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NORTH PACIFIC SPINY DOGFISH (*SQUALUS SUCKLEYI*) PRESENCE IN EELGRASS HABITAT IN THE SALISH SEA, WASHINGTON

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Key words: eelgrass, mesopredator, *Oncorhynchus*, Pacific Herring, Puget Sound, salmon, Spiny Dogfish, *Squalus suckleyi*, *Zostera marina*

Eelgrass (*Zostera marina*) is the dominant seagrass along the Pacific North American Coast, providing complex physical structure, high trophic productivity, and protection from predators (Phillips 1984; Simenstad 1994). Because of these multiple functions, many fish species and life stages use Eelgrass beds more than other nearshore habitat types (Dean and others 2000; Murphy and others 2000; Johnson and Thedinga 2005). Currently, there is growing evidence identifying nearshore habitats as places that may be regularly inhabited by large-bodied fish, including sharks (Tobin and others 2014), but it is not clear how much sharks use Eelgrass habitat. In other parts of North America, several sharks have been reported inhabiting Eelgrass habitat, including Sandbar Sharks (*Carcharhinus milberti*) in Chesapeake Bay, Maryland and Virginia (Orth and Heck 1980), Leopard Sharks (*Triakis semifasciata*) in Humboldt Bay, California (Ebert and Ebert 2005), and Gray Smooth-hound Sharks (*Mustelus californicus*) in Bolsa Chica, Orange County, California (Espinoza and others 2011). Conversely, reports of sharks are rare in Eelgrass beds in the Salish Sea region, which is located between the southwestern tip of British Columbia and the northwestern tip of Washington (Fig. 1; Farrer 2009). In this region, North Pacific Spiny Dogfish (*Squalus suckleyi* Girard 1854; Ebert and others 2010), hereafter Spiny Dogfish, are currently considered an abundant upper trophic level predator (Harvey and others 2010). Although Spiny Dogfish have been documented as making local movements along the nearshore in Puget Sound, Washington (Andrews and Harvey 2013), they have not generally been reported in Eelgrass habitat. Spiny Dogfish, however, have been captured in sand and Eelgrass habitat in Samish Bay, Washington, using overnight commercial gill net sets (Farrer

2009). Here we document the use of Eelgrass habitat by Spiny Dogfish.

We conducted our study in Padilla Bay National Estuarine Research Reserve, Mount Vernon, Washington. Padilla Bay sustains one of the most extensive Eelgrass beds in the inner Salish Sea region (Berry and others 2003; Fig. 1). The shallow estuary covers nearly 4500 ha, of which >3200 ha is Eelgrass of both the native *Z. marina* and the non-native *Z. japonica* (Shull 1999). Padilla Bay differs from most estuaries in the region because it has become isolated from major rivers as it has filled with sediment from the Skagit River to the south, and the Eelgrass has thrived in the absence of a major freshwater input. However, drainage from adjacent agricultural lands enters via sloughs with tidegates. Other nearby sources of freshwater are the Samish River to the north and the Skagit River via the Swinomish Channel to the south. Tides in the region are mixed semidiurnal.

We sampled 3 sites along major tidal channels in contiguous *Z. marina* habitats that were located over mud bottoms. These sites were located in the north (Short Channel), middle (Middle Channel), and south (Bayview Channel) portions of Padilla Bay (Fig. 1). At each site, we sampled 2 adjacent locations to have replicate samples, thereby completing 6 overnight gill-net sets for each month of May, June, and July of 2004. We trawled during the day to characterize the fish assemblage in the shallows (Penaluna 2006), and we set gill nets overnight in Eelgrass locations parallel to the adjacent tidal channel to document nocturnal movements of larger fishes. Each 15-m by 2-m experimental gill net was composed of five 3-m panels, with square mesh size increments of 12, 25, 38, 50, and 68 mm, with lead- and foam-core lines. We sampled when tidal elevations ranged from -1.5- to -3.0-m mean lower low water. Catch per unit of effort (CPUE) was measured as number of fish per net-hour.

