GROUNDFISH MANAGEMENT TEAM REPORT TO THE SCIENTIFIC AND STATISTICAL COMMITTEE ON A LITERATURE REVIEW OF SKATE DISCARD MORTALITY

The Groundfish Management Team (GMT) conducted a comprehensive literature review of skate discard mortality. This information is provided to aid the Scientific and Statistical Committee (SSC) in making a recommendation on the appropriate discard mortality rate to use for big skate (*Raja binoculata*). Due to the lack of studies focusing specifically on big skate, we focused the literature review on studies that reported discard mortality for any skate, and some species of ray, from commercial trawl gears.

We identified ten peer-reviewed publications that reported an estimate of skate discard mortality for fifteen Rajidae identified to the species level and a suite of species identified to genus. The average discard mortality rate across the ten papers was 38.3 percent, ranging from 19-50 percent across species within each study (Table 1). Mortality by species ranged from 0-100 percent depending on condition (e.g., fish condition, environmental condition, and fishing procedure; Appendix 1).

Almost all studies reported physical condition as a significant factor affecting discard mortality, with skates in poor physical condition having lower survival rates (Table 1). Studies found the codend weight to have a significant effect (Enever et al. 2010, Mandelman et al. 2013) as well as sex, with females having a higher survival rate in three studies (Enever et al. 2010, Laptikhovsky 2004, Stobutzki et al. 2002).

The depth range of big skate on the West Coast is 3-800 m or 1.6-437 fathoms (usually within 2-110 m or 2-60 fathoms; Allen et al. 1988) and the depth distribution for longnose skate is 9-1,069 m or 5-585 fathoms (usually within 44-350 m or 24-191 fathoms; Ormseth et al 2002). Laptikhovsky (2004) is the only study that compared discard mortality for species with different depth distributions and found skate with shallower distributions (*Psammobatis sp., Bathyraja brachyurops, and B. magellanica*) had a lower discard mortality rate than species commonly found in deeper waters *(B. albomaculata, B. griseocauda, and Bathyraja sp.*).

Our findings for big skate are consistent with the current discard mortality rate used for longnose skate (*Raja rhina*) of 50 percent in the West Coast individual fishing quota trawl fishery. The Pacific Fishery Management Council adopted the longnose skate stock assessment in 2007, which used a discard mortality of 50 percent (Gertseva and Schirripa 2007). The assessment authors derived the discard mortality rate from a personal communication with George McFarlane (Pacific Biological Station, Fisheries and Oceans Canada). A recent stock assessment for both big skate and longnose skate for British Columbia also used a discard mortality rate of 50 percent. The authors of the British Columbia assessment cited Gertseva (2009), Enever et al. (2009), Laptikhovsky (2004), and Stobutzki (2002), which reported skate discard mortalities of 50 percent, 45 percent, 40.9 percent, and 40 percent, respectively. Note that Gertseva (2009) is a peer-reviewed publication resulting from the 2007 longnose skate stock assessment.

Depth Range of Big Skate Encounters on the U.S. West Coast

As we noted in Agenda Item E.8.a, GMT Report 2, April 2015, the highest catches of big skate by the West Coast bottom trawl groundfish survey were at depths less than 100 fathoms (183 m). The GMT also demonstrated a similar depth distribution of catches of big skate by the commercial fishery using West Coast Groundfish Observer Data (Agenda Item H.4.b, GMT Report, November 2013). The U.S. west coast groundfish bottom trawl survey (2003-2010) surveys depths from 55-1,280 m (30 to 700 fathoms; Keller et al. 2012). Big skate were encountered at a mean depth of 104 m (59 fathoms), and depths ranging from 56 to 332 m (30 to 181 fathoms; Keller et al. 2012). The largest densities caught by this survey were in waters shallower than 183 m (100 fathoms; Bradburn et al., 2011).

The GMT contacted three independent shoreside bottom trawl fishermen with a request for anecdotal information on the depths where the fleet typically encounters big skates. They indicated that the shoreside bottom trawl fishery typically encounter the highest catches of big skate between 13-23 fathoms in the spring, but as summer progresses, they encounter high abundances of big skate as shallow as 3-4 fathoms. Some of the largest individual tows of big skate by some of these fishermen occur in 3-10 fathoms. In depths greater than 50 fathoms, at least 75 percent or more of skate encountered are longnose skate. Big skate are often not encountered by the commercial shoreside bottom trawlers in depths greater than 80 fathoms.

