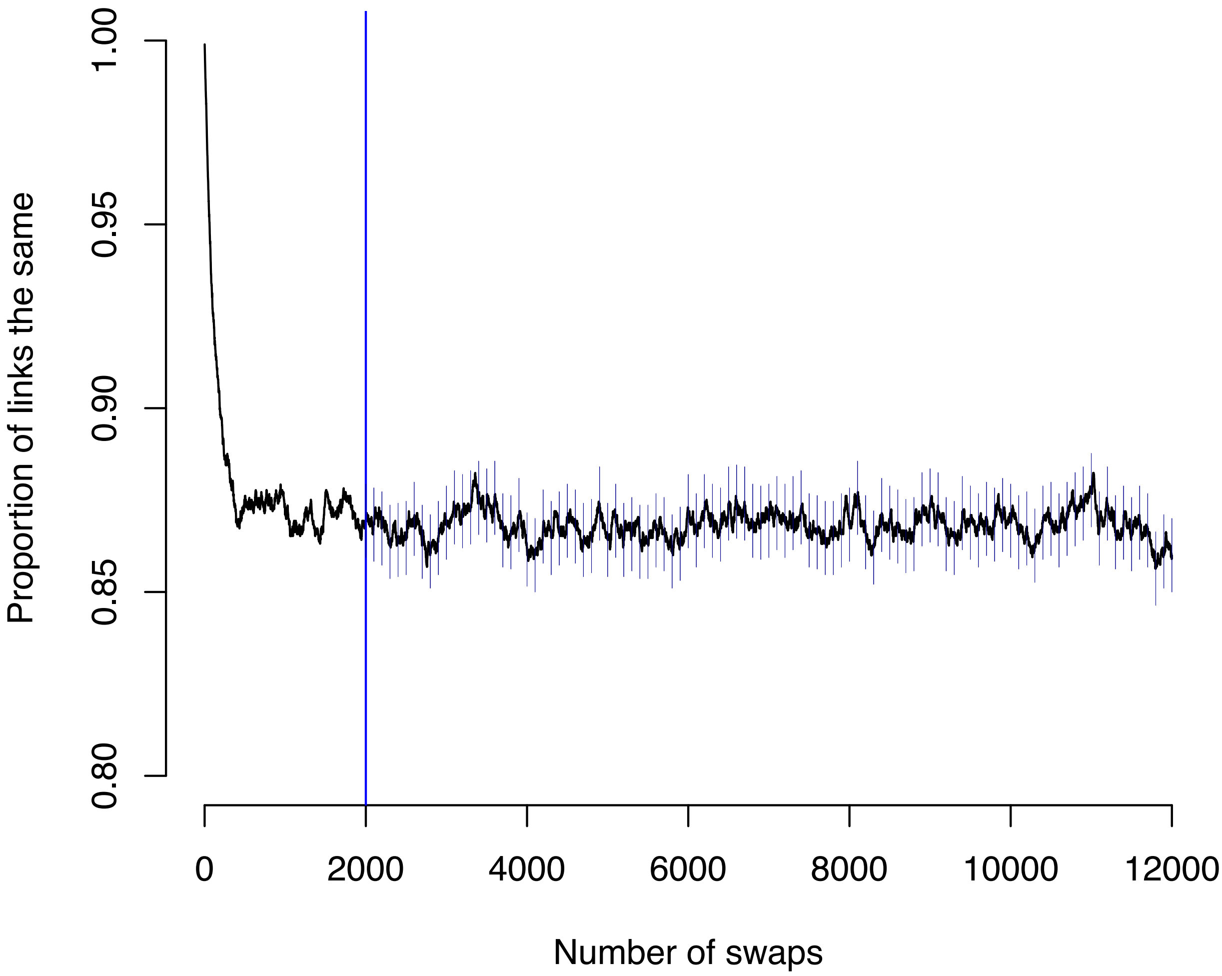
Supplementary Figure 5. The observed variance in node eccentricity in comparison to the null distributions (generated from the cross-network permutations) for the different information-sharing networks. Horizontal lines show the observed values from the actual networks (red = observed values are above the permutations, black = observed values are within the range of the permutations, purple = observed values are below the permutations). Polygon distributions show those generated by permutations (dark blue = cross-network swap that maintains the no. of nominations each individual makes and also the number of times each individual was nominated, but swaps the network these were made within whilst maintain the number of times each network was nominated as overall, light blue = conservative cross-network swap that is the same as dark blue, but also maintains the number of networks each dyad nominated each other for – but changes those networks (same as a gbi permutation but on the dyad-by-network edges). For details on fishing-related information-sharing networks refer to Table 1 in the main text.



