Dungeness Crab (*Metacarcinus magister*)

Certification Units Considered Under this Species:

- California Trap fishery

Summary

Dungeness crab was the highest value fishery in California during the 2011-12 commercial fishing season. The commercial fishery is managed by the state Legislature using the "3-S principle" – restricting take by sex, season, and size. Formal fishery management plans and stock assessments have not been produced for any West Coast population, though a "healthy" status has been assigned since landings have fluctuated around a moderately stable long-term mean for over 30 years. California, Oregon, and Washington Dungeness crab fisheries coordinate and develop consistent and potentially complementary management actions under a tri-state committee, and the Dungeness Crab Task Force (DCTF) was established in California to review and evaluate Dungeness crab management measures and makes recommendations to the Joint Committee on Fisheries and Aquaculture, the Department of Fish and Wildlife, and the Fish and Game Commission. California has created a pot limitation program to be implemented in the 2013-14 commercial fishing season. As of 2010, the Oregon Dungeness crab commercial trap fishery is certified sustainable by the Marine Stewardship Council (MSC). If California pursues certification, Oregon will serve as an excellent example.

Strengths:

- Relatively stable landings for over 30 years
- High value fishery in California
- High observed mating success of Dungeness crab
- DCTF established to make management recommendations
- Trap limitation program to be implemented for 2013-14 season will reduce impacts on marine habitats
- Traps have low habitat impacts
- Management measures largely coordinated among CA, OR, and WA

Weaknesses:

- No formal stock assessments
- Reference points not explicit
- Long-term fishery objectives and research plan unclear
- Bycatch data not collected

History of the Fishery in California

Biology of the Species

Dungeness crab, *Metacarcinus magister* (formerly *Cancer magister*), are endemic from Alaska to Magdalena Bay, Baja California though are rarely seen south of Santa Barbara, CA (CDFW 2001). Water temperature determines their distribution, and the 38° to 65° F (3° – 18° C) surface isotherms are considered the limits of the range. The geographic range of the species probably depends more on the restricted thermal tolerance range of larvae than of adults. This species has a preference for sandy to sandy-mud bottoms but may be found on almost any bottom type. Dungeness crabs may range from the intertidal zone to a depth of at least 750 feet (229 meters), but are not abundant beyond 300 feet (91 meters).

Crab mating occurs from March to July in offshore locations. After female crabs have molted, a male deposits a spermatophore inside a female, which contains sperm that is viable for up to several years (Hankin et al. 1989). Female eggs are fertilized upon extrusion during September to November (Orcutt et al. 1976; Wild 1983), after which they are carried beneath an abdominal flap for 60 – 120 days. Development of early stages is temperature-dependent and decreases in duration from north to south along the coast. A single brood may contain from one to two million eggs (Wild 1983), and a female may produce three to four broods during her lifetime. Larvae shed their outer skeleton (molt) through five planktonic zoeal stages (Poole 1966; Reed 1969; Lough 1976), and can be transported 3.1 – 3.7 miles (5 – 6 kilometers) offshore. Larvae metamorphose into megalopae and then settle as juveniles in shallow coastal waters and estuaries that provide nursery grounds for young crabs. Juveniles typically molt 11 to 12 times before reaching sexual maturity in approximately 2 to 3 years (Butler 1960; Butler 1961). Most adults reach marketable size in about 4 years and have a maximum lifespan of 8 to 10 years (Hankin et al. 2001). Food sources for adults include clams, crustaceans and fish (Gotshall 1977).

Commercial Fishery

The Pacific Ocean fishery for Dungeness crab is administered in the State waters of California, Oregon, Washington and Alaska in the exclusive economic zone (EEZ) adjacent to those States. The California commercial fishery occurs in two main areas: northern and central California (divided at the Sonoma-Mendocino border). Central California fishing areas include Santa Barbara, Avila-Morro Bay, Monterey, Half Moon Bay and San Francisco-Bodega Bay. Northern California fishing grounds extend from Fort Bragg to the California-Oregon border, with the prime area located between Eureka and Crescent City.

Dungeness crab populations undergo cyclic fluctuations due to varying oceanic conditions, including wind-driven currents, ocean temperature, and food availability (Higgins et al. 1997; WDFW 2006; Hankin and Warner 2001). As a result, Dungeness crab landings in California have experienced periods of highs and lows (Figure 1; CDFG 2001). Total statewide Dungeness crab landings for the past 50 seasons have averaged 10.3 million pounds (4700 metric tons), 12.7 million pounds (5800 metric tons) for the past 20 seasons, and 16.0 million pounds (7300 metric tons) for the past 10 seasons (CDFG 2011). Four of the top five record seasons have occurred in the past ten years. A new statewide record of 31.7 million pounds (14,370 mt) was landed in the 2011-12 season.

