Spatial Patterns of Fishing Effort from VMS and Implications for Fishing Mortality, 2017-2019

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Introduction

The spatial pattern of fishing effort has important implications for the magnitude of fishing mortality on a population. Fish are not distributed uniformly over space and not surprisingly, neither is fishing effort. The overlap of fishing effort and fish distribution creates a mosaic of fishing mortality over time and space. If populations and fishing fleets were totally random in their distributions, one could simply assume that catch is the product of fishing effort and fish abundance. This assumption becomes less tenable as the size of the spatial unit increases because habitat becomes more heterogeneous. Moreover, the fishing fleets' ability to find and exploit concentrations of fish also increase. These principles have been known since the earliest days of stock assessment theory (Beverton and Holt 1957, Paloheimo and Dickie, 1964) but the technology to acquire data at sufficient temporal and spatial resolution has developed only recently.

Most stock assessment models are not spatially distributed and operate at an annual time step. The fishing mortality estimates derived from these models represents the combined effects of spatial and temporal differences in effort and abundance. In most instances these approaches have been sufficient to develop a reasonable basis for management of fish stocks.

Spatial concentration of fishing effort on population abundance is common for sessile species such as scallops, especially in areas of high recruitment. Temporal concentration of effort can occur on species that have predictable seasonal, ontogenetic or diel migration patterns. For Illex squid the assessment problem becomes more significant because the population is open to migration and the dynamics of the total population are at best, poorly understood. So the following questions arise. Can these known variations in abundance and effort be ignored in modeling the population? Can we draw any inferences about fishing mortality from the known patterns of fishing effort? The purpose of this paper is to make a few small steps towards a broader understanding of current patterns of fishing effort on fishing mortality and to identify potential areas of research.

Data and Methods

The VMS data for this working paper were kindly provided by Lisa Hendrickson and Alicia Miller of the Northeast Fisheries Science Center, National Marine Fisheries Service. VMS data from 2017 to 2019 for May through October were filtered for putative towing speeds of 2.6 to 3.3 knots. Each VMS ping represents an interval censored observation since speed is derived from the distance between successive pings divided by the time between pings (one hour). Hence the average speed at a ping can reflect a mixture of steaming at higher speeds and actual towing, as well as processing time at lower speeds. (See Palmer and Wigley 20xx for more details).

Locations were binned into 3 minute squares of latitude and longitude. As distance between longitude degrees varies as a function of latitude, it was assumed the average fishing latitude was

39 degrees. At this latitude the average 3 minute square is cos(39°) x 3 minutes longitude x 3 minutes latitude ~6.99 nm^2. This approximation is used for all computations of swept area.

Lisa Hendrickson also provided estimates of average net width for each permit using records from the Fisheries Observer database. By linking these data to permit number and vessel speed for each ping it was possible to compute nominal estimates of swept area per ping (i.e., hour fished). The total area swept in any cell and time interval was computed as the sum of the vessel-specific swept area estimates.

Vessel permits without information on net width were assigned the average width for the measured set of permits. No vessel names were included in the database.

No spatially explicit methods were applied to the data. Instead I focused on the marginal distribution of fishing effort based on frequency of fishing in each cell. These distributions characterize a concentration profile (see Orensanz et al. 1998). The Gini index can also be applied to obtain a scalar measure of concentration.

Results

Table 1 illustrates that total swept area more than doubled between 2017 and 2019, with a concomitant increase in the total number of cells fished. Thus the fishing effort took place over an increasingly broad range of cells between 2017 and 2019 (i.e., 160 cells (1,118 nm2) to 283 cells (1,978 nm2)) .

Table 1. Summary of overall patterns of fishing effort based on VMS analyses.

	2017	***2018***	***2019***	***Total***
Total Area Swept (nm^2)	402.2	545.4	940.6	1888.2
Number cells	160	265	283	392
Total Area of cells with fishing activity (nm^2)	1118.4	1852.35	1978.17	2740.08
Ave Area Swept (nm^2)/cell	0.360	0.294	0.475	

A total of 392 cells were contacted over the 3-year period but only 118 cells had fishing activity in all three years (Figure 1). The total area swept over the 3-year period was 1,888.2 nm^2. These total swept area in these 118 cells was 1,749 nm^2 or 93% of the total fishing effort. Over the entire period the fishing effort was sufficient to sweep each of these cells 2.12 times

The Venn diagram of overlap of fishing activity suggests that number of cells that were fished only in a single year increased from 25 in 2017 to 93 in 2019. This suggests that fishing activity of the fleet was more dispersed during 2019. The Gini index (Figure 2) for the overall average distribution for all 392 cells is 0.822. Individual years, which have fewer cells per year (Table 1) have slightly higher Gini index values: 2017= 0.887, 2018= 0.850, 2019=0.836.

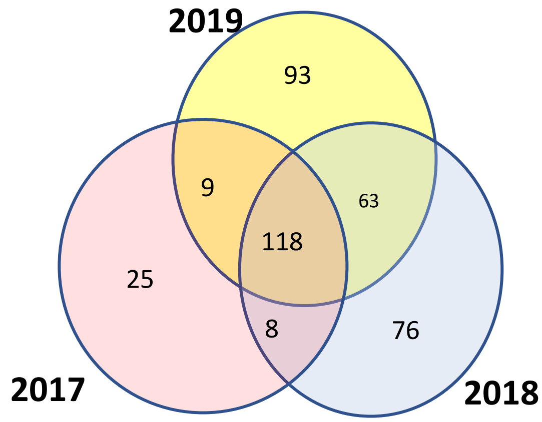

Figure 1. Venn diagram of overlap of 3 minute sqr fishing cells derived from VMS. Values are numbers of cells fished in each intersection. A total of 392 distinct cells were fished during this period. Each cell is 6.99 nm^2.

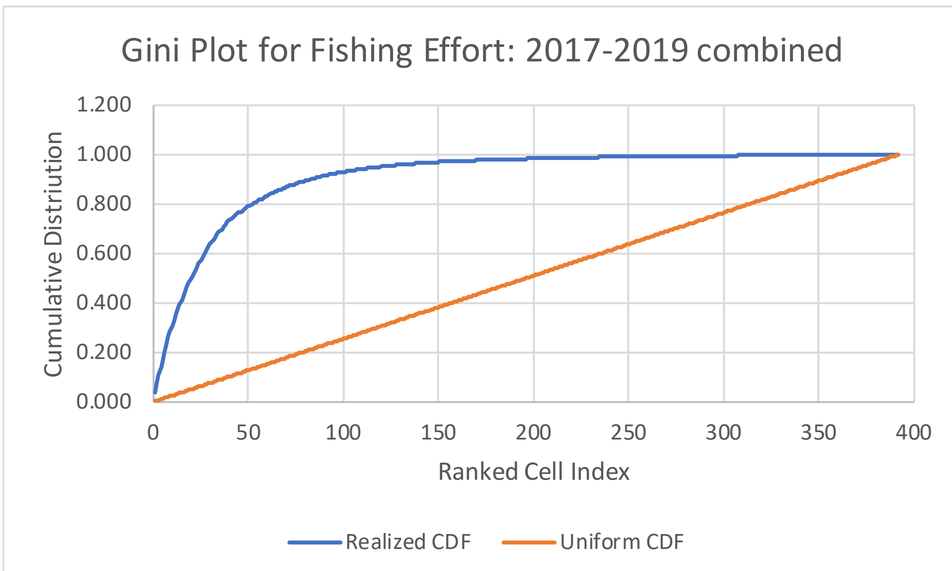

Figure 2. Gini plot of VMS fishing effort for 2017 to 2019 combined. X-axis is index of cells in which fishing occurred, sorted from highest to lowest frequency. Y-axis is cumulative distribution function for observed and hypothetical uniform distribution.

Most of the cells had two or more permits fishing in them over the 3-year period (Table 2). Twenty five cells had 10 or more permits fishing in the area. It would appear that the prime fishing locations are well known within the fleet.

The ratio of average total swept area to cell size for the top 50 cells is depicted in Figure 3. This can be called the “concentration profile” of the fishery as it depicts the spatial intensity of fishing.

Table 2. Overlap of fishing effort and total swept area, 2017-2019.

# cells	# permits observed fishing in cell	Total Number of Pings	Total Area Swept (nm^2)
163	1	310	28.11
66	2	399	43.36
26	3	214	22.42
16	4	239	24.09
14	5	348	38.65
16	6	544	56.87
10	7	322	32.61
13	8	792	74.55
14	9	1683	134.14
8	10	1381	153.21
8	11	1882	210.16
4	12	648	77.97
9	13	1427	165.58
7	14	2789	342.21
2	15	334	32.41
5	16	1266	93.94
3	17	815	66.18
1	18	289	20.01
3	19	1718	124.66
3	20	1487	106.53
1	21	469	40.51

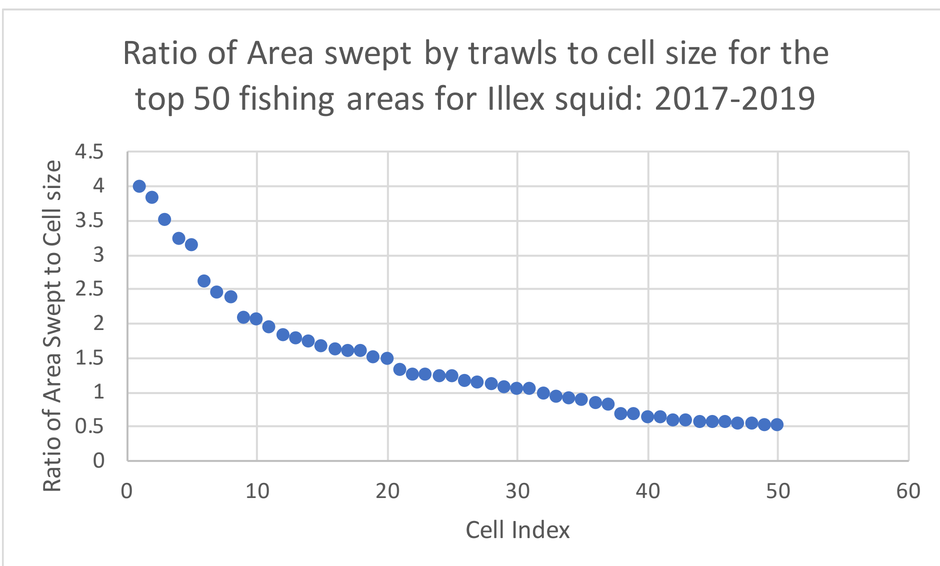

Figure 3. Concentration profile: ratio of total area swept to cell size for the top 50 fishing areas for Illex squid, 2017-2019.