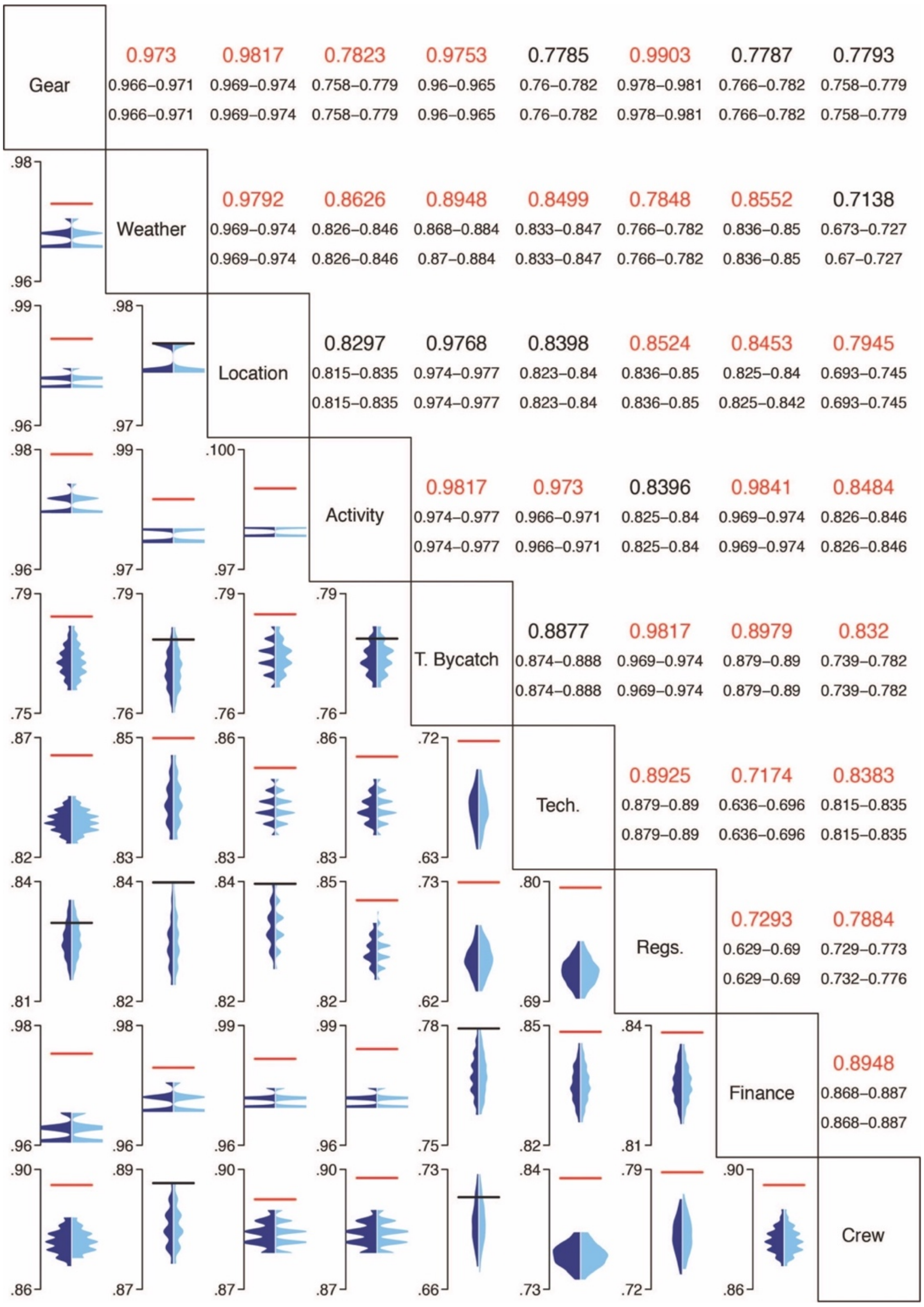
Supplementary Figure 6. The observed mean node eccentricity in comparison to the null distributions (generated from the cross-network permutations) for the different information-sharing networks. Horizontal lines show the observed values from the actual networks (red = observed values are above the permutations, black = observed values are within the range of the permutations, purple = observed values are below the permutations). Polygon distributions show those generated by permutations (dark blue = cross-network swap that maintains the no. of nominations each individual makes and also the number of times each individual was nominated, but swaps the network these were made within whilst maintain the number of times each network was nominated as overall, light blue = conservative cross-network swap that is the same as dark blue, but also maintains the number of networks each dyad nominated each other for – but changes those networks (same as a gbi permutation but on the dyad-by-context edges). For details on fishing-related information-sharing networks refer to Table 1 in the main text.