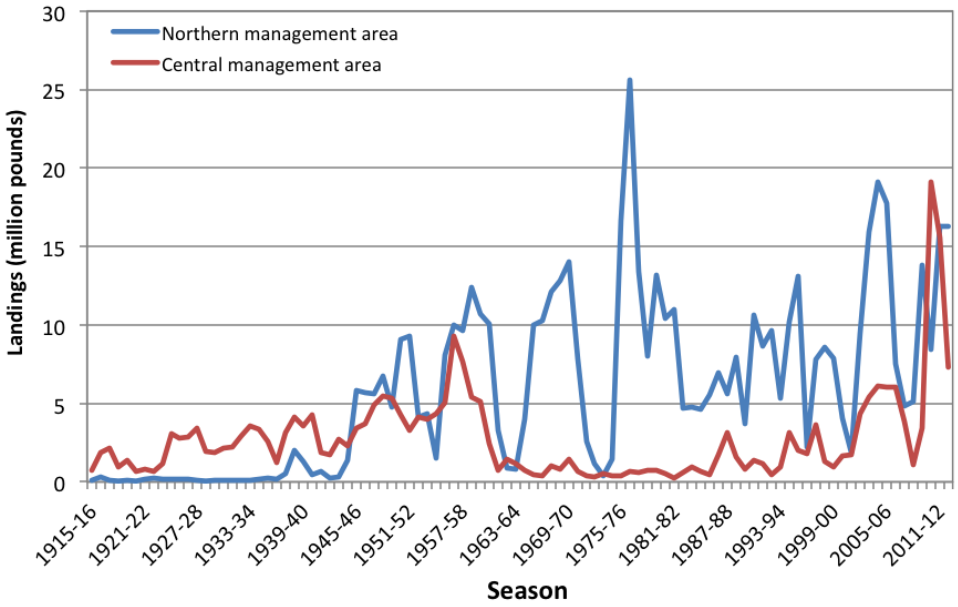

Figure 1. Dungeness crab commercial landings by season (1915-16 – 2012-13) and management region (divided at the Mendocino/Sonoma County line), all gear types combined (CDFG 2011).

Ex-vessel value (price paid to the fishermen for their catch) during the past 10 seasons has averaged $30.4 million, maintaining Dungeness crab as one of the most valuable fisheries in California (CDFG 2011). For the past 10 years Dungeness crab has ranked first compared to all other commercial fisheries in ex-vessel value for the following years: 2003, 2004, and 2006, and second after market squid for all other years. The 2011-12 catch was valued at $94.9 million ($2.99/lb), a record for Dungeness crab.

In California, commercial Dungeness crab is caught using traps. The traps are made from 2 circular iron frames 3 to 3.5 feet (0.9-1.1 meters) in diameter that are connected with spokes on the outer edges. The frame is wrapped with strips of rubber and the entire frame is enmeshed with stainless steel wire. Two entrance tunnels fitted with trigger bars prevent escapement of larger crabs and every trap must contain at least two escape ports with openings not less than 4.25 inches (10.8 centimeters) for the purpose of decreasing the likelihood of catching and retaining the generally smaller females and sublegal males. In the event the trap is not recovered, traps are equipped with a destruct device to allow the eventual escape of all crabs (CDFG 2011). Steel traps weigh 60 to 120 pounds (27 – 54 kilograms) and usually fished at depths from 60 to 240 feet (18 – 73 meters) overnight or longer, depending on sea conditions and regulations. The fishery includes vessel lengths from 22 -100 feet (7 – 30 meters) (CDFG 2004).

Recreational Fishery

The California Dungeness crab recreational fishery is regulated by the Fish and Game Commission (FGC), which controls take by season, daily bag limits, gear and size. Historically, California Recreational Fisheries Sampling (CRFS) have informally estimated the recreational catch at about one percent of commercial catch (CDFG 2011). However, due to the sparse sampling efforts, this number may not be an accurate representation. Recently, the CRFS

program began opportunistic sampling of the Dungeness crab catch for Catch Per Unit Effort (CPUE), size and sex ratios beginning with the 2009-10 season. However, due to funding restrictions the sampling is not rigorous enough to create reliable estimates of catch and effort at this time. Recreational catch is generally accepted by managers to be lower than commercial catch, in part based on Commercial Passenger Fishing Vessel (CPFV) logbook data (P. Kalvass, CDFW, pers.comm.).

The recreational fishery is open from November through June. Both sexes may be taken (unlike the commercial fishery), the bag limit is 10 crabs and the size limit is 5.75 in carapace width, except when fishing from a commercial passenger fishing vessel in Sonoma, Marin, San Francisco, San Mateo, Santa Cruz and Monterey counties, when the size limit is 6 in and the bag limit is 6 crabs.