Implications of Concentration Profiles for Fishing Mortality

The intense concentration of fishing effort in a relatively small number of cells obviously provides some insights into potential effects on overall fishing mortality. More importantly, it also provides insights into movement of squid from adjacent cells and underlying economics of fishing.

To begin, consider a population in a 3 minute square of size **A** (6.99 nm^2) that does not mix with adjacent 3 minute squares and is uniformly mixed within that square. Assuming that a trawl tow of size **a** is 100% efficient (i.e.,**q**=1.0) in capturing everything in its path, then each tow would represent a proportional reduction in the remaining population. The fraction **f** of a cell's population removed can be defined by the efficiency **q** times the ratio of the tow area **a** to the total cell area **A** is defined as

$$f = q\frac{a}{A} \qquad (1)$$

By definition the fraction of the population remaining after one tow is **1-f** = **(1-q a/A)**

Applying the removal process recursively, the fraction remaining after n tows is

$$(1-f)^n = \left(1-\frac{q\,a}{A}\right)^n \qquad (2)$$

As the fraction q a/A becomes small, the above equation can be expressed using instantaneous rates so that the fraction of the population remaining after n tows is

$$\left(1-\frac{q\,a}{A}\right)^n = e^{\left(-\frac{q\,a\,n}{A}\right)} \qquad (3)$$

Note that the product **a** x **n** is simply the total swept area (**TS**) if all of the tows are of equal size **a**. Building on this concept, then the total swept area after **n** tows of varying size $\mathbf{a_i}$ is

$$TS = \sum_{i=1}^{n} a_i \qquad (4)$$

Note that this generalization allows us to examine the fraction of the population remaining after it has been exploited **n** times by a gear with efficiency **q** and a swept area per tow of $\mathbf{a_i}$.

$$e^{\left(-\frac{q\,TS}{A}\right)} \qquad (5)$$

Thus the fraction of the population remaining after an area swept of **TS** or a ratio of **TS/A** times is given by Eq. 5. In the most heavily fished cells, the implied reductions in abundance are equivalent to the implied reductions in catch per unit effort. The "implied" depletion, given the VMS data is depicted in Figure 4.

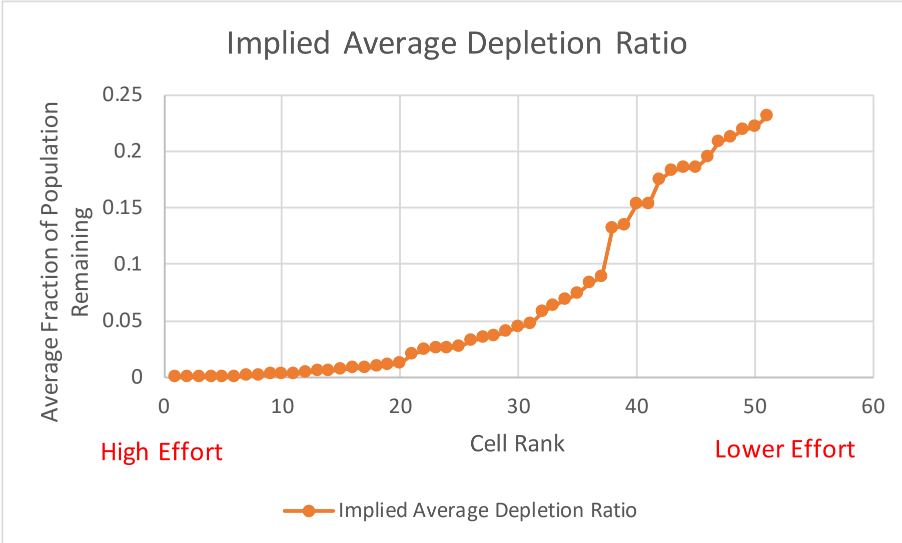

Figure 4. Implied depletion of population based on the ratio of average total area swept by trawls for the 50 most heavily fished cells. A gear efficiency of 100% is assumed for this plot.

For the top 50 cells where fishing activity occurred, the average fraction of the initial population remaining is predicted to be 0.064. In other words, this predicts a decline of ~94% between the beginning and end of the season. These depletion ratios would occur ONLY if the population was static and did not depend on a flux of squid from other areas. Although a firm criterion for continuation of fishing activity during a season is not possible to estimate, one might safely assume that depletions of more than 90% do not occur during the course of the season. Clearly an individual vessel would move to another cell well before this type of reduction occurred.

The fact that the fleet persisted in these areas to allow annual coverage rates of about 4X implies that the population in a given area is supplemented by a continuous influx of squid from other areas. Hence the areas where fishing is highly concentrated must also be "gates" or likely areas where squid are passing through from other areas, presumably offshore.

These deductions suggest the need for additional information for proper interpretation. The following questions are proposed as a starting point for discussion:

1. What level of reduction in CPUE is likely to induce movement to a new fishing area? 20% , 30%, etc? Is there a "move along" threshold?
2. Do areas that are heavily fished need a "rest" before squid from other areas can replenish? If so, how long?
3. Are there oceanographic conditions in these areas that focus fishing activity for much of the fleet?

These concepts are explored in the following section.

Virtual Area Fished.

Let γ represent the ratio of CPUE that induces a movement of a vessel into a new area. Conceptually, this might be related to an economic incentive related to the profitability and an assumed profitability of the next tow. Conversations with fishermen suggested that this may not be a hard and fast rule since many different factors can affect the decision to move to another fishing area. Let $CPUE_o$ represent the initial CPUE and $CPUE_t$ represent the CPUE after time t has elapsed. The ratio of $CPUE_t/CPUE_o=\gamma$ such that a new area is fished when the ratio falls below γ. For economy this ratio can be called a "move along" criterion.

Using the swept area notation from Eq. 5 the CPUE ratio can be written as

$$\gamma = \frac{CPUE_t}{CPUE_o} = e^{\left(-q\frac{TS}{A}\right)} \quad (6)$$

Where q is the gear efficiency, TS is the total area swept in time step **t** and **A** is the area of the cell. Equation 1 can be rearranged to solve for A such that

$$A_V = \frac{-q\ TS}{\ln(\gamma)} \quad (7)$$

If we assume that abundance in a cell is replenished by transfer of squid from adjacent areas, then the estimate of **A** can be called a virtual **A** or **A**v which implies the total area of all cells that would be impacted by a total swept area TS by a gear with efficiency **q** and a "move along" criterion of **γ**. As the acceptable ratio of CPUE decline becomes smaller, the virtual area the population that replenishes the cell fished becomes smaller.

Consider a few examples. Suppose that the estimated total swept area for a cell is 3 times the total area of the cell or **TS/A**=3.0 Assuming that the gear was 50% efficient (**q**=0.5), then the predicted depletion ratio from Eq. 5 is exp(-0.5 *3) = 0.22. This is what would occur if the population were closed to immigration. Clearly, fishing activity would move to another area if higher yields were available elsewhere. If a vessel "moves along" when the CPUE ration drops by only 10% then **γ**=0.9 and ln(**γ**)=-0.105. By Eq. 7 the virtual area of the cell increases by a factor of 9.49 (=1/0.105). Thus a fleet that moves along when fishing declines by 10% and yet returns to fish such that it covers the entire area 3 times over the course of the season, is in fact fishing a virtual area 9.49 times greater than the size of the cell. For a three-minute square this is 66.34 nm^2. Alternatively, a fleet that moves along when the CPUE ratio is 0.5 will have a virtual fishing area that is 1/ln(0.5)=1.44 times higher than the cell size.

Actual values for gear efficiency **q** and move along thresholds **γ** are unknown, but their consequences can be evaluated for the observed fishing patterns for 2017-2019. Table 3 illustrates the effect of assumed gear efficiency and the depletion ratio threshold on estimated virtual area swept. The virtual area swept ranges from 101.9 km^2 to 45,755 km^2. Wright et al (WP#xx, Table 2) independently reported fishing areas 12,993 to 15,313 km^2 for 2017 to 2019. These estimates were derived by binning the data into 5 minute squares (roughly 19.42 nm^2 or 2.8 times larger than the 3 minute square used herein.) Wright et al.'s method provided estimates of presence/absence in a given cell rather that estimates of swept area but are useful for comparison. If the Wright et al average of 14,315 km2 is used, the feasible range of **q** and **γ** parameters range from 0.3 to 1 for **q** and 0.95 to 0.8 for **γ**.

Table 3. Virtual area swept (km2) as a function of assumed gear efficiency and threshold for decline in CPUE with a trip for movement to a new fishing area. Combined years 2017-2019.

	Effective Area	Assumed Gear Efficiency									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Depletion Ratio Threshold	0.95	4575.5	9151.1	13726.6	18302.1	22877.7	27453.2	32028.7	36604.3	41179.8	45755.3
	0.85	1444.1	2888.2	4332.3	5776.4	7220.5	8664.6	10108.7	11552.8	12996.9	14441.0
	0.75	815.8	1631.6	2447.4	3263.2	4079.1	4894.9	5710.7	6526.5	7342.3	8158.1
	0.65	544.8	1089.6	1634.4	2179.2	2724.0	3268.9	3813.7	4358.5	4903.3	5448.1
	0.55	392.6	785.1	1177.7	1570.3	1962.9	2355.4	2748.0	3140.6	3533.2	3925.7
	0.45	293.9	587.8	881.7	1175.7	1469.6	1763.5	2057.4	2351.3	2645.2	2939.2
	0.35	223.6	447.1	670.7	894.2	1117.8	1341.3	1564.9	1788.4	2012.0	2235.6
	0.25	169.3	338.6	507.9	677.2	846.5	1015.8	1185.1	1354.4	1523.7	1693.0
	0.15	123.7	247.4	371.1	494.8	618.6	742.3	866.0	989.7	1113.4	1237.1

The concept of virtual area fished can now be expanded to compute an area weighted fishing mortality rate. (Table 4). For each cell it is possible to compute the virtual area swept from Eq. 7. When the virtual area fished exceeds the actual cell size the magnitude of the fishing mortality in a given cell **i** is constrained by the defined threshold parameter **γ**. This can be expressed as

$$F_i = \min\left(-\ln(\gamma)\,, q\,TS_i/A\right) \qquad (8)$$

The area weighted average F (**F_{ave}**) over the entire set of cells fished in a given year can now be estimated as

$$F_{ave} = \frac{\sum_i^n F_i A_{Vi}}{\sum_i^n A_{Vi}} \qquad (9)$$

Estimates of average F for 2017-2019 by year are given in Appendix 1. As expected, the average F is greatest under the assumption that gear efficiency **q** is 1.0 and that the depletion ratio threshold **γ** is small. The lowest estimates of average F occur when gear efficiency is assumed to be low and the depletion ratio is large (Table 4).