Final Remarks

Table 1 is a summary of the discard mortality rate information obtained from the GMT's literature review. Table 2 has information on the depth distribution of skate species listed in Table 1. More detailed information on the studies reviewed is contained in Appendix 1.

The GMT has provided this information as background to inform the SSC's recommendation to the Council on the discard mortality rate that should be applied to big skate.

PFMC
05/19/15

Table 1. Summary of discard mortality rate information from the literature search conducted by the GMT. Average discard mortality represent un-weighted averages across species within each study.

Species	Average discard mortality by study (percent)	Factors affecting mortality	Source
Leucoraja ocellata	50.0%	N/A	Benoît (2006)
Rajidae	31.8%	Physical condition	Benoît et al. (2010)
Rajidae	29.0%	Physical condition	Depestele et al. (2014)
Leucoraja naevus *Raja brachyura* *Raja clavata* *Raja microocellata*	45.0%	Physical condition	Evener et al. (2009)
Raja microocellata	45.0%	Physical condition sex codend weight	Enever et al. (2010)
Raja naevus	41.0%	N/A	Kaiser and Spencer (1995)
Bathyraja albomaculata *Bathyraja brachiurops* *Bathyraja griseocauda* *Bathyraja macloviana* *Bathyraja magellanica* *Bathyraja spp.* *Psammobatis spp.*	40.9%	Shallow-water species vs deep-water species	Laptikhovsky (2004)
Amblyraja radiata *Leucoraja erinacea* *Leucoraja ocellata* *Malacoraja senta*	19.0%	Tow duration (catch biomass, sex, temperature changes, and skate size factor for some species)	Mandelman et al. (2013)
Raja clavata *Raja miraletus*	41.0%	Physical condition	Saygu and Deval (2014)
Rays	40.0%		Stobutzki et al. (2002)
Avg. discard mortality (all studies combined)	38.3%		
Avg. survival	61.7%		

Table 2. Skate species depth distribution.

Scientific name	Common name	Depth distribution	Source
Amblyraja radiata	thorny skate	20-1,000 m	Stehmann (1990)
Bathyraja albomaculata	white-dotted skate	72-945 m (usually 200-35 0m)	Brickle et al. (2003)
Bathyraja brachiurops	broadnose skate	59-502 m (usually 200-350 m)	Brickle et al. (2003)
Bathyraja griseocauda	graytail skate	106-523 m (usually 200-350 m)	Brickle et al. (2003)
Bathyraja macloviana	Patagonian skate	80-250 m	Mabragana et al. (2005)
Bathyraja magellanica	Magellan skate	51-554 m	Menni and Stehmann (2000)
Leucoraja erinacea	little skate	0-329 m	Scott and Scott (1988)
Leucoraja naevus	cuckoo ray	20-500 m (usually 20-250 m)	Stehmann (1995)
Leucoraja ocellata	winter skate	0-90 m	Robins and Ray (1986)
Malacoraja senta	smooth skate	46-914 m	Robins and Ray (1986)
Raja binoculata	**big skate**	**3-800 m (usually 3-110 m)**	Allen et al. (1998); Eschmeyer et al. (1983)
Raja brachyura	blonde ray	10-380 m	Brito (1991)
Raja clavata	thornback skate	10-577 m	Mytilineou et al. (2005)
Raja microocellata	small-eyed ray	?-100 m	Stehmann (1990)
Raja miraletus	brown skate	17-462 m	Romero (2002)
Raja rhina	**longnose skate**	**9-1,069 m (usually 55-350 m)**	Ormseth et al. (2008); Mecklenburg and Thorsteinson (2002)

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Appendix 1. Detailed summary of literature reviewed.

Source	Region	Gear	Length of trawls	Depths	Summary of methods and additional notes	Common name (species)	Discard mortality
Benoît (2006)	southern Gulf of St. Lawrence (Canada)	research survey trawl gear	N/A	22-337 m	-study part of standard 2005 research survey -skates assessed for 10 seconds -proportion of skate not respiring was modeled -four significant covariates (time out of water, body length, interaction between time and body length, species)	Winter Skate (*Leucoraja ocellata*)	≥50%
Benoît et al. (2010)	southern Gulf of St. Lawrence (Canada)	bottom trawls (Danish and Scottish Seines)	1-2 h	N/A	-used at-sea observer data in a multinomial proportional-odds model -modeled observer-assigned vitality (1=excellent 4 = moribund) -significant covariates: catch amount -experimental fish tagged and put in onboard holding tanks held fish for 48 h;	Rajidae	Vitality 1= 0%; Vitality 3=37.5%; Vitality 4 = 57.9% mortality after 48h
Depestele et al. (2014)	southern North Sea	Euro-cutter beam trawl	1.5 h	10-50 m	-held fish in tanks after trawl -Kaplan-Meier survival estimates -Weibull model with survival rate as a function of physical injuries	Rajidae	28% mortality at 80 h; 23% mortality at 65 h

