### Sand lance (forage/prey species) within the PBGB LOMA

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<td>Other (specify)</td>
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Background Information

Sand lance are a small family of slender schooling marine fishes occurring in littoral and shoal waters, often burying themselves in the sand. Food consists of small marine organisms such as copepods, snails, small crabs, marine worms and fish fry, even their own (Scott & Scott, 1988). They are restricted to shallow water, generally in less than 90 m, either along the coast or to the tops of offshore banks, and to sand or light-gravel bottom. There is no evidence of long-distance migration but they make short passages from rest areas to feeding grounds. They do not appear to seek deeper, warmer water when temperatures fall in winter as so many other fish species do (Brethes et al., 1992; Dalley & Winters, 1987; Winters, 1983; Winters & Dalley, 1988).

During the day, sand lance school in the water column while foraging for their zooplankton food and bury in the sand during the night and for long overwintering periods (Fisheries and Ocean Canada, 2009; Pearson et al., 1984). Whilst foraging, sand lance are subject to intense predation from fish, birds and mammals. Although the importance of sand lance as fodder for predatory fish has been recognized, recent work indicates its importance in marine food webs to be even greater than previously believed (Dalley & Winters, 1987; Fisheries and Ocean Canada, 2009; Scott & Scott, 1988; Winters, 1983).

Probably the most interesting aspect of the sand lance is its habit of burrowing into the sand or gravel of the sea bottom. This habit is associated with rest between periods of feeding activity and may be correlated with tidal currents or time of day. There is some evidence that the fish avoids strong tidal currents and feeds mainly during the day. The burrowing habit leads to one of the most peculiar features of the sand lance. In many coastal areas in Europe and North America, the fish buries itself in the sand between tide levels so that it remains in exposed beaches when the tide falls. Digging for sand lances is a popular pastime in such areas - they are used as bait. How the fish survives for hours in the sand, when there is little water for respiration, is an interesting problem in physiology which does not appear to have been investigated (Fisheries and Ocean Canada, 2009).

Sand lance spawn in winter (Nov-Jan) on the Grand Banks and also on sandy coastal beaches (Rose, 2007). Sand lance in the northwest Atlantic mature towards the end of their second year of life. They spawn on sand in shallow water during the winter months and their eggs are laid on, or fall to the bottom where they stick to sand grains. The ovary forms a large part of the total weight of the ripe female and each fish lays many thousands of eggs. On hatching, the larvae rise to surface waters where they remain for a few weeks, providing an important food source for predators. When they are a few centimeters long, they develop into juveniles with adult coloration and descend to the bottom where they remain for the remainder of their lives (Fisheries and Ocean Canada, 2009).

Sand lance occur in small populations along the coast and as a large population on the plateau of Grand Bank (Winters, 1983). Inshore and offshore populations may belong to different species although the species compositions and nomenclature remain unclear (Winters & Dalley, 1988). are restricted to shallow water, generally in less than 90 m, either along the coast or to the tops of offshore banks, and to sand or light-gravel bottom.
Northern sand lance: Small, bottom-living forage species usually found on offshore banks over sandy or fine gravel bottoms. Individuals apparently found in large schools, when not schooling they burrow into sandy bottom to a depth of several inches (Scott & Scott, 1988). In the LOMA, they are found on the Grand banks, especially to the south, and on Green and St Pierre Banks where it supplants capelin as the most important food for cod, haddock and American Plaice (Rose, 2007). Sand lance inhabit the top of the banks in spring and summer when water is cool, and move to deeper water in winter, but not deeper than 250m (Rose, 2007). Sand lance are relatively short lived (3-4 yrs) and fast growing, but in the cold waters of the Grand Banks they grow more slowly and can live to 10 years of age (Rose, 2007).

American sand lance: Small, bottom-living forage species usually found inshore but also occurring on offshore banks over sandy bottoms. Found in large schools, when not schooling they burrow into sandy bottom to a depth of several inches. When inshore they may remain buried in sand between high and low tide, occasionally thrusting their head out of the sand (Scott & Scott, 1988). In the LOMA, they occur in coastal waters from Placentia Bay to Trinity Bay and sporadically northward, and are important food for seabirds, whales and groundfish (Rose, 2007), although not as important as capelin.