Table 4. Spatially weighted F over all fishing areas as a function of gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area. 2017-2019 combined.

	Spatially weighted average F	Assumed Gear Efficiency									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Depletion Ratio Threshold	0.95	0.0436	0.0468	0.0479	0.0486	0.0491	0.0494	0.0496	0.0498	0.0500	0.0501
	0.85	0.1066	0.1280	0.1370	0.1420	0.1455	0.1477	0.1493	0.1505	0.1514	0.1522
	0.75	0.1388	0.1968	0.2198	0.2312	0.2404	0.2465	0.2511	0.2549	0.2580	0.2603
	0.65	0.1511	0.2469	0.2949	0.3211	0.3359	0.3465	0.3560	0.3637	0.3693	0.3741
	0.55	0.1511	0.2818	0.3572	0.4042	0.4339	0.4534	0.4670	0.4776	0.4878	0.4967
	0.45	0.1511	0.3024	0.4053	0.4769	0.5278	0.5607	0.5871	0.6056	0.6197	0.6310
	0.35	0.1511	0.3024	0.4442	0.5379	0.6110	0.6683	0.7094	0.7410	0.7676	0.7880
	0.25	0.1511	0.3024	0.4540	0.5911	0.6860	0.7659	0.8321	0.8868	0.9287	0.9614
	0.15	0.1511	0.3024	0.4540	0.6059	0.7531	0.8652	0.9535	1.0344	1.1036	1.1643
	0.1	0.1511	0.3024	0.4540	0.6059	0.7579	0.9063	1.0218	1.1144	1.2007	1.2765

The estimates of **F_{ave}** in the area fished are, of course, inadequate to estimate the fishing mortality on the entire stock. The magnitude of fishing mortality on the stock depends on the overlap of the area that is fished to the total habitat and the fraction of the population in the area that is fished. High fishing effort on high concentrations of the resource induce a higher total fishing mortality than if the population was uniformly distributed. It is probably safe to assume that Illex are not uniformly distributed over all areas of habitat. Otherwise fishing would not exhibit the high degree of concentration observed. One can further assume that fishing is most likely to occur in preferred habitats, or at least in areas where Illex temporarily aggregate prior to a more general movement onto the shelf. The distributional patterns of abundance that define the overall F on the population are unknown, but the available data from the VMS and the fishing vs habitat overlap estimates of Wright et al (WPxx) are sufficient to at least bound the problem. Wright et al (WP xx, Table 3) estimated that availability, defined as the proportion of habitat that overlaps spatially with fishing effort, ranges between 0.9% to 9.6% depending on year (2000-2019) and the probability threshold (40-80%) used for habitat definition.

With a little algebra, the joint effects of overlap of fishing effort with habitat and the differences in abundance in the fished and unfished areas can now be addressed. Beverton and Holt (1957, p 148-151) were perhaps the first to introduce the concept of an "effective F" for fishing over spatially distributed population.

Let **A** represent the total habitat area of Illex and $\mathbf{A_f}$ and $\mathbf{A_u}$ denote the areas were fishing does and does not occur, respectively. Thus

$$A = A_f + A_u \quad (8)$$

Further, let $\mathbf{D_f}$ and $\mathbf{D_u}$ represent the densities of Illex in the fished and unfished areas, respectively. Density can be expressed in either numbers or weight per unit area without loss of generality as long as average weights per individual are the same in each habitat area. The total population size **P** is thus defined as

$$P = A_f D_f + A_u D_u \quad (9)$$

Beverton and Holt defined effective fishing mortality as the product of the fishing mortality times catch per unit effort summed over all spatial units, divided the sum of catch per unit effort over all spatial units. This is equivalent to a biomass weighted **F**. If we let $\mathbf{F_f}$ and $\mathbf{F_u}$ represent the fishing mortality rates in the fished and unfished areas, then the effective **F**, defined as $\mathbf{F_{eff}}$ is

$$F_{eff} = \frac{F_f A_f D_f + F_u A_u D_u}{A_f D_f + A_u D_u} \quad (10)$$

Equation 10 can be simplified by letting $\mathbf{D_u = \phi\ D_f}$, $\mathbf{A_f = \theta\ A}$, $\mathbf{A_u = (1-\theta)A}$ and noting that $\mathbf{F_u}$=0 by definition. Substituting these expressions into Eq 10 gives

$$F_{eff} = \frac{F_f \theta A\ D_f + 0\ (1-\theta) A \phi D_f}{\theta A D_f + (1-\theta) A \phi D_f} \quad (11)$$

Canceling out the relevant symbols leads to

$$F_{eff} = \frac{F_f \theta}{\theta + (1-\theta)\phi} \quad (12)$$

Thus the effective **F** on the entire population $\mathbf{F_{eff}}$ is a function of the **F** in the area fished $\mathbf{F_f}$, the relative density ratio in the fished and unfished areas ϕ, and the fraction of the total habitat in the fished area θ. As a starting point one can assume that the density in the unfished habitat area is less than or equal to one and that the Wright et al range of values for θ is between (0.01 and 0.2). The upper bound of 0.2 is roughly twice that estimated by Wright et al under any scenario.

To address the potential range of effective fishing mortalities, $\mathbf{F_{eff}}$ I chose the maximum value of $\mathbf{F_f}$ from Table 4 for various combinations of assumed gear efficiency **q** and depletion ratio γ. By inspection, it is clear that $\mathbf{F_{eff}}$ reaches its maximum value when θ =1(i.e. all of the habitat is fished) or when ϕ = 0 (i.e., no Illex are in the unfished area). Under either of these conditions, the effective F over the whole area is equal to the fishing mortality in the area where fishing occurs. For all other combinations of ϕ **(0,1)** and θ **(0,1)** the effective F will be less than the F in the fishing area because some fish are protected from fishing. Over the assumed range of parameter values, the maximum F in the area fished (=1.28 from Table 4) is reduced to a maximum value of 0.912 in Table 5. Based on these calculations and examination of the results for 2017 to 2019 individually, Appendix 1, it appears unlikely that the overall F on the population exceeds 1.2 in any of the recent 3 years.

Table 5. Estimated fishing mortality on the entire population within the US resource area. Estimates based on the highest spatially weighted F in Table 4 = 1.2765.

		Ratio of Density in Unfished Area to Density in Fished Area (phi)									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95
Ratio of Area Fished to Total Habitat (theta)	0.01	0.117	0.061	0.042	0.031	0.025	0.021	0.018	0.016	0.014	0.013
	0.03	0.302	0.171	0.119	0.092	0.074	0.063	0.054	0.048	0.042	0.040
	0.05	0.440	0.266	0.191	0.148	0.122	0.103	0.089	0.079	0.071	0.067
	0.07	0.548	0.349	0.256	0.202	0.167	0.142	0.124	0.110	0.099	0.094
	0.09	0.635	0.422	0.316	0.253	0.211	0.181	0.158	0.140	0.126	0.120
	0.11	0.706	0.488	0.372	0.301	0.253	0.218	0.192	0.171	0.154	0.147
	0.14	0.791	0.573	0.449	0.369	0.314	0.272	0.241	0.216	0.196	0.187
	0.15	0.815	0.598	0.473	0.391	0.333	0.290	0.257	0.231	0.209	0.200
	0.16	0.837	0.623	0.496	0.412	0.352	0.308	0.273	0.245	0.223	0.213
	0.17	0.858	0.646	0.518	0.432	0.371	0.325	0.289	0.260	0.237	0.226
	0.18	0.877	0.668	0.539	0.452	0.389	0.342	0.305	0.275	0.250	0.240
	0.2	0.912	0.709	0.580	0.491	0.426	0.375	0.336	0.304	0.278	0.266

Discussion

The derived fishing mortality estimates in this report rely heavily on the assumption that fishing effort is proportional to area swept by the trawl. Further it is assumed that the filtering of the VMS data for vessel speeds between 2.6 and 3.3 knots is sufficient to capture most likely fishing activity. The ping frequency of 1 per hour ultimately defines the resolution of fishing activity. Tows longer than 1 hour may not be captured if the post haul tow speed results in an average speed at the time of the ping reflects an average speed of a partial hour of towing and the balance of steam time to the next station. Similarly, it is assumed that the average speed during evening hours when fishing does not occur is less than 2.6 knots. These complications are not easily resolvable without additional information on fishing behavior or fine scale tracking of vessels using Study Fleet data or observed trips. Further analyses, perhaps incorporating principles from Ideal Free Distributions, may yield additional insights on the relationship between the distribution of effort and underlying abundance (Martel and Walters, 2004; Bordalo-Machado, 2006).

The approach used in this report relies on the concept of examining the implications of a wide range of parameters on estimates. Ultimately, the relevance of the fishing mortality estimates derived herein depend on further refinement of these parameters. However, the upper bounds on fishing mortality may be relevant for establishing whether modest changes to existing quotas impose significant risks to the Illex population. Comparisons of these crude aggregate fishing mortality rates with similarly rough estimates of natural mortality per week or more refined size/age dependent natural mortality rates (Hendrickson and Hart, 2006) may allow for a scoping of possible escapement rates for stock assumed to consist of a single cohort. The Fs derived herein represent the total F over a season from May to October. Assuming this period comprises 26 weeks, the predicted total M for a cohort born at the start of this period would be 2.6 to 7.9. Maximum estimates of F under the most extreme assumptions (Appendix 1) are less than 1.2. On a weekly basis this maximum F would be 0.05

Acknowledgements

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Appendix 1. Summary of estimates of virtual area swept, fishing mortality in the area fished, and effective fishing mortality over the entire population for 2017 to 2019.