Source	Region	Gear	Length of trawls	Depths	Summary of methods and additional notes	Common name (species)	Discard mortality
Enever et al. (2009)	Bristol Channel (UK)	twin-rig otter trawls	2.7-4.3 h	30-60 m	-onboard holding tanks used to assess short-term survival of trawl-caught skates -"health" a good indicator 795 of skates with poor health score did not survive survival for moderate health was 84% good health 95% -proportion in poor health positively correlated with codend weight	Cuckoo ray (*Leucoraja naevus*)	Short term survival of 33% (48 h) n=6 comm. Tow
						Small-eyed ray (*Raja microocellata*)	51% survival (58.5 h) n=39 commercial tow
						Blonde ray (*Raja bachyura*)	55% (48 h) n=11 commercial tow 67% (64 h) short two n=3
						Thornback skate (*Raja clavata*)	59% (60.6 h) commercial tow n=68 91% (64.1 h) short two n=34
Enever et al. (2010)	Bristol Channel (UK)	twin-rigged demersal trawl (3 different codends)	5.5 ± 0.1 hours	35-65 m	-fish held in holding tanks 10 and 20 min after catch brought onboard -each skate given a health score -retained skates examined again after 48 hours -skates entering the tanks with poor health had a 44% chance of survival those with better scores had 86% chance of survival -females survived better (67%) than males (49%)	Small-eyed skate (*Raja microcellata*)	44% standard codend; 41% with 100 mm diamond codend; 35% with the 100 mm square codend

Source	Region	Gear	Length of trawls	Depths	Summary of methods and additional notes	Common name (species)	Discard mortality
Kaiser and Spencer (1995)	North and Irish Seas	beam trawl	0.5 h	34 m	-one species of skate is in a table but is not mentioned anywhere else in the paper	Cuckoo ray (*Raja naevus*)	41% after 72 hours
Laptikhovsky (2004)	Falkland Islands	bottom trawl	N/A	80-190 m	-fish held in tanks Time in bin was 5-200 min. -65.2% of the individuals were initially assigned as dead the actual mortality was 40.9% though it took some up to 6 hours to recover -higher discard mortality for deeper dwelling species, lower discard mortality for females	White-dotted skate (*Bathyraja albomaculata*)	28.60%
						Broadnose skate (*Bathyraja brachiurops*)	45.40%
						Graytail skate (*Bathyraja griseocauda*)	100%
						Patagonian skate (*Bathyraja macloviana*)	100%
						Magellan skate (*Bathyraja magellanica*)	40%
						Bathyraja spp.	25%
						Psammobatis spp.	40%

Source	Region	Gear	Length of trawls	Depths	Summary of methods and additional notes	Common name (species)	Discard mortality
Mandelman et al. (2013)	Gulf of Maine	commercial otter trawl	15-20 min; 90-120 min; 180-240 min	15.8-75 m	-time on deck standardized to 10 min -Fish held in tanks -transferred into partially submerged net pens and slowly lowered to seafloor for 72 hour mortality trials -sex a significant factor (little skate), catch biomass and TL (thorny skate), tow duration (winter skate)	Little skate (*Leucoraja erinacea*)	14%; 22% when only accounting for moderate and extended tows
						Smooth skate (*Malcoraja senta*)	59%; 60% when only accounting for moderate and extended tows
						Thorny skate (*Amblyraja radiata*)	19%; 23% when only accounting for moderate and extended tows
						Winter skate (*Leucoraja ocellata*)	8%; 9% when only accounting for moderate and extended tows
Saygu and Deval (2014)	Antalya Bay (eastern Mediterranean)	bottom trawl	1-3 hours	150-200 m	-fish held in tanks -health status then determined -health checked at 2, 4, 6, 12, 24, and 48 hours -logistic regression models used for analysis of probably biological and physical factors	Thornback skate (*Raja clavata*)	19%
						Brown skate (*Raja miraletus*)	79%
Stobutzki et al. (2002)	north coast of Australia	bottom trawl	N/A	15 to 50 m	-ranked species by susceptibility to capture and mortality in the spot prawn trawl fishery	Rays	40% modelled (56% females, 67% males)