Scoping

Bottom trawl:
Sand lance are small, bottom-living forage species usually found inshore or on offshore banks (particularly the southern Grand, Green and St Pierre Banks) over sandy or fine gravel bottoms. Individuals are found in large schools, and when not schooling, they burrow into sandy bottoms to a depth of several inches (Scott & Scott, 1988). Bottom trawling occurs on a broad scale on the offshore banks of the LOMA. Exclusion grids on trawls will exclude fish which are larger than the target species, but not smaller species such as sand lance. These may escape through the trawl mesh if they have the opportunity, but may also be trapped among the crowded catch and crushed. Sand lance are not noted as significant bycatch in these fisheries, but little information is available. Screened out.

Scallop dredges:
Icelandic and sea scallop are fished using hydraulic dredges, and are largely confined to the St. Pierre and Green Banks area of the LOMA (Fisheries and Oceans Canada, 2007). The activity is not widespread within the LOMA, and dredging occurs outside of the primary spawning season for sand lance (Brethes et al., 1992; Dalley & Winters, 1987). Although scallop dredging is concentrated in the areas where sand lance occur it will not have a significant impact within the LOMA population and sand lance is unlikely to be significantly impacted by a localized activity. Screened out.

Clam dredges:
Stimpsons surf clams along with propeller and quahogs, are fished using hydraulic dredges, and are largely confined to the Southeast Shoal area of the LOMA. (Fisheries and Oceans Canada, 2007). The activity is not widespread within the LOMA, and dredging occurs outside of the primary spawning season for sand lance (Brethes et al., 1992; Dalley & Winters, 1987). Although scallop dredging is concentrated in the areas where sand lance
occur it will not have a significant impact within the LOMA population and sand lance is unlikely to be significantly impacted by a localized activity. Screened out.

Seining (pelagic):
Capelin and herring are the main species fished with purse seine, and the fishery is largely concentrated along the northeast coast, with landings (1989-2006) amounting to less than 7% of total fisheries within the LOMA. Seine fisheries have little or no observer coverage or bycatch information but sand lance is not expected to be a significant bycatch in this fishery, because both capelin and herring are schooling species which do not typically mix with sand lance. Given the relatively small scale of the threat and the low vulnerability of the CP to the threat, it has been screened out. Screened out.

Dredging:
Sediments accumulate in harbours as a result of river flow, shoreline erosion, stormwater runoff and direct discharge of suspended solids (sewage, fish plant waste, etc). Eighty harbours within the LOMA are dredged as required to facilitate continued navigation or allow access to larger ships. American sand lance is a small, bottom-living forage species often found inshore where they may remain buried in sand between high and low tide, occasionally thrusting their head out of the sand (Scott & Scott, 1988). In the LOMA, they occur in coastal waters from Placentia Bay to Trinity Bay and sporadically northward, and are an important forage fish, although not as important as capelin. Sand lance spawn in winter (Nov-Jan) on sandy coastal beaches, and larva are pelagic for a few weeks before settling to the bottom. Harbour dredging is generally conducted every year but only a fraction of the ~80 harbours require dredging in a given year. Since sand lance prefer sandy beaches rather than harbour bottoms, most harbour dredging is unlikely to impact sand lance habitat. Screened out.

Oil pollution:
Sand lance are a benthic species, and although they are thought to leave the bottom at night to feed, in offshore waters they not likely to encounter a surface oil slick. The larvae are pelagic, spawning occurs over an extended period (Nov-March), and individual larvae remain in surface waters for only for a few weeks. Both offshore and in coastal waters of the LOMA, sand lance is restricted to sandy littoral habitat which is not common along the LOMA’s rocky shoreline. Sandy coastal habitat occupied by sand lance could become contaminated during a coastal oil spill, and negatively impact the population. Petroleum hydrocarbons can persist at high levels in the sediment for years after oil spills (Pinto et al., 1984). For a species such as sand lance, dependent upon sediment as a refuge from predation, persistent widespread sediment contamination may be a problem (Pearson et al., 1984). If sand lance avoid oiled sand, they may be denied a refuge from predation and an overwintering ground. If the fish do not avoid oiled sand, they will be subject to many effects derived from prolonged intimate contact with oil in the sand. It has been observed in laboratory experiments that sand lance experienced hemorrhaging in the head and gill region when burrowing in oiled sand. This anterior hemorrhaging has also been seen as a precursor to more severe hemorrhaging and death in sand lance exposed to crude oil and chemically dispersed crude oil (Pearson et al., 1984). Pearson et al. (1984) showed that sand lance, when exposed to oil-contaminated sand alone and in combination with oil-contaminated seawater,
spent less time buried in the sand, thus mitigating the effects of exposure to the contaminant by a behavioral change (Pearson et al., 1984).