(a) Average over 2017-2010

Table 1a. Virtual area swept (km^2) as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area.

Depletion Ratio Threshold	Effective Area 11137.7	Assumed Gear Efficiency 0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
	0.95	4575.5	6863.3	9151.1	11438.8	13726.6	16014.4	18302.1	20589.9	22877.7	25165.4	27453.2	29741.0	32028.7	34316.5	36604.3	38892.0	41179.8	43467.6	45755.3
	0.9	2227.5	3341.3	4455.1	5568.8	6682.6	7796.4	8910.1	10023.9	11137.7	12251.4	13365.2	14479.0	15592.7	16706.5	17820.3	18934.0	20047.8	21161.6	22275.3
	0.85	1444.1	2166.2	2888.2	3610.3	4332.3	5054.4	5776.4	6498.5	7220.5	7942.6	8664.6	9386.7	10108.7	10830.8	11552.8	12274.9	12996.9	13719.0	14441.0
	0.8	1051.8	1577.6	2103.5	2629.4	3155.3	3681.2	4207.1	4732.9	5258.8	5784.7	6310.6	6836.5	7362.3	7888.2	8414.1	8940.0	9465.9	9991.8	10517.6
	0.75	815.8	1223.7	1631.6	2039.5	2447.4	2855.3	3263.2	3671.1	4079.1	4487.0	4894.9	5302.8	5710.7	6118.6	6526.5	6934.4	7342.3	7750.2	8158.1
	0.7	658.0	987.0	1316.0	1645.0	1974.0	2303.0	2632.0	2961.0	3290.0	3619.0	3948.0	4277.0	4606.0	4935.0	5264.0	5593.1	5922.1	6251.1	6580.1
	0.65	544.8	817.2	1089.6	1362.0	1634.4	1906.8	2179.2	2451.6	2724.0	2996.4	3268.9	3541.3	3813.7	4086.1	4358.5	4630.9	4903.3	5175.7	5448.1
	0.6	459.4	689.2	918.9	1148.6	1378.3	1608.0	1837.8	2067.5	2297.2	2526.9	2756.6	2986.4	3216.1	3445.8	3675.5	3905.2	4135.0	4364.7	4594.4
	0.55	392.6	588.9	785.1	981.4	1177.7	1374.0	1570.3	1766.6	1962.9	2159.1	2355.4	2551.7	2748.0	2944.3	3140.6	3336.9	3533.2	3729.4	3925.7
	0.5	338.6	507.9	677.2	846.5	1015.8	1185.1	1354.4	1523.7	1693.0	1862.3	2031.6	2200.8	2370.1	2539.4	2708.7	2878.0	3047.3	3216.6	3385.9
	0.45	293.9	440.9	587.8	734.8	881.7	1028.7	1175.7	1322.6	1469.6	1616.5	1763.5	1910.5	2057.4	2204.4	2351.3	2498.3	2645.2	2792.2	2939.2
	0.4	256.1	384.2	512.3	640.3	768.4	896.5	1024.5	1152.6	1280.7	1408.7	1536.8	1664.9	1792.9	1921.0	2049.1	2177.1	2305.2	2433.3	2561.4
	0.35	223.6	335.3	447.1	558.9	670.7	782.4	894.2	1006.0	1117.8	1229.6	1341.3	1453.1	1564.9	1676.7	1788.4	1900.2	2012.0	2123.8	2235.6
	0.3	194.9	292.4	389.9	487.3	584.8	682.3	779.7	877.2	974.7	1072.1	1169.6	1267.1	1364.5	1462.0	1559.5	1656.9	1754.4	1851.9	1949.3
	0.25	169.3	253.9	338.6	423.2	507.9	592.5	677.2	761.8	846.5	931.1	1015.8	1100.4	1185.1	1269.7	1354.4	1439.0	1523.7	1608.3	1693.0
	0.2	145.8	218.7	291.6	364.6	437.5	510.4	583.3	656.2	729.1	802.0	874.9	947.9	1020.8	1093.7	1166.6	1239.5	1312.4	1385.3	1458.2
	0.15	123.7	185.6	247.4	309.3	371.1	433.0	494.8	556.7	618.6	680.4	742.3	804.1	866.0	927.8	989.7	1051.5	1113.4	1175.3	1237.1
	0.1	101.9	152.9	203.9	254.8	305.8	356.7	407.7	458.7	509.6	560.6	611.6	662.5	713.5	764.4	815.4	866.4	917.3	968.3	1019.3

Table 2a. Spatially weighted F over all fishing areas as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing are

	Spatially weighted average F	Assumed Gear Efficiency																		
	0.097	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
Depletion Ratio Threshold	0.95	0.0436	0.0457	0.0468	0.0475	0.0479	0.0483	0.0486	0.0488	0.0491	0.0492	0.0494	0.0495	0.0496	0.0497	0.0498	0.0499	0.0500	0.0501	0.0501
	0.9	0.0789	0.0850	0.0892	0.0917	0.0936	0.0949	0.0959	0.0967	0.0973	0.0979	0.0983	0.0987	0.0991	0.0994	0.0997	0.1000	0.1002	0.1005	0.1007
	0.85	0.1066	0.1209	0.1280	0.1330	0.1370	0.1398	0.1420	0.1439	0.1455	0.1467	0.1477	0.1485	0.1493	0.1499	0.1505	0.1510	0.1514	0.1518	0.1522
	0.8	0.1254	0.1510	0.1649	0.1728	0.1783	0.1832	0.1874	0.1904	0.1929	0.1951	0.1970	0.1987	0.2001	0.2013	0.2024	0.2033	0.2041	0.2048	0.2055
	0.75	0.1388	0.1751	0.1968	0.2108	0.2198	0.2261	0.2312	0.2361	0.2404	0.2439	0.2465	0.2489	0.2511	0.2531	0.2549	0.2565	0.2580	0.2592	0.2603
	0.7	0.1484	0.1937	0.2249	0.2447	0.2591	0.2691	0.2764	0.2820	0.2872	0.2921	0.2965	0.3003	0.3034	0.3060	0.3084	0.3106	0.3127	0.3146	0.3164
	0.65	0.1511	0.2082	0.2469	0.2758	0.2949	0.3100	0.3211	0.3293	0.3359	0.3413	0.3465	0.3515	0.3560	0.3603	0.3637	0.3668	0.3693	0.3718	0.3741
	0.6	0.1511	0.2203	0.2658	0.3014	0.3287	0.3480	0.3634	0.3759	0.3854	0.3929	0.3992	0.4046	0.4097	0.4149	0.4196	0.4240	0.4281	0.4315	0.4345
	0.55	0.1511	0.2267	0.2818	0.3237	0.3572	0.3842	0.4042	0.4199	0.4339	0.4448	0.4534	0.4607	0.4670	0.4725	0.4776	0.4827	0.4878	0.4924	0.4967
	0.5	0.1511	0.2267	0.2952	0.3426	0.3825	0.4155	0.4429	0.4638	0.4801	0.4954	0.5078	0.5181	0.5265	0.5338	0.5401	0.5458	0.5510	0.5561	0.5613
	0.45	0.1511	0.2267	0.3024	0.3611	0.4053	0.4437	0.4769	0.5050	0.5278	0.5451	0.5607	0.5754	0.5871	0.5972	0.6056	0.6130	0.6197	0.6257	0.6310
	0.4	0.1511	0.2267	0.3024	0.3734	0.4265	0.4701	0.5082	0.5419	0.5709	0.5955	0.6152	0.6315	0.6472	0.6615	0.6732	0.6834	0.6921	0.6999	0.7070
	0.35	0.1511	0.2267	0.3024	0.3782	0.4442	0.4942	0.5379	0.5767	0.6110	0.6414	0.6683	0.6911	0.7094	0.7253	0.7410	0.7556	0.7676	0.7785	0.7880
	0.3	0.1511	0.2267	0.3024	0.3782	0.4540	0.5160	0.5657	0.6094	0.6499	0.6849	0.7177	0.7466	0.7724	0.7947	0.8129	0.8289	0.8446	0.8597	0.8730
	0.25	0.1511	0.2267	0.3024	0.3782	0.4540	0.5296	0.5911	0.6422	0.6860	0.7283	0.7659	0.8004	0.8321	0.8609	0.8868	0.9096	0.9287	0.9456	0.9614
	0.2	0.1511	0.2267	0.3024	0.3782	0.4540	0.5299	0.6059	0.6698	0.7249	0.7700	0.8139	0.8552	0.8919	0.9264	0.9588	0.9881	1.0157	1.0399	1.0620
	0.15	0.1511	0.2267	0.3024	0.3782	0.4540	0.5299	0.6059	0.6819	0.7531	0.8123	0.8652	0.9095	0.9535	0.9954	1.0344	1.0690	1.1036	1.1350	1.1643
	0.1	0.1511	0.2267	0.3024	0.3782	0.4540	0.5299	0.6059	0.6819	0.7579	0.8340	0.9063	0.9669	1.0218	1.0704	1.1144	1.1584	1.2007	1.2406	1.2765

Table 3a. Worst case scenario for effective F on total population given highest F in Table 2a.