MSC Principle 1: Health of Fish Stock

*Sustainability of Target Stock

The California Department of Fish and Wildlife (CDFW) (formerly, the California Department of Fish and Game prior to 2013) and the other west coast fishery agencies do not conduct formal stock assessments for Dungeness crab primarily due to the stochastic nature of recruitment that appears to be minimally linked to fishing pressure. This fact and the high costs associated with a formal stock assessment would not make for a cost-effective assessment (P. Kalvass, CDFW, pers. comm.). As a result, current population abundance and occurrence of overfishing in Dungeness crab fisheries are unknown, and biological reference points are not designated for this fishery. The Oregon Dungeness crab fishery used an age structure model a yield-per-recruit (YPR) and eggs-per-recruit to evaluate trade-offs in yield, and recommended a limit reference point (Heppell 2009):

"Recommended LRP: Decline in catch sustained over 4 years (approximately 1 generation time) and an overall reduction in catch of >=80% from the 20 year average (approximately 5 generations; current floor would be 2.8 million pounds)."

However, the major shortcoming of this LRP is that it is based on catch rather than an index of abundance.

Exploitation rates indicate from 80% to 90% of all legal-sized male crabs (typically one or two year classes) are captured annually in the fishery, but studies suggest this does not translate into decreased mating success for females (Hankin et al., 1997). Virtually all sexually mature females are fertilized each year and the size limit allows the males to spawn at least once, thus it may not be cost effective to conduct stock assessments for this species (P. Kalvass, CDFW, pers. comm.).

California populations have produced landings that have fluctuated around a moderately stable long-term mean for over 30 years. Although landings experienced dramatic and periodic cycles from around 1945 to 1982 (Figure 1), researchers suggest changes in climate and other oceanographic factors (including warming) and increased pollution in the San Francisco Bay as likely explanations for the observed fluctuations. It is probable that crab populations, similar to other crustacean populations such as Pacific shrimp, experience large natural variations in abundance since crabs produce large amounts of eggs and have vulnerable early life stages. In the past 4 – 5 years, CDFW researchers in association with UC Davis Wildlife Health Center at

*For California's Sustainable Seafood Program, this category must score an 80 or higher during an MSC assessment.

Bodega Marine Lab have been conducting Dungeness crab megalopae trapping studies utilizing light traps to attract megalopae at night, and monitored daily to obtain an index of abundance during the spring transition (CDFG 2011). Megalopae have been captured in Bodega Bay, Fort Bragg's Noyo Harbor, and in Humboldt Bay from about mid March to July, though results are not yet available (CDFG 2011; P. Kalvass, CDFW, pers. comm.).

The Dungeness crab fisheries along the coastal western states are considered sustainable due in part to the combination of a simple but effective fishery management scheme optimized by crab life history (CDFG 2011). Dungeness crabs exhibit life history characteristics that make them inherently resilient to fishing pressure, as they have a low age at first maturity, a short lifespan, and high fecundity (Table 1). It has been hypothesized that because the males also mature before they recruit to the fishery, there is no evolutionary pressure towards smaller size at age, as often is seen in finfish as a result of fishing selectivity (Field, NOAA Southwest Fisheries Science Center, pers. comm.). However, to definitively determine if variation in landings is a result of changes in abundance or differences in effort per season, it is necessary to examine CPUE data. CDFW do not collect CPUE data, so although stocks are believed to be healthy there is lack of empirical evidence to support this conclusion based solely on landings data. In the most recent 2012-13 season, researchers at Oregon State University obtained tissue samples for genetic analysis of Dungeness crab during the preseason testing to explore genetic connectivity of West Coast Dungeness crab stocks, though results are not yet available (P. Kalvass, CDFW, pers. comm.). Previous research suggests there is weak connectivity and likely genetic separation between the states (Toonen and Grosberg, 2003). Oregon State University and three west coast state's fish and wildlife agencies have initiated a collaborative project to further examine the population genetic structure of Dungeness crab off the west coast which will provide a higher degree of spatial and genetic resolution (ODFW, 2013)

Table 1. Life history characteristics of Dungeness crab (Hankin et al. 2001; Pauley et al. 1989; CDFG 2011).