Many coastal areas of the LOMA where sand lance occur, including Placentia Bay, Conception Bay and the south coast, are exposed to significant levels of tanker traffic on route to local ports and ports in the Gulf of St. Lawrence. This exposure increases the risk of oil pollution from in-port (transfer) spills, tanker accidents at sea and oily ballast discharge. Other sources of oil pollution which may affect coastal habitats include fuel oil spills from marine vessels of all sizes and land runoff (refuelling spills, storage tank leaks, fuel combustion emissions, etc.). Chronic oil pollution is a significant problem in coastal areas of the LOMA, particularly in active harbours and ports (Fisheries and Oceans Canada, 2002), and the risk of a large oil spill is a serious concern in areas with high tanker traffic.

The shallow water along the coast or to the tops of offshore banks, and the sand or light-gravel bottom where sand lance burrow are among the most sensitive areas to oil, providing quiet zones where oils can accumulate and bind to suspended particles, forming dense tar mats (The International Tanker Owners Pollution Federation Limited, 2002). Low oxygen levels limit the biodegradation of oil and result in extremely slow degradation, with oil persisting for as much as ten years or more, depending on the amount and type of oil spilled. Contaminated sediments can also occur as a result of chronic oil pollution, particularly in busy harbours and ports or heavily populated areas. Oil pollution could be a key stressor to the role of the CP in the LOMA ecosystem.

Eutrophication:
An oversupply of nutrients in aquatic ecosystems, known as eutrophication, may stimulate excessive and undesirable algal growth (blooms), particularly in sheltered, low flushing coastal waters. These blooms can be so dense that they block the penetration of sunlight to slower growing, long-lived macroalgae, and sea grasses, which are important habitat for many marine species. When phytoplankton die, oxygen-consuming micro-organisms begin to decompose the plant material and as a result, dissolved oxygen levels fall. Certain species of non-tolerant organisms abandon these waters due to depressed oxygen levels, while other less mobile or more sensitive species may die. Nutrients from complex organic sources such as animal manure, human sewage and industrial effluents (i.e. fish plants, saw mills, or paper mills) are released more slowly, and stimulate plant growth less dramatically than pure sources such as "chemical" fertilisers. However, micro-organisms consume oxygen as they breakdown the organic material to release the nutrients, contributing additional pressure on dissolved oxygen levels. This pressure is termed the Biological Oxygen Demand (BOD). Within the LOMA, major contributors of organic wastes into the coastal waters are fish plant waste, sewage, finfish aquaculture, and sawmill wastes. Although eutrophication develops in localized coast areas throughout the LOMA, it is not widespread - DFO water quality surveys conducted in Placentia Bay in nine relatively sheltered areas (Lawn, St. Lawrence, Burin, Marystown, Baine Harbour, Arnold’s Cove, Ship Harbour, Fox Harbour, and Northeast Arm Placentia) found no significant reduction of water quality (pH, turbidity, dissolved oxygen, salinity or redox) near sewage outfalls compared to reference sites (unpublished data, Oceans, 2005). American sand lance is a small, bottom-living forage species often found inshore where they may remain buried in sand between high and low tide, occasionally
thrusting their head out of the sand (Scott & Scott, 1988). Waters in the inter-tidal zone generally remain saturated with oxygen due to wave action and constant exposure to air. On a LOMA scale, eutrophication is not a major stressor, and there is no evidence that sand lance are particularly sensitive to it. Screened out.