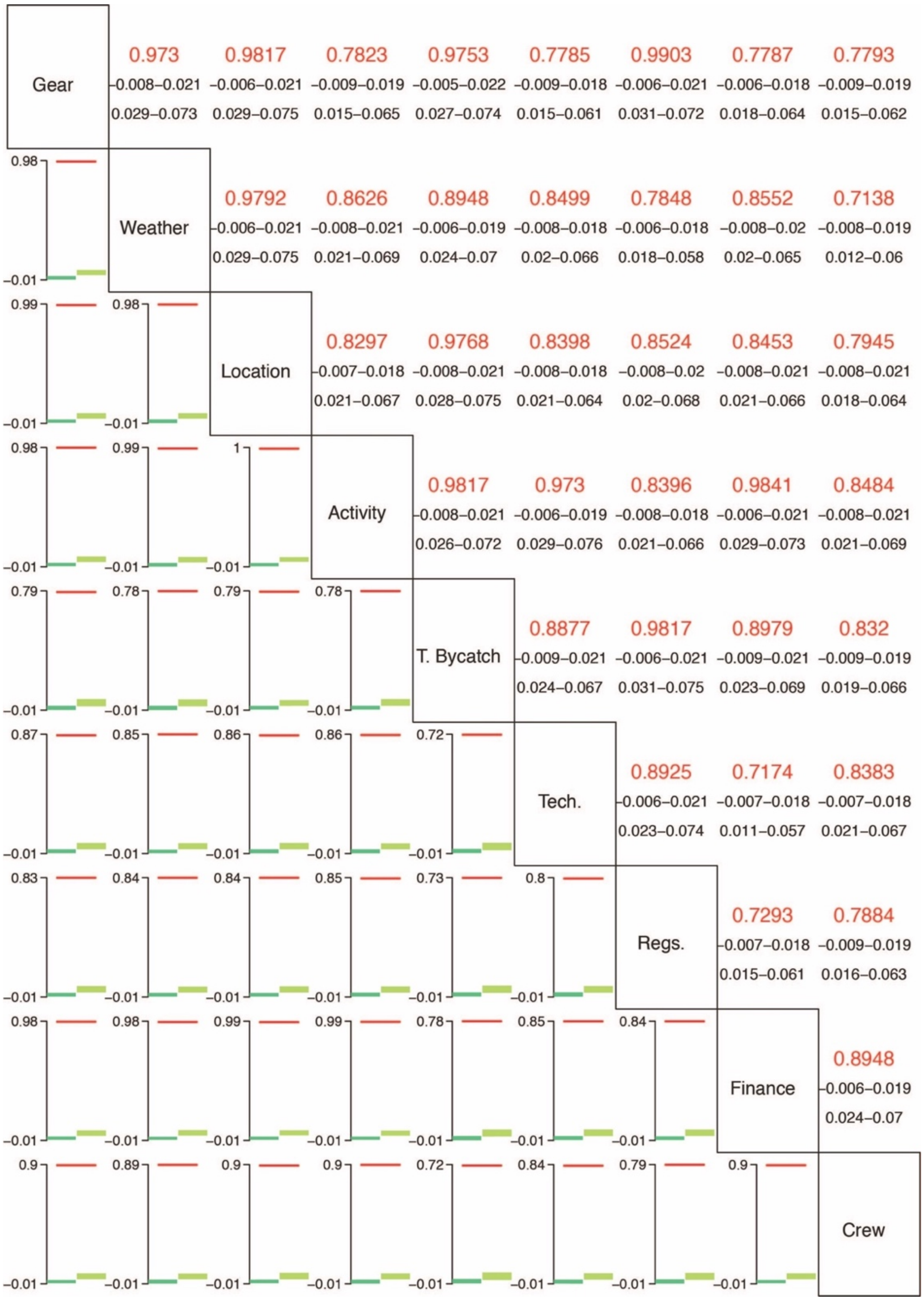
Supplementary Figure 7. Network differences to the 'any' nomination network. Differences seen between different networks in how predictive/correlated they are to the 'any' nomination network (lines show bootstrap). For details on information-sharing networks see main text Methods – Experimental Design –Table 1.



Supplementary Figure 8. Output for evaluation of cross-network null model 2. This permutation procedure required sequential swaps of the networks in which nominations occurred between dyads (see Supplementary methods - Assessing cross-network correlations) to generate the null networks. The y-axis illustrates the number of nominations between individual-to-individual dyads that are in the same network as those in the observed data, and the x-axis shows the number of swaps that took place during the permutation procedure. The long vertical blue line indicates the burn-in period for the randomization swaps (2000 swaps before a null network was stored) and the short vertical blue lines show the points at which the following 999 null networks were stored (i.e., every 100 swaps).



Supplementary Figure 9. Observed correlation (and the correlation expected from the cross-network permutations) between all of the information-sharing networks. Horizontal lines show the observed values from the actual networks (red = observed values are above the permutations, black = observed values are within the range of the permutations, purple = observed values are below the permutations). Polygon distributions show those generated by permutations (dark blue = cross-network swap that maintains the no. of nominations each individual makes and also the number of times each individual was nominated, but swaps the network these were made within whilst maintain the number of times each network was nominated as overall, light blue = conservative cross-network swap that is the same as dark blue, but also maintains the number of networks each dyad nominated each other for – but changes those networks (same as a gbi permutation but on the dyad-by-network edges). For details on information-sharing networks refer to Table 1 in the main text.



Supplementary Figure 10. Observed correlation (and the correlation expected from the edge permutations) between all of the information-sharing networks. Horizontal lines show the observed values from the actual networks (red = observed values are above the permutations, black = observed values are within the range of the permutations, purple = observed values are below the permutations). Polygon distributions show those generated by permutations (dark green = outgoing edge permutation that maintains the no. of nominations each individual makes, light green = edge swap that maintains the no. of nominations each individual makes and also the number of times each individual was nominated). For details on information-sharing networks refer to Table 1 in the main text.

Supplementary Table 1. Respondent-to-respondent network summary statistics. Respondents nominated up to 10 individuals that included other skippers in their community but also non-skipper community members that might be deemed valuable to their fishing success. This study only analysed respondent-to-respondent data but the full network links (i.e., skipper to any relation links) across information-sharing networks are included in table section B.