		Ratio of Density in Unfished Area to Density in Fished Area (phi)																	
	1.2765	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95
Ratio of Area Fished to Total Habitat (theta)	0.01	0.117	0.081	0.061	0.050	0.042	0.036	0.031	0.028	0.025	0.023	0.021	0.020	0.018	0.017	0.016	0.015	0.014	0.013
	0.02	0.216	0.153	0.118	0.096	0.081	0.070	0.062	0.055	0.050	0.046	0.042	0.039	0.036	0.034	0.032	0.030	0.028	0.027
	0.03	0.302	0.218	0.171	0.141	0.119	0.104	0.092	0.082	0.074	0.068	0.063	0.058	0.054	0.051	0.048	0.045	0.042	0.040
	0.04	0.375	0.278	0.220	0.182	0.156	0.136	0.120	0.108	0.098	0.090	0.083	0.077	0.072	0.067	0.063	0.060	0.056	0.054
	0.05	0.440	0.332	0.266	0.222	0.191	0.167	0.148	0.134	0.122	0.111	0.103	0.096	0.089	0.084	0.079	0.074	0.071	0.067
	0.06	0.497	0.381	0.309	0.260	0.224	0.197	0.176	0.159	0.145	0.133	0.123	0.114	0.107	0.100	0.094	0.089	0.085	0.080
	0.07	0.548	0.427	0.349	0.295	0.256	0.226	0.202	0.183	0.167	0.154	0.142	0.132	0.124	0.116	0.110	0.104	0.099	0.094
	0.08	0.594	0.468	0.387	0.329	0.287	0.254	0.228	0.207	0.189	0.174	0.162	0.151	0.141	0.133	0.125	0.118	0.112	0.107
	0.09	0.635	0.507	0.422	0.362	0.316	0.281	0.253	0.230	0.211	0.195	0.181	0.169	0.158	0.149	0.140	0.133	0.126	0.120
	0.1	0.672	0.543	0.456	0.393	0.345	0.308	0.278	0.253	0.232	0.215	0.199	0.186	0.175	0.165	0.156	0.148	0.140	0.134
	0.11	0.706	0.577	0.488	0.422	0.372	0.333	0.301	0.275	0.253	0.234	0.218	0.204	0.192	0.181	0.171	0.162	0.154	0.147
	0.12	0.736	0.608	0.518	0.451	0.399	0.358	0.325	0.297	0.274	0.254	0.236	0.221	0.208	0.196	0.186	0.176	0.168	0.160
	0.13	0.765	0.637	0.546	0.478	0.424	0.382	0.347	0.318	0.294	0.273	0.255	0.239	0.225	0.212	0.201	0.191	0.182	0.173
	0.14	0.791	0.664	0.573	0.503	0.449	0.405	0.369	0.339	0.314	0.292	0.272	0.256	0.241	0.228	0.216	0.205	0.196	0.187
	0.15	0.815	0.690	0.598	0.528	0.473	0.428	0.391	0.360	0.333	0.310	0.290	0.273	0.257	0.243	0.231	0.219	0.209	0.200
	0.16	0.837	0.714	0.623	0.552	0.496	0.450	0.412	0.380	0.352	0.328	0.308	0.289	0.273	0.259	0.245	0.234	0.223	0.213
	0.17	0.858	0.737	0.646	0.575	0.518	0.471	0.432	0.399	0.371	0.346	0.325	0.306	0.289	0.274	0.260	0.248	0.237	0.226
	0.18	0.877	0.758	0.668	0.597	0.539	0.492	0.452	0.419	0.389	0.364	0.342	0.322	0.305	0.289	0.275	0.262	0.250	0.240
	0.2	0.912	0.798	0.709	0.638	0.580	0.532	0.491	0.456	0.426	0.399	0.375	0.355	0.336	0.319	0.304	0.290	0.278	0.266

(b) 2017

Table 1. Virtual area swept (km^2) 2017 as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area.

	Effective Area	Assumed Gear Efficiency																		
	6547.7	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
Depletion Ratio Threshold	0.95	2689.9	4034.9	5379.8	6724.8	8069.8	9414.7	10759.7	12104.6	13449.6	14794.6	16139.5	17484.5	18829.4	20174.4	21519.4	22864.3	24209.3	25554.2	26899.2
	0.9	1309.5	1964.3	2619.1	3273.9	3928.6	4583.4	5238.2	5893.0	6547.7	7202.5	7857.3	8512.1	9166.8	9821.6	10476.4	11131.2	11785.9	12440.7	13095.5
	0.85	849.0	1273.5	1698.0	2122.4	2546.9	2971.4	3395.9	3820.4	4244.9	4669.4	5093.9	5518.4	5942.8	6367.3	6791.8	7216.3	7640.8	8065.3	8489.8
	0.8	618.3	927.5	1236.6	1545.8	1855.0	2164.1	2473.3	2782.5	3091.6	3400.8	3709.9	4019.1	4328.3	4637.4	4946.6	5255.7	5564.9	5874.1	6183.2
	0.75	479.6	719.4	959.2	1199.0	1438.8	1678.6	1918.4	2158.2	2398.0	2637.8	2877.7	3117.5	3357.3	3597.1	3836.9	4076.7	4316.5	4556.3	4796.1
	0.7	386.8	580.3	773.7	967.1	1160.5	1353.9	1547.3	1740.8	1934.2	2127.6	2321.0	2514.4	2707.9	2901.3	3094.7	3288.1	3481.5	3674.9	3868.4
	0.65	320.3	480.4	640.6	800.7	960.9	1121.0	1281.2	1441.3	1601.4	1761.6	1921.7	2081.9	2242.0	2402.2	2562.3	2722.5	2882.6	3042.7	3202.9
	0.6	270.1	405.2	540.2	675.3	810.3	945.4	1080.4	1215.5	1350.5	1485.6	1620.6	1755.7	1890.7	2025.8	2160.8	2295.9	2430.9	2566.0	2701.0
	0.55	230.8	346.2	461.6	577.0	692.4	807.8	923.2	1038.6	1154.0	1269.3	1384.7	1500.1	1615.5	1730.9	1846.3	1961.7	2077.1	2192.5	2307.9
	0.5	199.1	298.6	398.1	497.6	597.2	696.7	796.2	895.8	995.3	1094.8	1194.3	1293.9	1393.4	1492.9	1592.4	1692.0	1791.5	1891.0	1990.6
	0.45	172.8	259.2	345.6	432.0	518.4	604.8	691.2	777.6	864.0	950.3	1036.7	1123.1	1209.5	1295.9	1382.3	1468.7	1555.1	1641.5	1727.9
	0.4	150.6	225.9	301.2	376.4	451.7	527.0	602.3	677.6	752.9	828.2	903.5	978.8	1054.1	1129.3	1204.6	1279.9	1355.2	1430.5	1505.8
	0.35	131.4	197.1	262.9	328.6	394.3	460.0	525.7	591.4	657.1	722.8	788.6	854.3	920.0	985.7	1051.4	1117.1	1182.8	1248.6	1314.3
	0.3	114.6	171.9	229.2	286.5	343.8	401.1	458.4	515.7	573.0	630.3	687.6	744.9	802.2	859.5	916.8	974.1	1031.4	1088.7	1146.0
	0.25	99.5	149.3	199.1	248.8	298.6	348.3	398.1	447.9	497.6	547.4	597.2	646.9	696.7	746.5	796.2	846.0	895.8	945.5	995.3
	0.2	85.7	128.6	171.5	214.3	257.2	300.1	342.9	385.8	428.6	471.5	514.4	557.2	600.1	643.0	685.8	728.7	771.6	814.4	857.3
	0.15	72.7	109.1	145.5	181.8	218.2	254.6	290.9	327.3	363.6	400.0	436.4	472.7	509.1	545.5	581.8	618.2	654.6	690.9	727.3
	0.1	59.9	89.9	119.8	149.8	179.8	209.7	239.7	269.6	299.6	329.6	359.5	389.5	419.5	449.4	479.4	509.3	539.3	569.3	599.2

Table 2b. Spatially weighted F over all fishing areas 2017 as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area.

	Spatially weighted average F	Assumed Gear Efficiency																		
	0.100	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
Depletion Ratio Threshold	0.95	0.0455	0.0471	0.0481	0.0487	0.0491	0.0494	0.0496	0.0498	0.0500	0.0501	0.0502	0.0503	0.0504	0.0504	0.0505	0.0505	0.0506	0.0506	0.0507
	0.9	0.0838	0.0901	0.0932	0.0952	0.0966	0.0978	0.0986	0.0992	0.0998	0.1003	0.1007	0.1011	0.1014	0.1017	0.1019	0.1021	0.1023	0.1024	0.1026
	0.85	0.1105	0.1284	0.1363	0.1404	0.1434	0.1456	0.1473	0.1487	0.1499	0.1510	0.1518	0.1525	0.1531	0.1538	0.1543	0.1547	0.1552	0.1556	0.1559
	0.8	0.1316	0.1574	0.1749	0.1847	0.1895	0.1932	0.1963	0.1987	0.2006	0.2023	0.2037	0.2050	0.2062	0.2073	0.2081	0.2088	0.2095	0.2102	0.2108
	0.75	0.1476	0.1825	0.2058	0.2232	0.2343	0.2410	0.2453	0.2490	0.2522	0.2547	0.2571	0.2589	0.2606	0.2620	0.2634	0.2646	0.2657	0.2669	0.2678
	0.7	0.1610	0.2032	0.2335	0.2560	0.2735	0.2862	0.2953	0.3003	0.3045	0.3083	0.3115	0.3143	0.3167	0.3190	0.3208	0.3225	0.3240	0.3255	0.3268
	0.65	0.1675	0.2214	0.2589	0.2860	0.3084	0.3263	0.3411	0.3511	0.3586	0.3633	0.3675	0.3714	0.3746	0.3778	0.3804	0.3828	0.3851	0.3869	0.3887
	0.6	0.1686	0.2375	0.2798	0.3150	0.3408	0.3633	0.3821	0.3983	0.4097	0.4194	0.4259	0.4306	0.4350	0.4389	0.4424	0.4456	0.4487	0.4512	0.4535
	0.55	0.1686	0.2477	0.2999	0.3397	0.3731	0.3984	0.4212	0.4412	0.4577	0.4725	0.4825	0.4920	0.4983	0.5031	0.5076	0.5116	0.5154	0.5187	0.5219
	0.5	0.1686	0.2530	0.3192	0.3636	0.4017	0.4340	0.4593	0.4826	0.5039	0.5210	0.5376	0.5504	0.5605	0.5699	0.5767	0.5816	0.5861	0.5904	0.5944
	0.45	0.1686	0.2530	0.3305	0.3853	0.4280	0.4662	0.4981	0.5242	0.5477	0.5696	0.5892	0.6058	0.6221	0.6344	0.6445	0.6543	0.6621	0.6673	0.6720
	0.4	0.1686	0.2530	0.3375	0.4064	0.4541	0.4957	0.5338	0.5664	0.5938	0.6175	0.6404	0.6619	0.6801	0.6967	0.7131	0.7260	0.7361	0.7462	0.7552
	0.35	0.1686	0.2530	0.3375	0.4172	0.4808	0.5260	0.5673	0.6054	0.6398	0.6684	0.6934	0.7170	0.7393	0.7608	0.7788	0.7954	0.8120	0.8265	0.8373
	0.3	0.1686	0.2530	0.3375	0.4220	0.4965	0.5571	0.6021	0.6441	0.6823	0.7187	0.7498	0.7770	0.8011	0.8247	0.8470	0.8685	0.8876	0.9043	0.9209
	0.25	0.1686	0.2530	0.3375	0.4220	0.5066	0.5781	0.6389	0.6840	0.7279	0.7662	0.8045	0.8391	0.8691	0.8958	0.9199	0.9435	0.9665	0.9881	1.0094
	0.2	0.1686	0.2530	0.3375	0.4220	0.5066	0.5914	0.6628	0.7267	0.7741	0.8193	0.8603	0.8987	0.9370	0.9715	1.0019	1.0294	1.0548	1.0785	1.1022
	0.15	0.1686	0.2530	0.3375	0.4220	0.5066	0.5914	0.6761	0.7526	0.8203	0.8773	0.9225	0.9677	1.0090	1.0474	1.0858	1.1227	1.1558	1.1858	1.2131
	0.1	0.1686	0.2530	0.3375	0.4220	0.5066	0.5914	0.6761	0.7610	0.8459	0.9193	0.9871	1.0478	1.0948	1.1401	1.1854	1.2258	1.2643	1.3028	1.3413