Current shifts:
Ocean currents are predicted to change as a result of the warming of polar waters and influx of freshwater. Ocean circulation is driven by sinking of cold, salty (dense) water at the high latitudes which is replaced by warmer salty water from lower latitudes. This “thermohaline” circulation, which is driven by temperature and salinity (density) differences in seawater is basically a gigantic overturning motion. In the north Atlantic, the Gulf Stream brings water from the south, giving off heat and sinking as it moves north, returning as a deep, cold current. The strength of this circulation depends on a subtle balance between the rate of cooling in the Arctic and the input of less dense freshwater from ice and snow melt and river runoff. Global models generally show that Atlantic thermohaline circulation weakens by 15% to 50% with a doubling of atmospheric CO$_2$, but not in a simple linear manner. The actual amount of CO$_2$ is less important than the rate of increase – little happens at first as the circulation rapidly removes the freshwater, but there is a well defined threshold beyond which the thermohaline circulation cannot cope with additional freshwater and breaks down (Rahmstorf, 1997). This could lead to abrupt climate change, but this is not anticipated during the century (Drijfhout, 2008). On a LOMA scale, sand lance are widely distributed and have a high tolerance for variant salinities and water temperatures as they are a non migratory species. Screened out.

Harmful algal blooms:
Sand lance feed largely on benthic invertebrates such as copepods, snails, small crabs, and marine worms, and the LOMA population is unlikely to be significantly impacted by a localized HAB. Screened out.

Key Activities/Stressors:
- Oil pollution
Reference List


Sand lance (forage/prey species) within the PBGB LOMA ecosystem

Oil pollution

**Magnitude of Interaction**

**Areal extent:**

- Sand lance are restricted to shallow water, generally in less than 90 m, either along the coast or to the tops of offshore banks, and to sand or light-gravel bottom, and occur in small populations along the coast of the LOMA and as a large population on the plateau of Grand Bank (Winters, 1983).
- Oil pollution is considered a chronic stressor which is not restricted to a specific area, and therefore we have estimated areal extent (high, medium, low) based on the pollution potential of the area.
- Major sources of oil pollution within the LOMA include port activity (oil transshipment, storage, refueling), chronic discharge related to vessel traffic (bilge, ballast, 2-stroke outboard motors) and urban runoff (storm drains, sewers, river runoff). Each year small discharges of oil are being reported in coastal areas of the LOMA as well as in the offshore (Transport Canada, 2007), and the risk of a large spill is always a concern.
- In the early 1990’s, the Brander-Smith Final Report, *Public Review Panel on Tanker Safety and Marine Spills Response Capability*, identified Placentia Bay as the marine area with the highest potential for an oil-related environmental accident in Canada (Brander-Smith et al., 1990). Since this time, industrial activity within Placentia Bay has grown significantly and the offshore oil industry has continued to expand. Conception Bay is also one of the most rapidly growing areas of the province with population of well over 50,000, while St. John’s and Mount Pearl are also growing rapidly with almost half of the population of the province now living on the Avalon peninsula, with close to 250,000 residents.
- Ship traffic within the LOMA is also moderate, and chronic oil pollution related to vessel traffic is a concern.
- Based on the pollution potential of the area (moderate) and existing data, we have estimated the areal extent in the moderate range.

**Score 6**

**Contact:**

- Oil is repelled by water and therefore tends to float on the sea surface rather than sink and accumulate in lower sediments (Pearson et al., 1984) except in coastal areas where oil interacts directly with coastal sediments and shorelines.
- Sand lance thrive in deep soft, sand sediments which also provide attractive substrates for toxic components of oil to bind and accumulate. Sand lance bury in the sand during the night, and for long overwintering periods (Pinto et al., 1984).
- In the offshore, oil pollution disperses rapidly and sandlance are unlikely to be in direct contact with oil pollution.
- In the inshore, waves and tidal action repeatedly carry oil onto the shore, resulting in direct contact with the sand or light-gravel bottom where sand lance burrow. Therefore contact is likely to be high.
• We have selected a score an intermediate score the differing levels of contact anticipated for inshore and offshore populations of the CP.