(A) Respondent-to-respondent network data

	Number
Total no. of ties within all networks	3720
Total no. of ties of one or more networks	427
Total no. of eligible respondents for survey	168
Total no. of respondents surveyed	165
Levels of information-sharing networks	9
Mean number of networks nominated per nominee	7.7
Mean incoming ties of one or more network per respondent	3.7
Mean outgoing ties of one or more network per respondent	2.8
Range of networks nominated per nominee	1 to 9
Range of outgoing ties of one or more network	1 to 8
Range of incoming ties of one or more network	1 to 15

(B) Ties across networks

	Resp-resp	Full network
All	427	1102
Fish location & catch sites	418	1033
Fishing activity	418	1047
Weather conditions	415	1055
Gear type	411	1029
Fishing finances	411	1020
Captain hiring crew and managing them	342	868
Vessel technology & maintenance	311	807
Fishery regulations	304	822
Sea turtle bycatch	263	708

Supplementary Table 2. Measures of network structure with statistics describing in-assortment (in assort) and variance eccentricity (var eccent). Table includes the observed statistic and the statistic from the permutations as the mean, sd, 95% range from 2.5% (lq) to 97.5% (uq), and the p value (when compared to the observed stat).

stat	network	obs1	mean.sd.1	lq.uq.1	p1	mean.sd.2	lq.uq.2	p2
in assort	T.bycatch	0.0377	-0.0049 (0.0593)	-0.1228 to 0.1047	0.512	-0.0107 (0.0593)	-0.1316 to 0.1041	0.39
in assort	Gear	0.105	-0.0034 (0.0481)	-0.0921 to 0.0963	0.034	0.0052 (0.0486)	-0.088 to 0.1028	0.04
in assort	Weather	0.0932	-0.0089 (0.0494)	-0.1113 to 0.0882	0.044	0.0032 (0.0485)	-0.0859 to 0.0983	0.068
in assort	Location	0.1069	-0.005 (0.0471)	-0.095 to 0.0858	0.016	0.0057 (0.0467)	-0.0813 to 0.096	0.022
in assort	Activity	0.1038	-0.0048 (0.0452)	-0.0944 to 0.0822	0.022	0.004 (0.047)	-0.0885 to 0.1024	0.042
in assort	Tech	0.1143	-0.0091 (0.0547)	-0.1108 to 0.1041	0.032	0.0087 (0.0565)	-0.0982 to 0.1189	0.064
in assort	Regs	0.1246	-0.0051 (0.0566)	-0.113 to 0.1077	0.02	0.0038 (0.0507)	-0.0953 to 0.1038	0.026
in assort	Finance	0.1002	-0.0056 (0.0481)	-0.0995 to 0.0915	0.036	0.0049 (0.0473)	-0.0882 to 0.0976	0.048
in assort	Crew	0.1891	-0.0084 (0.0528)	-0.109 to 0.0956	0	0.0198 (0.0525)	-0.0821 to 0.1247	0
var eccent	T.bycatch	14.71	41 (13.5)	22.41 to 73.73	0.006	22.66 (5.335)	15.58 to 36.53	0.02
var eccent	Gear	16.24	8.819 (2.326)	5.209 to 14.11	0.016	12.84 (1.592)	10.67 to 16.65	0.066
var eccent	Weather	19.28	8.717 (2.206)	5.101 to 13.63	0.004	12.76 (1.563)	10.77 to 16.56	0.012
var eccent	Location	18.96	8.366 (2.17)	4.778 to 13.41	0.002	12.39 (1.397)	10.45 to 15.72	0.008
var eccent	Activity	19.6	8.595 (2.251)	5.068 to 13.99	0.004	12.48 (1.362)	10.52 to 15.63	0.002
var eccent	Tech	19.15	27.14 (7.831)	16.93 to 46.5	0.202	20.19 (3.709)	14.95 to 29.94	0.894
var eccent	Regs	22.85	30.48 (9.694)	18.21 to 57.39	0.392	19.87 (3.483)	15.04 to 28.13	0.342
var eccent	Finance	17	8.884 (2.249)	5.369 to 14.09	0.014	12.74 (1.405)	10.65 to 16.2	0.03
var eccent	Crew	24.46	19.43 (5.77)	11.87 to 34.63	0.264	16.87 (2.629)	13.3 to 23.2	0.022

Supplementary Table 3. Measures of network structure with statistics describing assortativity coefficient for outgoing links (out assort), mean node eccentricity (mean eccent) and variance in node betweenness (var between). Table includes the observed statistic and the statistic from the permutations as the mean, sd, 95% range from 2.5% (lq) to 97.5% (uq), and the p value (when compared to the observed stat).