Age at Maturity	Max Age	Max Size	Fecundity	Species Range
2-3 years	8-10 years	Males: 8.6 in (22 cm) CW; Females: 6.3 in (16 cm) CW	0.5-2 million eggs per brood	Aleutian Islands to Santa Barbara

Evaluation against MSC Component 1.1: Sustainability of Target Stock

MSC Performance Indicators	Rating	Justification
1.1.1 Stock Status [1]		Landings have fluctuated around a moderately stable long-term mean; stock assessments not conducted, though fishery is generally considered healthy due to management measures and crab life history characteristics
1.1.2 Reference Points		No designated reference points or landings limits, but other management measures in place ('3-S' principle, limited entry)
1.1.3 Stock Rebuilding		Was not assessed

Harvest Strategy (Management)

The west coast Dungeness crab fishery is conducted in both state (0-3 nautical miles from shore) and federal (3-200 nautical miles) waters of Oregon, Washington and California. Most fishing is conducted within 50 miles (80 kilometers) from shore (ODFW 2006c). A fishery spanning both state and federal zones is normally managed through a federal fishery management plan (FMP) developed through a regional fishery management council, with explicit state-federal coordination. The Dungeness crab fishery is an exception to this rule. Section 302(e) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) exempts the Dungeness crab fishery from the requirement of a federal FMP and instead authorizes the states of California, Oregon, and Washington to adopt and enforce state laws and regulations governing Dungeness crab fishing and processing in the federal exclusive economic zone adjacent to each state. California, Oregon and Washington share many management concerns and have the ability to discuss and align management of Dungeness crab through the Tri-State Dungeness Crab Committee which is overseen by the Pacific States Marine Fisheries Commission, and a Memorandum of Understanding is in effect among the three states in setting size, sex, and season limits (U.S. House of Representatives 1998; Anon. 2005; CDFG 2012c; CDFG 2011). To date, California has had less success in passing legislation to update and streamline the management of the Dungeness crab fishery in coordination with Oregon and Washington. As of 2010, the Oregon Dungeness crab commercial trap fishery is certified sustainable by the Marine Stewardship Council (MSC) (MSC 2010).

Currently, Dungeness crab management plans and stock assessments have not been produced for any West Coast populations. Landing quotas have never been used in this fishery, however the limited entry program limits the number of permits issued each season. Commercial Dungeness crab management relies on the "3-S" principle (sex, season and size restrictions), and is considered successful since males can reproduce several times before reaching legal size, females are protected and the season is set to avoid molting and mating periods and make sure crabs are ready for harvesting. In the northern region, a delay of season opening may be authorized based on quality tests of the stock, conducted in concert with tests in Washington and Oregon. The states then mutually agree on whether to delay the opening of the season in

[1]This includes one of the two performance indicators (PI 1.1.1) that the California certification will require a higher score (80) than MSC.

order to let the crabs accumulate more body meat. Seasonal openings differ between regions since central California crabs typically molt earlier and achieve adequate market condition earlier than northern region crabs due to the temperature dependence of crab development.

In 2009, pursuant to Senate Bill (SB) 1690, the Dungeness Crab Task Force[1] was established in California. The DCTF is composed of commercial and recreational Dungeness crab fishermen from ports between Morro Bay and Crescent City and crab processors, as well as non-voting members from CDFW, Sea Grant, and non-governmental organizations (CDFG 2011). The DCTF is charged with making recommendations on commercial and recreational management measures such as trap limits, fleet size reduction, and season opening date changes, among others, to the Legislature's Joint Committee on Fisheries and Aquaculture, CDFW, and FGC. Through the efforts of the DCTF, new legislation was passed in 2011, which re-established the DCTF and implemented trap limits on commercial Dungeness crab vessel permit holders. The trap limit program is scheduled to take effect by the 2013-14 season which will limit the number of traps allowed per permitee based on a their total catch from a consecutive five-season period.

Commercial permits are required on all commercial fishing vessels that use Dungeness crab traps, and a permitee is allowed to fish only in the state, or management region within a state, for which that permit is designated; additionally, catch does not have to be landed in the state from which the permit was issued. In 1995, a limited entry program was implemented which limits the total number of permits in the fishery. As of 2012, there are currently less than 600 permits, with approximately 450 active permits (CDFG 2012c). Crab traps must contain escape openings for sub-legal males that do not meet catch regulations, and must also possess a destruction device that will release crabs should the trap become lost or derelict. Recreational crabbing is not allowed from vessels licensed for commercial Dungeness crab fishing (CDFG 2012a).