The highest CPUEs of Spiny Dogfish captured during overnight gill-net sets were recorded in June and July (Table 1; Fig. 2). Spiny



FIGURE 1. Padilla Bay habitat map distinguishing ground cover types of *Zostera marina* Eelgrass, *Z. japonica* Eelgrass, and intertidal sand and mud, with its location in the greater Salish Sea region. Habitat types were determined by aerial photos taken on 14–15 July 1996 in Puget Sound, Washington (modified from Shull 1999).

Dogfish are the largest predatory fish in Padilla Bay, and they are also the largest among fishes reported in other studies of nearshore habitat for the Salish Sea region (Miller and others 1977; Fresh 1979; Simenstad and others 1988; Simenstad 1994; Micucci 2000; Hosack and others 2006). They are a mobile, transitory mesopredator known to inhabit nearshore estuarine environments with higher salinities (NOAA 1990) and water temperature in the range of 8 to 12°C (Andrews and

Harvey 2013). Some sharks, such as Gray Smooth-hound Sharks, use Eelgrass beds seasonally in Bolsa Chica (Espinoza and others 2011), while others are year-round residents, such as the Leopard Sharks in Elkhorn Slough, California (Carlisle and Starr 2009).

Forays by Spiny Dogfish into shallower waters are likely limited to nighttime (NOAA 1990), suggesting that they may not use Eelgrass habitat during the day or may use Eelgrass

TABLE 1. Catch per unit effort and fish size (total length in mm) for fishes captured by overnight gill net sets in 2004. Fish size ranges are from minimum to maximum values and are noted in parentheses.

Species	May	June	July
North Pacific Spiny Dogfish (<i>Squalus suckleyi</i>)	7 (750–851)	60 (685–1000)	64 (640–1010)
Shiner Perch (<i>Cymatogaster aggregata</i>)	233 (72–152)	36 (46–154)	12 (85–125)
Snake Prickleback (<i>Lumpenus sagitta</i>)	0	0	3 (235–285)
English Sole (<i>Parophrys vetulus</i>)	0	0	1 (104)
Starry Flounder (<i>Platichthys stellatus</i>)	0	1 (410)	5 (385–485)
Pacific Staghorn Sculpin (<i>Leptocottus armagus</i>)	7 (110–181)	12 (110–176)	22 (105–235)
Whitespotted Greenling (<i>Hexagrammos stelleri</i>)	0	1 (170)	1 (105)
Great Sculpin (<i>Myoxocephalus polyacanthocephalus</i>)	1 (132)	0	0
Pacific Herring (<i>Clupea pallasii</i>)	12 (171–232)	0	0
Pile Perch (<i>Rhacochilus vacca</i>)	3 (82–272)	0	2 (150–290)
Surf Smelt (<i>Hypomesus pretiosus</i>)	11 (92–180)	0	0

habitat differently between day and night. Deployment of gill nets overnight has been the only successful method documented for capturing Spiny Dogfish in Eelgrass beds (this study; Farrer 2009). Previous studies in Eelgrass beds of Padilla Bay using daytime gill-net sets did not capture Spiny Dogfish (Fresh 1979; Simenstad and others 1988; Micucci 2000; Penaluna 2006). In support of our finding, Brown Smooth-hound Sharks (*Mustelus henlei*) are most active at night compared to day (Campos and others 2009), and Gray Smooth-hound Sharks are most often found in Eelgrass habitat at night (Espinoza and others 2011). All other fishes captured in overnight gill-net sets (Table 1) were also captured during daytime netting (Penaluna 2006).

We captured Spiny Dogfish of both sexes, and based on their size distribution it is likely that they were individuals reaching or at sexual maturity (Jones and Geen 1977). Based on more than 131 specimens, females tended to be larger and less abundant than males (Fig. 2). Females ($n = 17$ in June, $n = 23$ in July) measured 640- to 1010-mm total length and comprised one-third of the sample, while males ($n = 43$ in June, $n = 41$ in July) ranged from 660 to 860 mm. In the nearby Strait of Georgia, British Columbia, lengths of Spiny Dogfish at 50% maturity were 935 mm for females and 785 mm for males (Jones and Geen 1977). Accordingly, it is possible that Eelgrass beds are used as a nursery area (Heupel and others 2007), and immature sharks are staying near their birthing grounds until they mature. Some female sharks in Padilla Bay may also have been staging in early summer to prepare for parturition, which has been shown to occur from September to January in the Strait

of Georgia (Jones and Geen 1977). Based on the size distribution in our study, we did not capture young-of-year sharks (Jones and Geen 1977).