stat	network	obs1	mean.sd.1	lq.uq.1	p1	mean.sd.2	lq.uq.2	p2
out assort	turtle	-0.0563	-0.008 (0.0614)	-0.1223 to 0.1124	0.424	-0.0208 (0.0576)	-0.1297 to 0.0968	0.534
out assort	gear	0.0205	-0.004 (0.049)	-0.0981 to 0.0937	0.584	-0.0055 (0.0471)	-0.0983 to 0.0882	0.544
out assort	weather	0.0517	-0.0078 (0.0475)	-0.1025 to 0.0854	0.212	-0.0044 (0.0471)	-0.1021 to 0.0911	0.226
out assort	loc	0.0129	-0.0078 (0.05)	-0.1028 to 0.0914	0.65	-0.0091 (0.0465)	-0.1004 to 0.0794	0.626
out assort	activ	0.0152	-0.0039 (0.0506)	-0.1043 to 0.1003	0.662	-0.0082 (0.046)	-0.0926 to 0.0818	0.628
out assort	tech	0.0425	-0.0095 (0.055)	-0.1145 to 0.1023	0.36	-0.004 (0.0523)	-0.1058 to 0.0985	0.384
out assort	regs	0.0129	-0.0049 (0.0592)	-0.119 to 0.1104	0.766	-0.01 (0.0533)	-0.1103 to 0.0955	0.648
out assort	financ	0.0232	-0.0053 (0.0481)	-0.0982 to 0.0863	0.58	-0.0044 (0.0479)	-0.1062 to 0.0856	0.544
out assort	capt	0.0735	-0.0057 (0.0529)	-0.1101 to 0.1018	0.13	-0.0025 (0.0493)	-0.0998 to 0.0976	0.136
mean eccent	turtle	3.309	8.754 (1.498)	5.988 to 11.82	0	4.63 (0.5432)	3.776 to 5.867	0
mean eccent	gear	4.546	8.259 (0.6509)	7.242 to 9.782	0	4.701 (0.2994)	4.194 to 5.37	0.612
mean eccent	weather	5	8.28 (0.6363)	7.285 to 9.813	0	4.708 (0.2935)	4.254 to 5.352	0.26
mean eccent	loc	4.994	8.216 (0.674)	7.157 to 9.808	0	4.735 (0.2826)	4.261 to 5.376	0.336
mean eccent	activ	5.242	8.266 (0.6777)	7.218 to 9.813	0	4.792 (0.2752)	4.333 to 5.449	0.13
mean eccent	tech	4.358	9.346 (1.164)	7.472 to 12.15	0	5.188 (0.4979)	4.357 to 6.297	0.052
mean eccent	regs	4.461	9.576 (1.21)	7.652 to 12.44	0	5.233 (0.4729)	4.46 to 6.249	0.056
mean eccent	financ	4.933	8.259 (0.6506)	7.242 to 9.891	0	4.809 (0.2827)	4.291 to 5.431	0.572
mean eccent	capt	5.042	9.198 (0.9606)	7.606 to 11.47	0	5.18 (0.4175)	4.473 to 6.116	0.79
var between	turtle	55170	321700 (147600)	61560 to 633200	0.042	147500 (38430)	86450 to 234900	0
var between	gear	159300	285100 (39540)	218300 to 375500	0	178100 (21950)	140500 to 226800	0.376
var between	weather	214700	290400 (40420)	223900 to 381500	0.016	182700 (20020)	147900 to 224800	0.136
var between	loc	197800	280400 (42240)	213200 to 372600	0.01	180200 (19870)	143900 to 224500	0.344
var between	activ	239300	284800 (42540)	215400 to 377400	0.264	184700 (20600)	148500 to 228600	0.02
var between	tech	158600	428400 (108200)	272400 to 700500	0	206500 (40180)	143000 to 293500	0.18
var between	regs	129000	454000 (125800)	275500 to 768900	0	214900 (38420)	149300 to 305400	0.004
var between	financ	234000	286700 (40670)	222700 to 378600	0.136	182200 (20930)	144800 to 226000	0.034
var between	capt	174800	405800 (84840)	282100 to 606900	0	215600 (32690)	161400 to 287600	0.176

Supplementary Table 4. Measures of cross-network comparisons with statistics describing variance in node eccentricity (var eccent) and mean node eccentricity (mean eccent). Table includes the observed statistic and the statistic from the permutations as the mean, sd, 95% range from 2.5% (lq) to 97.5% (uq), and the p value (when compared to the observed stat).

stat	network	obs1	mean.sd.1	lq.uq.1	p1	mean.sd.2	lq.uq.2	p2
var eccent	turtle	14.71	31.63 (10.14)	16.98 to 56.19	0.02	30.91 (10.73)	15.05 to 59.44	0.038
var eccent	gear	16.24	16.74 (1.665)	13.95 to 20.67	0.874	16.72 (1.661)	14.04 to 20.62	0.926
var eccent	weather	19.28	16.26 (1.372)	13.96 to 19.57	0.058	16.33 (1.449)	13.94 to 19.76	0.088
var eccent	loc	18.96	16.13 (1.282)	13.94 to 19.36	0.06	16.09 (1.308)	13.89 to 19.38	0.074
var eccent	activ	19.6	16.07 (1.207)	13.92 to 18.98	0.034	15.98 (1.247)	13.9 to 19.2	0.042
var eccent	tech	19.15	28.23 (6.785)	18.65 to 45.21	0.07	28.42 (7.11)	18.88 to 47.12	0.068
var eccent	regs	22.85	29.16 (7.625)	17.81 to 47.81	0.338	29.18 (8.034)	18.08 to 51.99	0.382
var eccent	financ	17	16.66 (1.606)	14.07 to 20.22	0.75	16.76 (1.651)	13.98 to 20.8	0.8
var eccent	capt	24.46	24.1 (4.986)	17.49 to 35.94	0.774	24.17 (4.963)	17.3 to 34.21	0.786
mean eccent	turtle	3.309	4.831 (0.7783)	3.491 to 6.455	0.022	4.771 (0.824)	3.381 to 6.498	0.04
mean eccent	gear	4.546	4.824 (0.2212)	4.424 to 5.285	0.216	4.824 (0.221)	4.418 to 5.321	0.182
mean eccent	weather	5	4.786 (0.1861)	4.442 to 5.2	0.238	4.796 (0.1884)	4.442 to 5.218	0.262
mean eccent	loc	4.994	4.786 (0.1698)	4.46 to 5.188	0.202	4.779 (0.177)	4.442 to 5.182	0.208
mean eccent	activ	5.242	4.776 (0.1616)	4.46 to 5.134	0.03	4.765 (0.1657)	4.448 to 5.127	0.03
mean eccent	tech	4.358	5.207 (0.5926)	4.194 to 6.492	0.102	5.208 (0.5861)	4.206 to 6.485	0.102
mean eccent	regs	4.461	5.194 (0.6411)	4.024 to 6.558	0.212	5.184 (0.6511)	4.073 to 6.661	0.228
mean eccent	financ	4.933	4.817 (0.2121)	4.448 to 5.267	0.522	4.831 (0.216)	4.436 to 5.328	0.548
mean eccent	capt	5.042	5.152 (0.4853)	4.351 to 6.285	0.904	5.159 (0.4691)	4.364 to 6.103	0.852