Evaluation against MSC Component 1.2: Harvest Strategy (Management)

MSC Performance Indicators	Rating	Justification
Harvest Strategy (PI 1.2.1)		The 3-S principle limits take by sex, season and size; limited entry; Trap limits to be implemented starting for the 2013-14 season
Harvest Control Rules and Tools (PI 1.2.2)		3-S principle, gear restrictions, limited entry permitting, season closures
Information/Monitoring (PI 1.2.3)		Landings data, fishery dependent and independent research, logbooks
Assessment of Stock Status (PI 1.2.4)		Stock assessments are not performed; Megalopae trapping studies currently being conducted to assess abundance but results not yet available

[1]More information about the Dungeness crab task force may be found on Ocean Protection Council's website: http://www.opc.ca.gov/2009/04/dungeness-crab-task-force/

MSC Principle 2: Impact on Ecosystem

Retained Species

Traps

Incidental catch is reportedly low but an unquantified number of octopuses are often kept (P. Kalvass, CDFW, pers. comm.). Octopuses are allowed incidentally in several fisheries though no direct octopus fishery is allowed. Legislation in 2009 permits the incidental commercial take of other rock crab species in Dungeness crab traps and Dungeness crab in rock crab traps, provided that all crabs retained are in season and fishermen possess the proper licenses and permits (CDFG 2011). Any fish may be taken incidentally in crab traps being used to take Dungeness crab; data on the species and number retained are likely available from landings receipts (CDFG 2012a).

Evaluation against MSC Component 2.1: Retained Species

MSC Performance Indicators	Rating	Justification
2.1.1 Outcome		Low levels of octopus retained but not quantified; any fish may be taken incidentally in traps – species and quantity unknown; likely green but more information is necessary
2.1.2 Management		Qualitative reports suggest incidental catch is minimal; octopus are allowed incidentally; unclear which fish species are retained; likely green but more information is necessary
2.1.3 Information		Landings receipts; likely green but information is currently inaccessible

Bycatch Species

Traps

Non-target species captured in the California Dungeness crab fishery are known synoptically but are not quantified. Bycatch is perceived to be very low by managers; thus no effort is made to record information on non-target catch when it occurs and, to date, no consistent studies have been done that address non-target species in the Dungeness crab fishery (MSC 2010). According to Harrington et al. (2005), pot/trap fisheries produce less bycatch than most fisheries (MSC 2010). Bycatch is minimized by characteristics of the gear and the style of harvest. For instance, Valdemarsen and Suuronen (2001) point out that traps initiate selectivity through the use of bait that has the potential to attract the target species and/or repel unwanted organisms. Moreover, catch of non-target species is reduced by design elements, including mesh sizes and the size, shape, location(s) and design of pot entrances and escape openings (Valdemarsen and Suuronen 2001). Occasionally, sublegal male Dungeness crabs, lingcod, sculpins, flat fish, rockfish, and sea stars are caught in the pots, but they either exit through the pots' escape mechanisms or are discarded alive at sea (Kalvass, CDFW, pers. comm.). Dungeness crab

bycatch that dies relative to landings is less than 5%, however for soft shell crabs, mortality has been reported as high as 22% to 25% (Alverson et al. 1994). Since the Northern season does not open until shells are harder, this is not a major issue in this region. Additionally, egg-bearing female Dungeness crabs typically bury themselves in the sand and do not enter traps. In the most recent 2012-13 season, federal groundfish observers collected preliminary data on bycatch rates in the Dungeness crab fishery during preseason testing, although this data is not yet available (Kalvass, CDFW, pers. comm.). Although trap gear may be highly selective, the lack of data on bycatch rates in the California Dungeness crab fishery make it difficult to assess if the fishery poses a risk of serious or irreversible harm to bycatch species.

Evaluation against MSC Component 2.2: Bycatch Species

MSC Performance Indicators	Rating	Justification
2.2.1 Outcome		Bycatch is low but not quantified; likely green but more empirical data is needed on species and quantities discarded to determine if the fishery poses a risk to bycatch
2.2.2 Management		Bycatch is low and many species can be discarded alive, however rates are unknown; likely green but more data is necessary on species discarded to determine what management measures exist
2.2.3 Information		Preseason observer data collected for 2012-13 season; likely green but information is currently inaccessible

*Endangered, Threatened, & Protected Species

Traps

National Marine Fisheries Service (NMFS) classifies all U.S. commercial fisheries into one of three categories (I, II, III) based on the level of serious injury and mortality of marine mammals that occurs in each fishery. NMFS List of Fisheries (LOF) classified the California Dungeness crab trap fishery as a category II, indicating occasional incidental mortality or serious injury of marine mammals. Humpback whales (*Megaptera novaeangliae*) and gray whales (*Eschrichtius robustus*) may occasionally become entangled in Dungeness crab fishing gear (NMFS 2012; MSC 2010). The two serious injury humpback whale entanglement events (occurring from 2002-2006) could not be identified to a trap fishery by gear type, although the Dungeness crab fishery operates with similar gear in the same location as the confirmed humpback whale entanglement events (NMFS 2012). Similarly, NMFS had not determined which specific fisheries were involved in the entanglements of gray whales in trap gear (NMFS 2012). However, the Dungeness crab fishery is the largest fishery with trap gear in California and along the west coast (around 400,000 pots allowed to fish each year) and approximately 10% of these pots are lost each year; thus it is highly likely that pot entanglements are a consequence of this fishery (PFMC 2013).