Spiny Dogfish may use Eelgrass habitat because it offers increased prey availability and protection from larger predators. For example, in Tomales Bay, California, Brown Smooth-hound Sharks exhibit behaviors that could be attributed to avoidance of predatory Sevengill Sharks (*Notorynchus cepedianus*) or increased access to productive foraging areas during higher tides (Campos and others 2009). Spiny Dogfish are opportunistic predators feeding on pelagic and benthic prey (Reum and Essington 2008), and, hence, it is possible that they enter Eelgrass beds at night during high tide to forage when other fish and invertebrates are available in both mud and Eelgrass habitats. For example, based on their movement patterns, Gray Smooth-hound Sharks seem to forage at night likely accessing prey items that are more abundant in Eelgrass habitats (Espinoza and others 2011). Although salmon are considered a very small portion of the diet of Spiny Dogfish (Jones and Geen 1977), we attribute occasional depredation in our gill nets, including an adult Chinook Salmon (*Oncorhynchus tshawytscha*), to feeding by them (Beamish and others 1992; Schari and others 2000).

In conclusion, given the relatively high abundance of Spiny Dogfish in months with warmer water temperatures (June and July) as reported in this study, it is reasonable to consider that this species is an important component of the fish assemblage and thus, part of the food web associated with Eelgrass beds of Padilla Bay. Likely, Spiny Dogfish occupy a similar ecological role as an upper trophic level predator as do other shark species in other

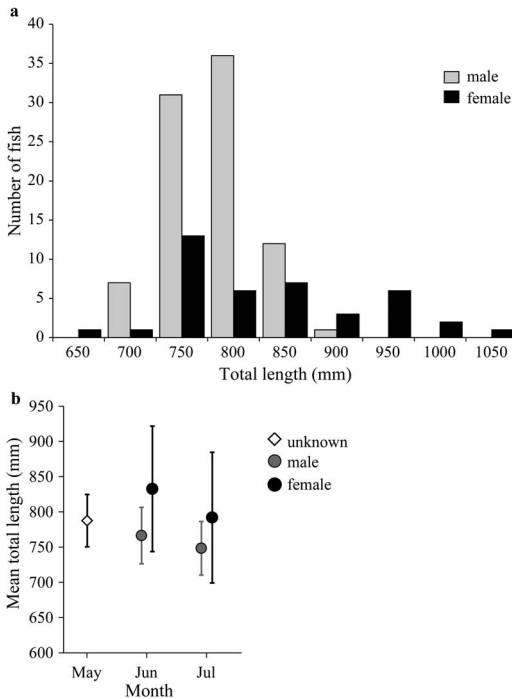


FIGURE 2. North Pacific Spiny Dogfish (*Squalus suckleyi*): (a) length-frequency distribution; and (b) total length by month in Padilla Bay, Salish Sea, Washington, from May, June, and July 2004.

intact Eelgrass beds of the Pacific coast of North America. Although it is still unclear why many sharks use Eelgrass habitat, it seems that this habitat provides a broad range of ecological benefits for them, including refuge from larger predators, and enhanced reproduction, parturition, growth, and foraging (Tobin and others 2014). Currently there is widespread recognition of the conservation value of Eelgrass beds as nursery areas for juvenile fishes. Here, we provide empirical evidence that these habitats are used by sharks and we suggest that Eelgrass habitat ecologically supports a broader range of the fish assemblage than previously acknowledged. This study represents an initial contribution in documenting the use of Eelgrass beds by Spiny Dogfish, and we encourage future studies that elucidate the ecological role of this mesopredator in nearshore habitat dominated by Eelgrass.

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