Social network analysis questionnaire (English)

Individual socio-demographic information

First, I'm going to ask you a few questions about yourself. Note that your individual responses to this survey will remain confidential and we will only use the data collected in aggregate form.

Survey ID
Da

Full name ______________________ **Nickname** ______________________

Gender ❍ Male ❍ Female

Fisher / decision maker status: ❍Skipper ❍Vessel owner ❍Skipper AND Owner

Plate number ______________________ **Name of boat** ______________________

Q1) What is your age? _________________

Q2) Do you live in San José. Y________ yrs., N, where do you live? _______________region / city

Q3) If < 5 years, where did you live before and why did you move here? ________________________

Q4) What generation of gillnet fisherman in San Jose are you? ________________

For boat owners that are not skippers:

Q5) Were you formally a gillnet captain**?**

- ❍ No
- ❍ Yes (please specify when you stopped fishing) ______________________

Q6) Which best describes your situation:

- ❍ My family fish with my boat as we divide the profits evenly. Or some other percentage______
- ❍ I hire my boat to non-family members and receive a percentage of the catch profit: ________

For skippers and skippers AND boat owners

Q7) How many years have you been fishing? ____

Q8) Do you launch or land at any other ports?

- ❍ No

❍ Yes (please specify) ______________________

Q9) During which months did you not fish last year? _______________________________________

Q10) What is the principal net that you use? Trammel, Lineal, Other: ____________________

❍ Surface / driftnet
❍ Mid-water net
❍ Bottom net
❍ Other net type (please specify) ____________________

Q11) Do you ever switch net types from your main net type?

❍ No
❍ Yes (please explain to what, and under what circumstances) _________________________

____

Q12) What are you three main target species?

1. _________________________________

2. _________________________________

3. _________________________________

For everyone:

Q13) Which of the following best describes you?

❍ President of a gremio / social group (which) ____________________

❍ Board member of a gremio / social group (which) ____________________

❍ Member of gremio / social group (which) ____________________

❍ I'm not a member of any gremio / social group (Individual owner operator)

Q14) What is your highest level of education?

❍ No formal education

❍ Primary school, please specify if completed _________________

❍ Secondary school, please specify if completed _________________

❍ Trade or technical certificate / fishing course, please specify if completed _______________

❍ University degree, please specify if completed _________________

[Personal income]

Q15) Is fishing your primary occupation/source of income?

❍ Yes

❍ No (please specify what is) ____

Q16) How much do you spend on fishing trips per month (on average)? Summer_____ Winter_____

Q17) How many days a month (in average) do you spend on fishing trip? Summer____ Winter____

Q18) What is your take-home monthly income (in soles) after all expenses in:

Summer: Max: __________ Winter: Max: ____________

Average: __________ Average: ____________

Min: __________ Min: _____________

[Household income]

Q19) Which of the following household descriptions best fits you?

❍ Couple with children – with some children still living at home
❍ Couple with children – with all children having left home
❍ Couple without children
❍ Single with children
❍ Single without children

Q20) Are you the main wage earner in your household?

❍ No
❍ Yes

Q21) How many people are currently living in your household? ______________________________

Q22) Of these, how many are fishermen? ______________________________

Q23) Are there any other wage earners in your household that are not fishermen?

❍ No
❍ Yes (what jobs do they do?) ____

Q24) What percentage of your household income (including all wage earners) comes from fishing?

❍ 0-20% ❍ 21-40% ❍ 41-60% ❍ 61-80% ❍ 81-100% ❍All ❍Don't know / rather not say

---

Section B: Social Network Analysis structured questionnaire

We need you to think about the people from San Jose that you share useful information about fisheries with; consider those you think may influence your fishing success. Remember that the shared information and names will remain anonymous and will not be revealed. This will help us understand how the information flows between fishermen.

Please consider relationships that you have had with other vessel owners, captains, owner/captains (owners who also captain their vessel), other fishery leaders, fishery management officials, members of the scientific or NGO community, boat launching / landing support, fish transport associations, fish sellers/market operators, your family and friends, and any other people you have fished with, or shared information with about fishing over the last 5 years.