Two additional species, bocaccio (*Sebastes paucispinus*) and cowcod (*Sebastes levis*), may

*For California's Sustainable Seafood Program, this category must score an 80 or higher during an MSC assessment.

also interact with Dungeness crab fisheries (MSC 2010). However, no records were available describing these two particular species as bycatch in crab pots in the Oregon Dungeness crab fishery. While traps may be highly selective, there is some evidence to suggest that crab traps are responsible for periodic entanglements and may pose some risk to endangered, threatened and protected species.

Evaluation against MSC Component 2.3: ETP Species

MSC Performance Indicators	Rating	Justification
2.3.1 Outcome		NMFS category II fishery indicates occasional incidental mortality of marine mammals
2.3.2 Management		Management measures exist to protect ETP species, including CEQA, Migratory Bird Act, Marine Mammal Protection Act
2.3.3 Information		Logbooks

Habitats

Traps

The coastal Dungeness crab fishery is for the most part conducted in areas of low relief and low complexity (MSC 2010). Most commercial fishing occurs in nearshore waters with silty sand to sandy bottoms less than 40 m deep, habitats less affected by fishing activity than structurally complex habitats (PFMC 1978; Kaiser et al. 2001). Morever, these habitats tend to be more prone to natural disturbance, such as wave, surge, current and tidal forces that may disturb and/or redistribute material. Kaiser et al. (2001) suggests that benthic communities adapted to high levels of natural disturbance have shorter recovery trajectories than more structurally complex habitats and may be less likely to experience long-term shifts in community structure or composition as a result of fishing (MSC 2010). Dungeness crabs are captured with traps, which are not highly mobile, so although they are bottom gear, they have contact with a substantially smaller area of the seafloor than do other gears. Traps can affect habitat, however, because they do not always remain entirely stable on the seafloor. They bounce off the seafloor in the presence of large swells, and get dragged across the bottom when being removed, especially during a storm or when traps are stuck in the sand, and may dislodge sessile organisms or disturb biogenic structures (Morgan and Chuenpagdee 2003; MSC 2010). Moreover, some estimates suggest that as many as 10% of traps are lost each year as a consequence of fishing in inclement weather (PFMC 2013)

The impact of fishing gear on habitat also depends on the spatial scale of the fishery because although each trap may have a small impact, the cumulative effect of thousands of traps can be larger (Morgan and Chuenpagdee 2003). While it is unclear what impact the density of Dungeness crab traps have had on the west coast, a new pot limitation program is being established in California and will be implemented for the 2013-14 season that may reduce the impact of traps.

While there is some data indicating minimal impacts to low complexity habitat, more empirical evidence may be necessary for the California Dungeness crab fishery should they pursue MSC

certification.

Evaluation against MSC Component 2.4: Habitats

MSC Performance Indicators	Rating	Justification
2.4.1 Outcome		Trap impacts are moderate, likely do not irreversibly damage the seafloor but more empirical evidence is necessary in California to support this assertion
2.4.2 Management		Measures in place to limit habitat impacts (area and seasonal closures); trap limitation program to be implemented for the 2013-14 season which may reduce the impact of traps
2.4.3 Information		Trap impacts are documented in several research studies, but none specific to habitats in California

Ecosystem

The Marine Life Management Act (MLMA) sets out an underlying goal of conserving entire systems. It is not simply exploited populations of marine life that are to be conserved, but the species and habitats that make up the ecosystem of which they are a part. Rather than focusing on single fisheries management, the MLMA requires an ecosystem perspective including the whole environment.

The '3-S' management approach is generally believed to provide adequate opportunity for sexually mature male Dungeness crabs to mate for one to two years before reaching legal fishery size. Although a study conducted in the British Columbia Dungeness crab fishery, which also has a minimum size limit, suggested that heavy exploitation of large males in the fishery can greatly reduce the amount of mating opportunities for females resulting in low or no egg production (Smith and Jamieson 1991), research on Northern California Dungeness crabs indicated that intense fishing of male crabs did not impair mating success of females (Hankin et al, 1997).

Dungeness crabs consume a wide variety of food organisms and are prey to numerous predators. Crabs contribute to several trophic levels as they progress through successive life stages. The larvae largely consume plankton (Lough 1976) and are preyed upon by numerous fishes. Adults and juveniles are preyed upon by sea otters, fishes, and octopuses (Butler 1954; Waldrom 1958; Stevens 1982; Reilly 1983; Kimker 1985). In their various life stages, Dungeness crabs feed on a variety of mollusks, crustaceans, and fish species (Stevens et al. 1982). The impacts of fishing mortality on the ecosystem inhabited by Dungeness crab are unclear.