Score 5

Duration:
• Sand lance are small semi-pelagic, non-migratory species which are very common in coastal waters and offshore banks in the LOMA. They are located in the LOMA throughout the year, but may be more sensitive to acute oil pollution during the spawning season (November-March) (Fisheries and Ocean Canada, 2009).
• Oil pollution is considered a chronic stressor that occurs every year, but intermittently, and so is scored in the medium range.
• Oil pollution is moderately persistent, particularly in coastal areas where oil can bind with sediments. Low oxygen levels limit the biodegradation of oil caught on beaches, shorelines, and the seabed, and results in extremely slow degradation with oil persisting for many years. In sheltered areas, components or degradation products of crude oil can enter the food chain in significant quantities and persist for a period of years.
• In the offshore, oil pollution is rapidly dispersed, and degradation may occur more rapidly. Since sand lance is distributed both inshore and offshore, we have selected a score in the middle of the moderate range.

Score 6.5

Intensity:
• Halpern et al. (2008) has developed a map showing the global intensity of several anthropogenic stressors including marine pollution based on the relative density of major pollution sources including shipping, and port activity/population density (see Figure 1 below) (Halpern et al., 2008). This map has been modified to include local oil and gas exploration and development areas within the PBGB LOMA. This map can be used to provide guidance in scoring the intensity of a stressor in relation to maximum (100%) intensity in a global context, in accordance with the scale provided below.

<table>
<thead>
<tr>
<th>Map colour</th>
<th>Intensity</th>
</tr>
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<tbody>
<tr>
<td>Red</td>
<td>80-100%</td>
</tr>
<tr>
<td>Orange</td>
<td>60-80%</td>
</tr>
<tr>
<td>Yellow</td>
<td>40-60%</td>
</tr>
<tr>
<td>Light Blue</td>
<td>20-40%</td>
</tr>
<tr>
<td>Dark Blue</td>
<td>0-20%</td>
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</tbody>
</table>

Figure 1. Global Intensity of Oil Pollution (adapted from (Halpern et al., 2008)).
Based on Figure 1, on a global scale, most coastal areas of the LOMA are high risk areas in relation to oil pollution (80-100%), while most of the offshore is moderate (20-60%). Since sand lance occur in both coastal waters and offshore banks, we have selected an intermediate score.

Score 7

**Magnitude of Interaction:** \[ (6 \times 5 \times 6.5 \times 7) / 1000 = 1.4 \]

**Sensitivity of the CP to acute impacts:**
- Oil has the potential to impact spawning success, as eggs and larvae of many fish species, are highly sensitive to oil toxins (US Fish and Wildlife Service, 2004)
- Risks to recruitment are generally viewed as being higher for spills in shallow enclosed inshore waters as opposed to more open deeper waters in the offshore. Species whose larval forms are found in the first few meters of the water column for a number of months, would also be at higher risk (DFO, 2007).
- Sand lance in the laboratory, when exposed to oil-contaminated sand alone and in combination with oil-contaminated seawater, spent less time buried in the sand, thus mitigating the effects of exposure to the contaminant by a behavioral change, although increasing their risk of predation (Pearson et al., 1984).
- Sand lance experienced hemorrhaging in the head and gill region when burrowing in oiled sand. This anterior hemorrhaging has also been seen as a precursor to more severe hemorrhaging and death in sand lance exposed to crude oil and chemically dispersed crude oil (Pearson et al., 1984).
- There is concern that a large spill could destroy a significant concentration of sand lance although the effects of major spills would be reduced by factors such as species distribution over a large geographical area, restriction of oil to mainly surface slicks, larval immigration to uncontaminated area, and the proportionally low mortalities to be expected from oil-stress versus natural mortality (DFO, 2007).
- For example, after the "Torrey Canyon" oil spill, there were reported mortalities of sand lance on the beaches of Cornwall, England (Pinto et al., 1984).
- Based on this information we have selected a moderate score.

Score 6

**Sensitivity of the CP to chronic impacts:**
- Sub-lethal affects include decreased egg hatching frequency and delayed hatching, larval deformities, and reduced ratio between RNA and DNA. The larval stage appears to be more sensitive to soluble oil compounds than eggs (DFO, 2007).
- There is concern that a large spill could destroy sufficient proportions of larvae to have a negative effect on stock recruitment, particularly if the timing/location of the spill coincides with a key spawning period (DFO, 2007).
For example, studies following the 1989 Exxon Valdez spill showed that Pacific herring eggs, which are laid in eelgrass beds and intertidal habitats, are especially susceptible to hydrocarbons and related chemicals, displaying high rates of mutation and disease (Carroll, 2008).