Q25) Please identify up to 10 individuals (providing first and last names, and known nicknames) that you *exchange useful information* with about fishing that you consider *valuable to your fishing success*.

Full name		Nickname	Rel	Crew	Meet	tMeet	Often	Topic of conversation									Value
								I	II	III	IV	V	VI	VII	VIII	IX	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Rel = Relation: A) Professional acquaintance, B) Friend, C) Family
Crew = Crew member: Y / N
Meet = How did you meet: A) family member, B) through a friend, C) through fishing, D) from a family member, E) Other: ________________
tMeet = How long have you known this person: A) <1 yr, B) 1-5 yrs, C) >5 yrs
Often = How often do you share useful information about aspects of fishing with this person? A) 1-3 times/yrs, B) 1-3 times/month, C) 1-3 times/week or more
I: Gear type (i.e. Changes, technology, maintenance)
II: Weather conditions
III: Fish location / catch sites
IV: Fishing activity (How many people fishing, who is fishing, who caught what, etc.)
V: Turtle bycatch
VI: Vessel technology / maintenance
VII: Fishery regulations (laws, rules)
VIII: Fishing finances (market prices, loans, fines, penalties)
IX: Hiring new crew / captain
Value: In general, how valuable do you feel the information that you exchange with this individual is to your fishing success? A) Very valuable, B) somewhat valuable, C) a little valuable
To finish up with the network analysis, I have four more questions on bycatch and new gear uptake

Q26) Which of the people you've identified is the most influential to you when you are considering making changes to your fishing gear?

____

Q27) Which of the people you've identified is the most influential to you in (potentially) deciding about changing the way you fish (e.g. changing your behaviour such as shorter soak time)?

____

Q28) What do you think about taking on new technologies to reduce bycatch of turtles and dolphins? (-1 Negative, 0 Neutral, +1 Positive)

____

Q29) Are you aware of the work that the NGO ProDelphinus is undertaking with a few fishermen here in San Jose to help reduce the number of turtles and dolphins that are captured in nets? Do you know about the technologies that they are using?

____

Q30) Do you think the Orca underwater acoustic alarm used to deter dolphins attract sea lions to your nets?

- ❍ No
- ❍ Yes
- ❍ I don't know

Q31) Do you think lights on your nets to deter turtles attract sea lions to your nets?

- ❍ No
- ❍ Yes
- ❍ I don't know

If you have any comments on this survey or about information sharing between fishermen within the San José community, please tell us or write them below.

Thank you very much for your time and help in this survey

Social network analysis questionnaire (Spanish)

Información socio-demográfica individual

Primero, voy a preguntarte acerca de ti. Ten en cuenta que las respuestas individuales en esta encuesta se mantendrán confidenciales y solo usaremos la información de forma agregada.

ID de la encuesta	**Fecha**

Nombre completo	**Apodo**

Género ❍ Masculino ❍ Femenino

Estado en toma de decisiones: ❍Patrón ❍Dueño de embarcación ❍Ambos

Número de matrícula	**Nombre de la embarcación**

Q1) ¿Cuál es tu edad?______________________

Q2) ¿Vives aquí? Y _________ yrs, N____________________ región / ciudad

Q3) Si < 5 años, ¿dónde vivías antes y por qué te mudaste aquí? ____________________________

Q4) ¿Qué generación de pescador de redes de enmalle de San José eres tú? __________________

Para dueños de embarcaciones que no son PATRONES.

Q5) **¿**Fuiste alguna vez formalmente un patrón**?**

- ❍ No
- ❍ Si (¿hace cuantos años dejaste de pescar?) ______________________

Q6) ¿Cuál describe mejor tu situación?:

- ❍ Mi familia pesca con mi bote, dividimos las ganancias igual. Otro porcentaje? ____________
- ❍ Rento mi bote a un ajeno y recibo un porcentaje de la ganancia, cuanto? ________________

Solo para PATRONES y PATRONES que son ARMADORES

Q7) ¿Cuántos años llevas pescando? __________________________

Q8) ¿Embarcas o desembarcas de otros puertos?

- ❍ No

- Sí (por favor especifica) ______________________

Q9) ¿En que meses descansaste el año pasado? ____

Q10) ¿Cuál es el tipo principal de red de enmalle que usas? Trasmallo, Lineal Otro:_______________

- Red de superficie / red de deriva
- Red de mediagua
- Red de fondo
- Otro tipo de red (por favor especifica) _____________________

Q11) ¿Cambias tu tipo de red principal por otros?

- No
- Sí (por favor especifica a qué, y debido a qué) ___________________________

____

Q12) ¿Cuáles son tus 3 objetivos principales de pesca? 1. ___________________________________

2. ___________________________________

3. ___________________________________

Para todos

Q13) ¿Cuál de los siguientes te describe mejor?

- Presidente de un gremio / grupo social (cuál) ____

- Miembro de consejo de gremio / grupo social (cuál) ___________________________________

- Miembro de gremio / grupo social (cuál)____

- No soy agremiado / no pertenezco a grupos sociales (Dueño operador individual)

Q14) ¿Cuál es tu nivel educativo?