Another concern in the trap fishery is "ghost fishing" when pots are lost or abandoned but continue to fish. Annual percentage of commercial traps lost has been estimated at 10% for the Oregon fishery and 11% (Breen 1987) in other Dungeness crab fishing sectors (SCS 2010). Dungeness crab fisheries have adopted regulations that require escape rings and time release devices (e.g., biodegradable meshes or cord ties on trap doors) that allow crab to escape from

derelict traps. Moreover, derelict gear removal programs have been undertaken in some areas and continue to be discussed by the DCTF.

While existing management measures (including Marine Protected Areas) may indirectly benefit ecosystem health, direct measures to assess ecosystem impacts of Dungeness crab fishing are lacking. The California Dungeness crab fishery likely does not cause serious or irreversible harm to key elements of ecosystem structure and function, though more information is necessary to support this assertion.

Evaluation against MSC Component 2.5: Ecosystem

MSC Performance Indicators	Rating	Justification
2.5.1 Outcome		Likely does not cause irreversible harm to ecosystem, but no quantitative measures available to assess
2.5.2 Management		MLMA contains ecosystem based management goals; MPAs will protect some habitat; destructive devices to prevent ghost fishing
2.5.3 Information		Some data available on retained, bycatch species, and habitat impacts, however more information is needed to assess

MSC Principle 3: Management System

Governance and Policy

The California Legislature manages various fisheries within state waters, including commercial Dungeness crab. Once the Legislature adopts a regulation and it is signed into law, Fish and Game Code or the Public Resources Code is amended to reflect any new management changes (OPC 2011). The recreational fishery is managed by FGC and placed in Title 14 of the California Code of regulations. CDFW is responsible for enforcement of regulations for both fisheries.

Any changes to the current commercial management regime must be done by introducing a bill into the state legislature. After introduction, the bill goes through a process of hearings, reading, reviewing, and amending. If approved by the houses, the bill is given to the Governor for final approval. Once the Governor signs the bill, it becomes law and amends either Fish and Game Code or the Public Resources Code. Once the bill becomes law, CDFW is the body that enforces the new regulations. Regulations must comply with the goals and objectives outlined in the Marine Life Management Act (MLMA), including (but not limited to) sustainability, limited bycatch and habitat conservation.

Evaluation against MSC Component 3.1: Governance and Policy

MSC Performance Indicators	Rating	Justification
3.1.1 Legal and/or Customary Framework		A management system exists - changes to fishery must be done by introducing a bill into legislature – a process of hearings, reviews and amending
3.1.2 Consultation, Roles and Responsibilities		State management authority clearly defined; Legislative process is open to interested parties
3.1.3 Long-term Objectives		Goals and objectives outlined in Marine Life Management Act
3.1.4 Incentives for Sustainable Fishing		Sustainability is an underlying goal of the Marine Life Management Act

Fishery Specific Management System

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) exempts the Dungeness crab fishery from the requirement of a federal FMP, recognizing a fiscal burden on taxpayers, and detraction from efforts to conserve and manage other species. Instead, it authorizes the states of California, Oregon and Washington to adopt and enforce state laws and regulations governing Dungeness crab fishing and processing in the federal exclusive economic zone adjacent to each state. Under the MSA, California, Oregon and Washington have jurisdiction over their respective permit holders and permit conditions (such as gear and seasons) as well as control over conditions for making landings within a state.. Regulatory issues that affect more than one state's fishery are negotiated through the Tri-State Dungeness Crab Committee coordinated by the Pacific States Marine Fisheries Commission (PSMFC). The Committee comprises one member from each state management agency, each with five industry advisors, and is chaired by the PSMFC. The committee signed an interstate Memorandum of Understanding (MOU) stating that all 3 state management agencies will develop consistent and complementary management actions for Dungeness crab. There is concern that although CDFW are represented on the Committee, they don't have authority to change regulations in concert with Oregon and Washington. In addition, Washington and Oregon vessels are allowed to fish in California waters, and while steps have been taken to address this with amendments to the MSA that give authority to the three states to manage the fishery (Dungeness Crab Conservation and Management Act in 1998), the concern may not be fully resolved.

The PSMFC is required to submit to the Senate Committee on Commerce, Science and Transportation and the House Committee on Resources a biennial report on the status and management of the fishery including:

- stock status and trends throughout its range;
- description of the research and scientific review processes used to determine stock status and trends; and
- measures implemented or planned to prevent or end overfishing.