Table 3b. Worst case scenario for Effective F on total population in 2017 given highest F in Table 2b

		Ratio of Density in Unfished Area to Density in Fished Area (phi)																	
	1.3413	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95
Ratio of Area Fished to Total Habitat (theta)	0.005	0.064	0.043	0.033	0.026	0.022	0.019	0.017	0.015	0.013	0.012	0.011	0.010	0.010	0.009	0.008	0.008	0.007	0.007
	0.02	0.227	0.161	0.124	0.101	0.085	0.074	0.065	0.058	0.053	0.048	0.044	0.041	0.038	0.036	0.033	0.031	0.030	0.028
	0.03	0.317	0.229	0.180	0.148	0.125	0.109	0.096	0.086	0.078	0.071	0.066	0.061	0.057	0.053	0.050	0.047	0.045	0.042
	0.04	0.395	0.292	0.231	0.192	0.164	0.143	0.127	0.114	0.103	0.094	0.087	0.081	0.075	0.071	0.066	0.063	0.059	0.056
	0.05	0.463	0.348	0.279	0.233	0.200	0.175	0.156	0.140	0.128	0.117	0.108	0.100	0.094	0.088	0.083	0.078	0.074	0.070
	0.06	0.523	0.400	0.325	0.273	0.235	0.207	0.185	0.167	0.152	0.139	0.129	0.120	0.112	0.105	0.099	0.094	0.089	0.084
	0.07	0.576	0.448	0.367	0.310	0.269	0.237	0.212	0.192	0.176	0.161	0.150	0.139	0.130	0.122	0.115	0.109	0.104	0.098
	0.08	0.624	0.492	0.406	0.346	0.301	0.267	0.240	0.217	0.199	0.183	0.170	0.158	0.148	0.139	0.132	0.124	0.118	0.112
	0.09	0.667	0.533	0.444	0.380	0.333	0.296	0.266	0.242	0.222	0.204	0.190	0.177	0.166	0.156	0.148	0.140	0.133	0.126
	0.1	0.706	0.571	0.479	0.413	0.363	0.323	0.292	0.266	0.244	0.225	0.210	0.196	0.184	0.173	0.164	0.155	0.147	0.140
	0.11	0.741	0.606	0.512	0.444	0.391	0.350	0.317	0.289	0.266	0.246	0.229	0.214	0.201	0.190	0.179	0.170	0.162	0.154
	0.12	0.774	0.639	0.544	0.473	0.419	0.376	0.341	0.312	0.287	0.266	0.248	0.233	0.219	0.206	0.195	0.185	0.176	0.168
	0.13	0.804	0.669	0.574	0.502	0.446	0.401	0.365	0.334	0.309	0.287	0.267	0.251	0.236	0.223	0.211	0.201	0.191	0.182
	0.14	0.831	0.698	0.602	0.529	0.472	0.426	0.388	0.356	0.329	0.306	0.286	0.269	0.253	0.239	0.227	0.216	0.205	0.196
	0.15	0.856	0.725	0.629	0.555	0.497	0.450	0.411	0.378	0.350	0.326	0.305	0.286	0.270	0.255	0.242	0.231	0.220	0.210
	0.16	0.880	0.750	0.654	0.580	0.521	0.473	0.433	0.399	0.370	0.345	0.323	0.304	0.287	0.272	0.258	0.246	0.234	0.224
	0.17	0.901	0.774	0.679	0.604	0.544	0.495	0.454	0.420	0.390	0.364	0.341	0.321	0.304	0.288	0.273	0.260	0.249	0.238
	0.18	0.922	0.797	0.702	0.627	0.567	0.517	0.475	0.440	0.409	0.383	0.359	0.339	0.320	0.304	0.289	0.275	0.263	0.252
	0.2	0.958	0.838	0.745	0.671	0.610	0.559	0.516	0.479	0.447	0.419	0.395	0.373	0.353	0.335	0.319	0.305	0.292	0.279

(.C) 2018

Table 1c. Virtual area swept (km^2) 2018 as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area.

	Effective Area	Assumed Gear Efficiency																		
	8877.0	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
Depletion Ratio Threshold	0.95	3646.8	5470.2	7293.6	9117.0	10940.4	12763.8	14587.2	16410.6	18234.0	20057.4	21880.8	23704.2	25527.6	27351.0	29174.4	30997.8	32821.2	34644.6	36468.0
	0.9	1775.4	2663.1	3550.8	4438.5	5326.2	6213.9	7101.6	7989.3	8877.0	9764.7	10652.4	11540.1	12427.8	13315.5	14203.2	15090.9	15978.6	16866.3	17754.0
	0.85	1151.0	1726.5	2302.0	2877.5	3452.9	4028.4	4603.9	5179.4	5754.9	6330.4	6905.9	7481.4	8056.9	8632.4	9207.9	9783.4	10358.8	10934.3	11509.8
	0.8	838.3	1257.4	1676.6	2095.7	2514.8	2934.0	3353.1	3772.3	4191.4	4610.5	5029.7	5448.8	5868.0	6287.1	6706.2	7125.4	7544.5	7963.7	8382.8
	0.75	650.2	975.3	1300.4	1625.5	1950.7	2275.8	2600.9	2926.0	3251.1	3576.2	3901.3	4226.4	4551.5	4876.6	5201.8	5526.9	5852.0	6177.1	6502.2
	0.7	524.4	786.7	1048.9	1311.1	1573.3	1835.6	2097.8	2360.0	2622.2	2884.4	3146.7	3408.9	3671.1	3933.3	4195.6	4457.8	4720.0	4982.2	5244.5
	0.65	434.2	651.3	868.4	1085.6	1302.7	1519.8	1736.9	1954.0	2171.1	2388.2	2605.3	2822.5	3039.6	3256.7	3473.8	3690.9	3908.0	4125.1	4342.2
	0.6	366.2	549.3	732.4	915.5	1098.6	1281.6	1464.7	1647.8	1830.9	2014.0	2197.1	2380.2	2563.3	2746.4	2929.5	3112.6	3295.7	3478.8	3661.8
	0.55	312.9	469.3	625.8	782.2	938.7	1095.1	1251.6	1408.0	1564.4	1720.9	1877.3	2033.8	2190.2	2346.7	2503.1	2659.6	2816.0	2972.4	3128.9
	0.5	269.9	404.8	539.7	674.7	809.6	944.5	1079.5	1214.4	1349.3	1484.3	1619.2	1754.1	1889.1	2024.0	2158.9	2293.9	2428.8	2563.7	2698.7
	0.45	234.3	351.4	468.5	585.6	702.8	819.9	937.0	1054.2	1171.3	1288.4	1405.5	1522.7	1639.8	1756.9	1874.1	1991.2	2108.3	2225.4	2342.6
	0.4	204.1	306.2	408.3	510.4	612.4	714.5	816.6	918.7	1020.7	1122.8	1224.9	1326.9	1429.0	1531.1	1633.2	1735.2	1837.3	1939.4	2041.5
	0.35	178.2	267.3	356.4	445.4	534.5	623.6	712.7	801.8	890.9	980.0	1069.1	1158.2	1247.3	1336.3	1425.4	1514.5	1603.6	1692.7	1781.8
	0.3	155.4	233.0	310.7	388.4	466.1	543.8	621.5	699.1	776.8	854.5	932.2	1009.9	1087.6	1165.2	1242.9	1320.6	1398.3	1476.0	1553.7
	0.25	134.9	202.4	269.9	337.3	404.8	472.3	539.7	607.2	674.7	742.1	809.6	877.1	944.5	1012.0	1079.5	1146.9	1214.4	1281.9	1349.3
	0.2	116.2	174.3	232.4	290.6	348.7	406.8	464.9	523.0	581.1	639.2	697.3	755.5	813.6	871.7	929.8	987.9	1046.0	1104.1	1162.2
	0.15	98.6	147.9	197.2	246.5	295.8	345.1	394.4	443.7	493.0	542.3	591.6	640.9	690.2	739.5	788.8	838.1	887.4	936.7	986.0
	0.1	81.2	121.9	162.5	203.1	243.7	284.3	325.0	365.6	406.2	446.8	487.4	528.0	568.7	609.3	649.9	690.5	731.1	771.8	812.4

Table 2c. Spatially weighted F over all fishing areas 2018 as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area.