Contaminated sediments can also occur as a result of chronic oil pollution, particularly in busy harbours and ports or heavily populated areas (The International Tanker Owners Pollution Federation Limited, 2002).

Demersal species and species that depend on inshore areas for spawning or nursery grounds could be unable to avoid exposure to contaminated sediments after the spill (Pinto et al., 1984).

Petroleum hydrocarbons are incorporated into intertidal and subtidal sediments during oil spills, where they may remain for a long time (Pinto et al., 1984) resulting in low recovery rates for burrowing sand lance in the areas of oil spills/pollution where there is oil in the sandy bottom and burrowing sediment.

Score 6

**Sensitivity of the ecosystem to harmful impacts to the CP:**

- Sand lance fill a strategic niche in the marine ecosystem, acting as an important trophic link between secondary producers and a variety of fish, birds, and marine mammals (Brethes et al., 1992), specifically commercially important fish such as haddock, Atlantic cod, silver hake, yellowtail flounder, and American plaice (Scott & Scott, 1988). In addition such large marine mammals as fin and humpback whales also feed heavily on sand lance (Winters, 1981).
- Sand lance are a major link between zooplankton production and fisheries of commercial importance (Pinto et al., 1984).
- Feeding studies have shown sand lance to be a major prey species in the marine food chain on the Newfoundland Grand Bank, particularly for cod and American plaice (Winters, 1981). These two species typical prey upon capelin, the other important prey species, although in recent history capelin stocks have fluctuated in abundance (Winters, 1983).
- Sand lance may be expected to avoid oiled sediments by moving into clean adjacent areas or into deeper waters. Such a shift in the regional distribution of sand lance populations could have a considerable impact on commercial fisheries (Pinto et al., 1984).
- Sand lance are an important component of the LOMA ecosystem, providing food for larger species, while at the same time they are the vital link to the recruitment and stability of key fish populations within the bay and the LOMA as a whole. (Score 6)
- Sand lance are listed as an Ecologically Significant Species in the CP document, as they are a forage/prey species (**add one point**).

Score 7

**Sensitivity:** \( (6 + 6 + 7)/3 = 6.3 \)

**Risk of Harm:** \( \text{MoI} \times S = 1.4 \times 6.3 = 8.8 \)
Certainty Checklist

Answer yes or no to all of the following questions. Record the number of NO’s to the 9 questions, and record certainty according to the scale provided below:

1  No’s = High certainty
2 - 3  No’s = Medium certainty
≥ 4  No’s = Low certainty

Y/N
N  Is the score supported by a large body of information?
Y  Is the score supported by general expert agreement?
N  Is the interaction well understood, without major information gaps/sources of error?
N  Is the current level of understanding based on empirical data rather than models, anecdotal information or probable scenarios?
N  Is the score supported by data which is specific to the region, (EBSA, LOMA, NW Atlantic)?
N  Is the score supported by recent data or research (the last 10 years or less)?
N  Is the score supported by long-term data sets (ten years or more) from multiple surveys (5 years or more)?
Y  Do you have a reasonable level of comfort in the scoring/conclusions?
N  Do you have a high level of confidence in the scoring/conclusions?

Score: Low

For interactions with Low certainty, underline the main factor(s) contributing to the uncertainty:

- Lack of comprehensive data
- Lack of expert agreement
- Predictions based of future scenarios which are difficult to predict
- Other (provide explanation)

Suggest possible research to address uncertainty.
Reference List


Summary Table: Sand lance (forage/prey species) within the PBGB LOMA.

<table>
<thead>
<tr>
<th>Key Activity/Stressor</th>
<th>a</th>
<th>c</th>
<th>d</th>
<th>i</th>
<th>Mol</th>
<th>as</th>
<th>cs</th>
<th>es</th>
<th>S</th>
<th>Risk of Harm</th>
<th>Certainty</th>
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<tbody>
<tr>
<td>Oil pollution</td>
<td>6</td>
<td>5</td>
<td>6.5</td>
<td>7</td>
<td>1.4</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6.3</td>
<td>8.8</td>
<td>Low</td>
</tr>
</tbody>
</table>

Cumulative CP Score: 8.8