The DCTF was established in California in 2009, pursuant to SB 1690, and re-established by SB 369, to review and evaluate Dungeness crab management measures and make recommendations related to Dungeness crab fishery to the Legislature's Joint Committee on Fisheries and Aquaculture, the Department of Fish and Wildlife, and the Fish and Game Commission. The DCTF is comprised of the following stakeholders: commercial and recreational fishermen, crab processors, commercial passenger fishing vessels, non-governmental organizations (NGOs), as well as representatives from California Sea Grant and CDFW. The DCTF is expected to generate recommendations addressing the need for a permanent task force; the economic impact of the trap limit program; the cost of the program to CDFW, including enforcement costs; refining commercial and sport Dungeness crab management; and the need for statutory changes to accomplish task force objectives (CDFW 2011).

Enforcement of fishing regulations is conducted in state waters by CDFW's Law Enforcement Division and in federal waters by NOAA's Office of Law Enforcement. Additionally tools such as port sampling, logbooks, and observer coverage are used to monitor catch and ensure vessels have the correct permits for the catch they are landing. Violators are prosecuted under the law. There is no evidence of systemic non-compliance.

Evaluation against MSC Component 3.2: Fishery Specific Management System

MSC Performance Indicators	Rating	Justification
3.2.1 Fishery Specific Objectives		No well defined goals or objectives – lacking measure of overfishing, target or limit reference points or biomass thresholds
3.2.2 Decision-making Processes		Changes to fishery must be done by introducing a bill into legislature – a process of hearings, reviews and amending; the DCTF does provide recommendations for the Legislature, CDFG, and FGC
3.2.3 Compliance & Enforcement		An enforcement system exists and has demonstrated an ability to enforce relevant management measures, strategies and/or rules.
3.2.4 Research Plan		No research plan due to lack of funding – OR has a plan (ODFW 2013)
3.2.5 Management Performance Evaluation		No formal evaluation of management; the DCTF does review management measures and make recommendations

California Specific Requirements

The California voluntary sustainable seafood program requires fisheries seeking certification to meet California specific standards in addition to the standards and requirements of the Marine Stewardship Council (MSC) sustainable fisheries certification program. These include:

1. Higher scores (80 instead of 60) for two performance indicators (PI) of the MSC program: “Stock Status” (PI 1.1.1) and “Bycatch of Endangered, Threatened, or Protected (ETP) Species” (PI 2.3.1). These two PIs are highlighted in the report.

2. Additional independent scientific review: The OPC Science Advisory Team will be engaged in the certification process through early consultation in reviewing minimum eligibility criteria, and review of the MSC-required pre-assessments and full assessments. The reviews will be conducted in addition to MSC’s peer review, thus bringing additional credibility, transparency, and independence to California’s certification process.

3. Additional traceability components: The California program will develop a unique barcode for California certified sustainable fish. This barcode can be either scanned by a smart-phone or linked to a website that will reveal additional information about the fishery, and information about toxicity when available.

Recommendations

California may want to consider working with Oregon (whose Dungeness crab fishery is already certified) and Washington as well as MSC to certify the fishery for the entire west coast. This may result in reduced costs for certification and recertification in the future for all three states. If California pursues certification, Oregon will serve as an excellent example.

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Appendix A

MSC Assessment Tree			Dungeness Crab
			Trap
Principle	**Component**	**Performance Indicator**	**All**
Principle 1: Health of Fish Stock	Outcome	1.1.1: Stock status	
		1.1.2: Reference points	
		1.1.3: Stock rebuilding	*Did not assess*
	Harvest Strategy (Management)	1.2.1: Harvest strategy	
		1.2.2: Harvest control rules	
		1.2.3: Info/ monitoring	
		1.2.4: Stock assessment	
Principle 2: Impact on Ecosystem	Retained species	2.1.1: Status	
		2.1.2: Mgmt strategy	
		2.1.3: Information	
	By-catch species	2.2.1: Status	
		2.2.2: Mgmt strategy	
		2.2.3: Info	
	ETP species	2.3.1: Status	
		2.3.2: Mgmt strategy	
		2.3.3: Info	
	Habitats	2.4.1: Status	
		2.4.2: Mgmt strategy	
		2.4.3: Info	
	Ecosystem	2.5.1: Status	
		2.5.2: Mgmt strategy	
		2.5.3: Info	
Principle 3: Management System	Governance & Policy	3.1.1: Legal framework	
		3.1.2: Consultation, roles, and responsibilities	
		3.1.3: Long term objectives	
		3.1.4: Incentives for sustainable fishing	
	Fishery Specific Mgmt System	3.2.1: Fishery specific objectives	
		3.2.2: Decision making process	
		3.2.3: Compliance & enforcement	
		3.2.4: Research plan	
		3.2.5: Management performance evaluation	