	Spatially weighted average F	Assumed Gear Efficiency																		
	0.099	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
Depletion Ratio Threshold	0.95	0.0449	0.0465	0.0475	0.0482	0.0486	0.0489	0.0491	0.0493	0.0495	0.0496	0.0498	0.0499	0.0500	0.0500	0.0501	0.0502	0.0502	0.0503	0.0504
	0.9	0.0822	0.0886	0.0920	0.0939	0.0953	0.0965	0.0974	0.0982	0.0988	0.0993	0.0997	0.1001	0.1004	0.1006	0.1009	0.1011	0.1013	0.1014	0.1016
	0.85	0.1133	0.1260	0.1334	0.1384	0.1415	0.1436	0.1454	0.1467	0.1479	0.1490	0.1500	0.1508	0.1516	0.1522	0.1527	0.1532	0.1537	0.1540	0.1544
	0.8	0.1341	0.1598	0.1720	0.1801	0.1862	0.1906	0.1937	0.1959	0.1979	0.1997	0.2010	0.2022	0.2034	0.2045	0.2055	0.2064	0.2073	0.2080	0.2087
	0.75	0.1521	0.1872	0.2082	0.2203	0.2289	0.2357	0.2413	0.2457	0.2489	0.2514	0.2534	0.2554	0.2572	0.2585	0.2599	0.2610	0.2622	0.2633	0.2644
	0.7	0.1667	0.2074	0.2400	0.2588	0.2709	0.2802	0.2880	0.2943	0.2995	0.3040	0.3075	0.3102	0.3125	0.3145	0.3164	0.3183	0.3198	0.3211	0.3224
	0.65	0.1738	0.2280	0.2640	0.2938	0.3119	0.3245	0.3346	0.3430	0.3500	0.3563	0.3615	0.3659	0.3698	0.3729	0.3755	0.3776	0.3796	0.3816	0.3835
	0.6	0.1749	0.2463	0.2863	0.3221	0.3500	0.3681	0.3813	0.3924	0.4012	0.4094	0.4160	0.4223	0.4276	0.4321	0.4364	0.4399	0.4428	0.4454	0.4475
	0.55	0.1749	0.2575	0.3106	0.3467	0.3820	0.4092	0.4279	0.4420	0.4536	0.4635	0.4721	0.4800	0.4867	0.4930	0.4987	0.5033	0.5078	0.5119	0.5152
	0.5	0.1749	0.2625	0.3304	0.3732	0.4093	0.4444	0.4719	0.4918	0.5071	0.5193	0.5305	0.5396	0.5482	0.5562	0.5629	0.5692	0.5754	0.5804	0.5849
	0.45	0.1749	0.2625	0.3435	0.4024	0.4387	0.4748	0.5100	0.5389	0.5604	0.5766	0.5902	0.6021	0.6130	0.6219	0.6305	0.6387	0.6457	0.6522	0.6585
	0.4	0.1749	0.2625	0.3501	0.4206	0.4715	0.5076	0.5437	0.5793	0.6104	0.6335	0.6520	0.6675	0.6801	0.6920	0.7029	0.7120	0.7206	0.7290	0.7366
	0.35	0.1749	0.2625	0.3501	0.4333	0.4974	0.5448	0.5809	0.6171	0.6533	0.6859	0.7125	0.7343	0.7511	0.7665	0.7789	0.7909	0.8020	0.8117	0.8204
	0.3	0.1749	0.2625	0.3501	0.4378	0.5163	0.5772	0.6239	0.6601	0.6963	0.7325	0.7674	0.7987	0.8227	0.8441	0.8607	0.8763	0.8893	0.9013	0.9128
	0.25	0.1749	0.2625	0.3501	0.4378	0.5256	0.6005	0.6615	0.7108	0.7470	0.7833	0.8195	0.8558	0.8900	0.9208	0.9448	0.9667	0.9846	1.0004	1.0152
	0.2	0.1749	0.2625	0.3501	0.4378	0.5256	0.6134	0.6892	0.7521	0.8080	0.8454	0.8817	0.9180	0.9543	0.9906	1.0253	1.0569	1.0842	1.1069	1.1281
	0.15	0.1749	0.2625	0.3501	0.4378	0.5256	0.6134	0.7013	0.7815	0.8494	0.9088	0.9618	0.9981	1.0344	1.0707	1.1071	1.1435	1.1799	1.2139	1.2453
	0.1	0.1749	0.2625	0.3501	0.4378	0.5256	0.6134	0.7013	0.7893	0.8773	0.9548	1.0227	1.0840	1.1400	1.1837	1.2200	1.2564	1.2928	1.3293	1.3657

Table 3c. Worst case scenario for F on total population in 2018 given highest F in Table 2c.

Ratio of Area Fished to Total Habitat (theta)	1.3657	Ratio of Density in Unfished Area to Density in Fished Area (phi) 0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95
	0.01	0.125	0.086	0.066	0.053	0.044	0.038	0.034	0.030	0.027	0.025	0.023	0.021	0.019	0.018	0.017	0.016	0.015	0.014
	0.02	0.231	0.164	0.126	0.103	0.087	0.075	0.066	0.059	0.054	0.049	0.045	0.042	0.039	0.036	0.034	0.032	0.030	0.029
	0.03	0.323	0.233	0.183	0.150	0.128	0.111	0.098	0.088	0.080	0.073	0.067	0.062	0.058	0.054	0.051	0.048	0.045	0.043
	0.04	0.402	0.297	0.235	0.195	0.167	0.145	0.129	0.116	0.105	0.096	0.089	0.082	0.077	0.072	0.068	0.064	0.060	0.057
	0.05	0.471	0.355	0.285	0.238	0.204	0.179	0.159	0.143	0.130	0.119	0.110	0.102	0.096	0.090	0.084	0.080	0.075	0.072
	0.06	0.532	0.408	0.330	0.278	0.240	0.211	0.188	0.170	0.155	0.142	0.131	0.122	0.114	0.107	0.101	0.095	0.090	0.086
	0.07	0.587	0.456	0.373	0.316	0.274	0.242	0.216	0.196	0.179	0.164	0.152	0.142	0.133	0.125	0.117	0.111	0.105	0.100
	0.08	0.635	0.501	0.414	0.352	0.307	0.272	0.244	0.221	0.202	0.186	0.173	0.161	0.151	0.142	0.134	0.127	0.120	0.115
	0.09	0.679	0.543	0.452	0.387	0.339	0.301	0.271	0.246	0.226	0.208	0.193	0.180	0.169	0.159	0.150	0.142	0.135	0.129
	0.1	0.719	0.581	0.488	0.420	0.369	0.329	0.297	0.270	0.248	0.230	0.213	0.199	0.187	0.176	0.167	0.158	0.150	0.143
	0.11	0.755	0.617	0.522	0.452	0.398	0.356	0.322	0.294	0.271	0.251	0.233	0.218	0.205	0.193	0.183	0.173	0.165	0.157
	0.12	0.788	0.650	0.554	0.482	0.427	0.383	0.347	0.318	0.293	0.271	0.253	0.237	0.223	0.210	0.199	0.189	0.180	0.171
	0.13	0.818	0.682	0.584	0.511	0.454	0.409	0.371	0.340	0.314	0.292	0.272	0.255	0.240	0.227	0.215	0.204	0.194	0.186
	0.14	0.846	0.711	0.613	0.539	0.480	0.434	0.395	0.363	0.335	0.312	0.291	0.274	0.258	0.244	0.231	0.220	0.209	0.200
	0.15	0.872	0.738	0.640	0.565	0.506	0.458	0.418	0.385	0.356	0.332	0.310	0.292	0.275	0.260	0.247	0.235	0.224	0.214
	0.16	0.896	0.764	0.666	0.591	0.530	0.481	0.441	0.406	0.377	0.351	0.329	0.310	0.292	0.277	0.263	0.250	0.239	0.228
	0.17	0.918	0.788	0.691	0.615	0.554	0.504	0.462	0.427	0.397	0.371	0.348	0.327	0.309	0.293	0.278	0.265	0.253	0.242
	0.18	0.938	0.811	0.715	0.639	0.577	0.526	0.484	0.448	0.417	0.390	0.366	0.345	0.326	0.309	0.294	0.280	0.268	0.256
	0.2	0.976	0.854	0.759	0.683	0.621	0.569	0.525	0.488	0.455	0.427	0.402	0.379	0.359	0.341	0.325	0.310	0.297	0.285

(.d) 2019

Table 1d. Virtual area swept (km^2) 2019 as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area.

	Effective Area	Assumed Gear Efficiency																		
	15310.1	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
Depletion Ratio Threshold	0.95	6289.6	9434.5	12579.3	15724.1	18868.9	22013.7	25158.6	28303.4	31448.2	34593.0	37737.8	40882.7	44027.5	47172.3	50317.1	53462.0	56606.8	59751.6	62896.4
	0.9	3062.0	4593.0	6124.0	7655.1	9186.1	10717.1	12248.1	13779.1	15310.1	16841.1	18372.1	19903.2	21434.2	22965.2	24496.2	26027.2	27558.2	29089.2	30620.2
	0.85	1985.1	2977.7	3970.2	4962.8	5955.3	6947.9	7940.4	8933.0	9925.5	10918.1	11910.6	12903.2	13895.7	14888.3	15880.8	16873.4	17865.9	18858.5	19851.0
	0.8	1445.8	2168.7	2891.6	3614.4	4337.3	5060.2	5783.1	6506.0	7228.9	7951.8	8674.7	9397.6	10120.5	10843.3	11566.2	12289.1	13012.0	13734.9	14457.8
	0.75	1121.4	1682.2	2242.9	2803.6	3364.3	3925.0	4485.7	5046.5	5607.2	6167.9	6728.6	7289.3	7850.0	8410.8	8971.5	9532.2	10092.9	10653.6	11214.3
	0.7	904.5	1356.8	1809.0	2261.3	2713.5	3165.8	3618.0	4070.3	4522.6	4974.8	5427.1	5879.3	6331.6	6783.8	7236.1	7688.3	8140.6	8592.9	9045.1
	0.65	748.9	1123.4	1497.8	1872.3	2246.7	2621.2	2995.6	3370.1	3744.5	4119.0	4493.4	4867.9	5242.4	5616.8	5991.3	6365.7	6740.2	7114.6	7489.1
	0.6	631.6	947.3	1263.1	1578.9	1894.7	2210.5	2526.2	2842.0	3157.8	3473.6	3789.4	4105.1	4420.9	4736.7	5052.5	5368.3	5684.0	5999.8	6315.6
	0.55	539.6	809.5	1079.3	1349.1	1618.9	1888.7	2158.6	2428.4	2698.2	2968.0	3237.8	3507.7	3777.5	4047.3	4317.1	4586.9	4856.8	5126.6	5396.4
	0.5	465.4	698.2	930.9	1163.6	1396.3	1629.0	1861.7	2094.5	2327.2	2559.9	2792.6	3025.3	3258.1	3490.8	3723.5	3956.2	4188.9	4421.7	4654.4
	0.45	404.0	606.0	808.0	1010.1	1212.1	1414.1	1616.1	1818.1	2020.1	2222.1	2424.1	2626.2	2828.2	3030.2	3232.2	3434.2	3636.2	3838.2	4040.2
	0.4	352.1	528.1	704.2	880.2	1056.3	1232.3	1408.4	1584.4	1760.4	1936.5	2112.5	2288.6	2464.6	2640.7	2816.7	2992.8	3168.8	3344.9	3520.9
	0.35	307.3	461.0	614.6	768.3	921.9	1075.6	1229.2	1382.9	1536.5	1690.2	1843.8	1997.5	2151.1	2304.8	2458.4	2612.1	2765.8	2919.4	3073.1
	0.3	268.0	401.9	535.9	669.9	803.9	937.9	1071.8	1205.8	1339.8	1473.8	1607.8	1741.7	1875.7	2009.7	2143.7	2277.7	2411.6	2545.6	2679.6
	0.25	232.7	349.1	465.4	581.8	698.2	814.5	930.9	1047.2	1163.6	1280.0	1396.3	1512.7	1629.0	1745.4	1861.7	1978.1	2094.5	2210.8	2327.2
	0.2	200.5	300.7	400.9	501.1	601.4	701.6	801.8	902.0	1002.3	1102.5	1202.7	1302.9	1403.2	1503.4	1603.6	1703.8	1804.1	1904.3	2004.5
	0.15	170.1	255.1	340.1	425.1	510.2	595.2	680.2	765.3	850.3	935.3	1020.3	1105.4	1190.4	1275.4	1360.4	1445.5	1530.5	1615.5	1700.6
	0.1	140.1	210.2	280.2	350.3	420.3	490.4	560.4	630.5	700.6	770.6	840.7	910.7	980.8	1050.8	1120.9	1190.9	1261.0	1331.1	1401.1