- Sin educación formal

- Primaria (por favor especificar si completó)___________________

- Secundaria (por favor especificar si completó)___________________

- Técnico / capacitado en pesca (por favor especificar si completó)___________________

- Universitario (por favor especificar si completó)___________________

[Ingresos personales]

Q15) ¿Es la pesca tu principal ocupación / fuente de ingresos?

- Sí

- ❍ No (por favor especifica cuál es) ____________

Q16) Cuánto es el gasto promedio mensual en viajes en: Verano_________, Invierno____________

Q17) Cuántos días (promedio) te embarcas al mes en: Verano_________, Invierno____________ .

Q18) ¿Cuál es el ingreso mensual promedio (después de costos) que obtienes en:

Verano:	Bueno: __________	Invierno:	Bueno: ____________
	Medio: __________		Medio: ____________
	Bajo: ___________		Bajo: ______________

[Ingresos familiares]

Q19) ¿Cuál de las siguientes descripciones familiares se aplica a ti?

- ❍ Pareja con hijos – con algunos de los hijos viviendo en el hogar
- ❍ Pareja con hijos – con todos los hijos fuera del hogar
- ❍ Pareja sin hijos
- ❍ Soltero sin hijos
- ❍ Soltero con hijos

Q20) ¿Eres el sustento económico principal de tu hogar?

- ❍ No
- ❍ Sí

Q21) ¿Cuántas personas viven actualmente en tu hogar?___________________________________

Q22) De ellos, ¿cuántos son pescadores? _________________________________

Q23) ¿Existen otros proveedores de sustento económico en tu hogar que no sean pescadores?

- ❍ No
- ❍ Sí (¿qué trabajos realizan?) ____

Q24) ¿Qué porcentaje del ingreso de tu hogar (incluyendo a todos los que proven) proviene de la pesca?

❍ 0-20% ❍ 21-40% ❍ 41-60% ❍ 61-80% ❍ 81-100% ❍Todos ❍ No se / Preferiria no decirlo

Sección B: Cuestionario estructurado de Análisis de Red Social

Piensa con quienes intercambias INFORMACION UTIL de pesca en San Jose y que sientes que PODRIA INFLUENCIAR en que te vaya bien en la pesca. Los nombres y la informacion que des se mantendran en anonimato y no sera revelada. Esto servira para saber como fluye la informacion entre pescadores.

Recuerda a: otros dueños de embarcaciones, capitanes, otros líderes pesqueros, oficiales de manejo pesquero, científicos o ONGs, embarcadores/ayudantes de embarque y desembarque, asociaciones de chalaneros, vendedores de pescado/operadores de mercado, tu familia y amigos, y todas las otras personas con las que hayas pescado o compartido información de pesca en los últimos 5 años.

<u>Q25</u>) Social Network Analysis questionnaire (Spanish). Por favor identifica hasta 10 individuos (nombres y apellidos, no solo apodos) con los que *intercambias información útil* acerca de la pesca que consideres *valioso para tu éxito pesquero*.

Nombre completo		Apodo	Rel	Crew	Meet	tMeet	Often	Tema de conversaciòn									Valor
								I	II	III	IV	V	VI	VII	VIII	IX	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Rel = Relacion: A) Profesional conocido, B) Amigo, C) Familiar
Crew = Colega-tripulante, Y / N
Meet = Como lo conociste: A) familiar, B) por un amigo, C) a traves de la pesca, D) por un familiar, E) OTRO:___________________________
tMeet = Cuanto tiempo lo conoces: A) <1 año, B) 1-5 años, C) >5 años
Often = Que tan seguido comparten info: A) 1-3 veces/año, B) 1-3 veces/mes, C) 1-3 veces/semana o más
I: tipo de arte (i.e. cambios, tecnologia, mantenimiento)
II: condiciones climaticas
III: ubicacion de los peces y sitios de captura
IV: actividad pesquera (cuanto, quienes estan pescando, que estan pescando, quien cogio que, etc.)
V: Captura incidental de tortuga
VI: tecnologia y mantenimiento de la nave
VII: regulaciones pesqueras (leyes, reglas)
VIII: finanza pesquera (precios del Mercado, prestamos, multas, penalidades)
IX: Contratacion de tripulantes o capitan
Value: Que tan valiosa es la informacion que intercambias: A) muy valiosa, B) algo valiosa, C) un poco valiosa
Solo para terminar el análisis de red social, tengo cuatro preguntas más acerca de pesca incidental y aceptación de nuevos artes de pesca.

Q26) ¿Cuál de las personas que has identificado es la más influyente para ti cuando se trata de hacer cambios en los artes de pesca?

Q27) ¿Cuál de las personas que has identificado es la más influyente para ti en (potencialmente) decidir cambiar la forma en la que pescas (e.g. cambiar el momento y duracion que pones la red)?

Q28) ¿Qué opinas de adoptar nuevas tecnologias para reducir la captura incidental de tortugas y delfines? (-1 , 0 , +1)

Q29) ¿Estás al tanto del trabajo que la ONG ProDelphinus viene llevando a cabo con un pequeño grupo de pescadores aquí en San José para ayudar a reducir el número de tortugas y delfines que son capturados en las redes? Conoces las tecnologias que usan?

Si tienes comentarios acerca de esta encuesta por favor dinos o escríbelos en el cuadro.

Muchas gracias por tu tiempo y colaboración con esta encuesta

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