Table 2d. Spatially weighted F over all fishing areas 2019 as a function of assumed gear efficiency and threshold for decline in CPUE within a trip for movement to a new fishing area.

	Spatially weighted average F	Assumed Gear Efficiency																		
	0.102	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
Depletion Ratio Threshold	0.95	0.0472	0.0485	0.0491	0.0495	0.0497	0.0499	0.0501	0.0502	0.0503	0.0504	0.0505	0.0505	0.0506	0.0506	0.0507	0.0507	0.0508	0.0508	0.0508
	0.9	0.0891	0.0943	0.0967	0.0983	0.0994	0.1002	0.1008	0.1012	0.1016	0.1018	0.1021	0.1023	0.1025	0.1027	0.1028	0.1030	0.1031	0.1032	0.1033
	0.85	0.1261	0.1367	0.1433	0.1466	0.1489	0.1506	0.1520	0.1531	0.1540	0.1548	0.1553	0.1558	0.1562	0.1565	0.1568	0.1571	0.1574	0.1576	0.1578
	0.8	0.1608	0.1766	0.1868	0.1942	0.1986	0.2017	0.2040	0.2058	0.2074	0.2088	0.2099	0.2108	0.2117	0.2124	0.2130	0.2135	0.2140	0.2144	0.2147
	0.75	0.1856	0.2154	0.2294	0.2396	0.2473	0.2533	0.2570	0.2599	0.2623	0.2643	0.2660	0.2676	0.2690	0.2701	0.2711	0.2721	0.2730	0.2737	0.2743
	0.7	0.2058	0.2518	0.2714	0.2849	0.2954	0.3034	0.3105	0.3154	0.3189	0.3218	0.3245	0.3265	0.3283	0.3300	0.3316	0.3330	0.3342	0.3353	0.3363
	0.65	0.2159	0.2781	0.3136	0.3303	0.3437	0.3546	0.3630	0.3705	0.3771	0.3814	0.3849	0.3879	0.3907	0.3929	0.3950	0.3967	0.3984	0.4000	0.4015
	0.6	0.2209	0.3024	0.3499	0.3771	0.3927	0.4061	0.4176	0.4265	0.4345	0.4417	0.4479	0.4521	0.4557	0.4588	0.4617	0.4643	0.4664	0.4684	0.4702
	0.55	0.2221	0.3191	0.3784	0.4214	0.4440	0.4593	0.4728	0.4851	0.4947	0.5030	0.5108	0.5179	0.5241	0.5284	0.5321	0.5354	0.5383	0.5412	0.5437
	0.5	0.2221	0.3275	0.4067	0.4558	0.4942	0.5156	0.5309	0.5447	0.5576	0.5682	0.5771	0.5852	0.5930	0.6000	0.6066	0.6111	0.6150	0.6185	0.6217
	0.45	0.2221	0.3328	0.4257	0.4885	0.5361	0.5717	0.5929	0.6085	0.6226	0.6357	0.6479	0.6578	0.6664	0.6744	0.6822	0.6893	0.6962	0.7015	0.7058
	0.4	0.2221	0.3333	0.4362	0.5203	0.5738	0.6203	0.6552	0.6772	0.6934	0.7079	0.7215	0.7345	0.7459	0.7557	0.7643	0.7723	0.7802	0.7876	0.7946
	0.35	0.2221	0.3333	0.4432	0.5378	0.6130	0.6638	0.7099	0.7465	0.7701	0.7876	0.8027	0.8167	0.8301	0.8431	0.8543	0.8642	0.8729	0.8812	0.8892
	0.3	0.2221	0.3333	0.4445	0.5499	0.6396	0.7097	0.7601	0.8066	0.8471	0.8730	0.8931	0.9092	0.9241	0.9380	0.9514	0.9644	0.9763	0.9864	0.9958
	0.25	0.2221	0.3333	0.4445	0.5559	0.6557	0.7445	0.8140	0.8647	0.9125	0.9569	0.9891	1.0129	1.0317	1.0475	1.0625	1.0765	1.0901	1.1032	1.1161
	0.2	0.2221	0.3333	0.4445	0.5559	0.6667	0.7646	0.8538	0.9286	0.9815	1.0309	1.0775	1.1204	1.1504	1.1742	1.1935	1.2101	1.2252	1.2397	1.2537
	0.15	0.2221	0.3333	0.4445	0.5559	0.6673	0.7788	0.8785	0.9701	1.0527	1.1175	1.1681	1.2173	1.2641	1.3083	1.3427	1.3690	1.3912	1.4097	1.4262
	0.1	0.2221	0.3333	0.4445	0.5559	0.6673	0.7788	0.8903	0.9965	1.0936	1.1846	1.2683	1.3371	1.3898	1.4405	1.4887	1.5355	1.5801	1.6181	1.6463

Table 3d. Worst case scenario for F on total population in 2019 given highest F in Table 2d.

		Ratio of Density in Unfished Area to Density in Fished Area (phi)																	
Ratio of Area Fished to Total Habitat (theta)	1.6463	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95
	0.01	0.151	0.104	0.079	0.064	0.054	0.046	0.041	0.036	0.033	0.030	0.027	0.025	0.023	0.022	0.021	0.019	0.018	0.017
	0.02	0.279	0.197	0.152	0.124	0.105	0.091	0.080	0.071	0.065	0.059	0.054	0.050	0.047	0.044	0.041	0.039	0.037	0.035
	0.03	0.389	0.281	0.220	0.181	0.154	0.134	0.118	0.106	0.096	0.088	0.081	0.075	0.070	0.065	0.061	0.058	0.055	0.052
	0.04	0.484	0.358	0.284	0.235	0.201	0.175	0.155	0.140	0.127	0.116	0.107	0.099	0.092	0.087	0.081	0.077	0.073	0.069
	0.05	0.568	0.428	0.343	0.286	0.246	0.215	0.191	0.172	0.157	0.144	0.133	0.123	0.115	0.108	0.102	0.096	0.091	0.086
	0.06	0.641	0.491	0.398	0.335	0.289	0.254	0.227	0.205	0.186	0.171	0.158	0.147	0.138	0.129	0.122	0.115	0.109	0.104
	0.07	0.707	0.550	0.450	0.381	0.330	0.291	0.261	0.236	0.215	0.198	0.183	0.171	0.160	0.150	0.142	0.134	0.127	0.121
	0.08	0.766	0.604	0.499	0.425	0.370	0.328	0.294	0.267	0.244	0.225	0.208	0.194	0.182	0.171	0.161	0.153	0.145	0.138
	0.09	0.819	0.654	0.545	0.467	0.408	0.363	0.326	0.297	0.272	0.251	0.233	0.217	0.204	0.192	0.181	0.172	0.163	0.155
	0.1	0.866	0.701	0.588	0.507	0.445	0.397	0.358	0.326	0.299	0.277	0.257	0.240	0.226	0.212	0.201	0.190	0.181	0.172
	0.11	0.910	0.744	0.629	0.545	0.480	0.430	0.389	0.355	0.326	0.302	0.281	0.263	0.247	0.233	0.220	0.209	0.199	0.190
	0.12	0.950	0.784	0.667	0.581	0.514	0.462	0.419	0.383	0.353	0.327	0.305	0.285	0.268	0.253	0.240	0.228	0.217	0.207
	0.13	0.986	0.822	0.704	0.616	0.547	0.493	0.448	0.410	0.379	0.352	0.328	0.308	0.290	0.273	0.259	0.246	0.234	0.224
	0.14	1.020	0.857	0.739	0.649	0.579	0.523	0.476	0.437	0.404	0.376	0.351	0.330	0.311	0.294	0.278	0.265	0.252	0.241
	0.15	1.051	0.890	0.772	0.681	0.610	0.552	0.504	0.464	0.429	0.400	0.374	0.352	0.331	0.314	0.298	0.283	0.270	0.258
	0.16	1.080	0.921	0.803	0.712	0.639	0.580	0.531	0.490	0.454	0.423	0.397	0.373	0.352	0.333	0.317	0.301	0.288	0.275
	0.17	1.106	0.950	0.833	0.741	0.668	0.608	0.557	0.515	0.478	0.447	0.419	0.394	0.373	0.353	0.336	0.320	0.305	0.292
	0.18	1.131	0.978	0.861	0.770	0.696	0.635	0.583	0.540	0.502	0.470	0.441	0.416	0.393	0.373	0.354	0.338	0.323	0.309
	0.2	1.176	1.029	0.915	0.823	0.748	0.686	0.633	0.588	0.549	0.514	0.484	0.457	0.433	0.412	0.392	0.374	0.358	0.343