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## To the Minister of Medical Care

### Advice from the Director of the Office for Risk Assessment & Research

#### Opinion of BuRO on the risks of consuming meat from the body (brown meat) of the Chinese mitten crab (*Eriocheir sinensis*) for the Dutch consumer

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## Background

The Chinese mitten crab (*Eriocheir sinensis*) is an invasive species that has been present in Dutch waters since the 1930s. The mitten crab in the Netherlands frequently contains high levels of dioxins<sup>1</sup> and dioxin-like PCBs (polychlorinated biphenyls). For this reason, a ban on catching mitten crabs has been in effect for various catch areas in the Netherlands since 1 April 2011. The consumable parts of the mitten crab consist of white and brown meat. Maximum levels for the white meat of the crab (general) have been laid down in Regulation (EC) No 1881/2006<sup>2</sup>. Maximum levels for the brown meat of the crab (general) have not been set because legislators assume that the brown meat of this crab is not eaten.

In September 2017, the review committee of the Ministry of Health, Welfare and Sport (VWS) advised the minister to establish a fixed standard for the maximum level of dioxins and dioxin-like PCBs in the brown meat of the Chinese mitten crab. The Ministry of VWS then asked the Office for Risk Assessment and Research (BuRO) of the Netherlands Food and Consumer Product Safety Authority (NVWA) to conduct a risk assessment of the health risks posed to Dutch consumers by eating the Chinese mitten CRAB.

## Approach

Consumption data on the Chinese mitten crab are limited. In 2013, the Institute of Food Safety (RIKILT) conducted a small-scale survey of the consumption of the mitten crab (van Leeuwen *et al.*, 2013b). BuRO therefore asked market research agency Motivaction to repeat the same consumption survey on a larger scale for the purpose of this advisory report. To do so, Motivaction used an online questionnaire (in Dutch and simplified Chinese) and face-to-face research. BuRO then analysed this collected consumption data (Appendix I).

Following this, BuRO asked the Front Office Food and Product Safety (hereinafter: Front Office) of the National Institute of Public Health and the Environment (RIVM) and RIKILT to use the collected consumption data to calculate what the maximum level of dioxins and dioxin-like PCBs can be in the brown meat of the Chinese

<sup>1</sup> In this advisory report, the term dioxins is used to refer to polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans.

<sup>2</sup> Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs.

mitten crab before possible health effects occur (Appendix II). In addition to this, BuRO calculated a few additional usage scenarios.

BuRO also studied the trade flows of the mitten crab. The Agricultural Economics Research Institute (Landbouw Economisch Instituut, LEI) and RIKILT had already done research on the latter in 2012 and 2013 (Bakker & Zaalmink, 2012; van Leeuwen *et al.*, 2013b). For this advisory report, BuRO asked Wageningen Economic Research (previously LEI) to repeat the study into the trade flows and supplement it with recent information (Appendix III).

Because the terms white meat and brown meat are confusing, this BuRO report refers to meat from the legs and claws (the "appendages") and meat from the body of the crab. The meat from the legs and claws is white meat. The meat from the body is primarily brown meat, though it also contains a small portion of white meat. However, no distinction is made in this regard when it comes to consumption of the body of the crab. BuRO's risk assessment was based on this information.

## Findings

- The Chinese mitten crab is an invasive species that is commercially fished in Dutch waters. The vast majority of the mitten crab caught in the Netherlands is exported to Chinese communities and restaurants in the EU and China.
- The mitten crab that remains in the Netherlands is intended for the Asian (primarily Chinese) communities and Chinese restaurants.
  - o The mitten crab is primarily consumed by people of Asian origin, mostly Chinese or those of Chinese origin. The Dutch do not eat mitten crab because it is an unfamiliar dish to them and it would involve too much work to eat the crab (breaking open the legs/claws/body before reaching the edible parts).
  - o Based on the consumption survey, which specifically targeted people of Chinese origin, 708 of the total 990 respondents eat mitten crab (72%).
  - o During the crabbing season of the mitten crab, which lasts from September to November, a normal mitten crab consumer eats mitten crab once every two weeks, at four to five crabs per meal. A crab-lover eats mitten crab more frequently and in greater amounts (two to three times a week, eight or more crabs per meal) (see Substantiation on p. 11-12).
  - o Some consumers also eat mitten crab outside of crabbing season (18%).
  - o In general, all edible parts of the mitten crab are consumed. Children and adults eat mitten crab equally often, with children eating portions that are equal to or smaller than those of the adults.
- Dioxins and dioxin-like PCBs have effects on one's offspring<sup>3</sup>. In 2001, the Scientific Committee on Food (SCF) established a tolerable weekly intake (TWI) for dioxins and dioxin-like PCBs of 14 pg WHO-TEQ<sup>4</sup> (World Health Organisation toxic equivalency) per kg body weight. Recently, the European Food Safety Authority (EFSA) published a comprehensive risk assessment in which it set the tolerable weekly intake (TWI) at 2 pg

<sup>3</sup> Based on various animal studies involving rats (which were exposed to TCDD orally or through the skin), effects observed on male offspring included reduced sperm concentration, altered sexual behaviour or reduced anogenital distance (i.e. the distance from the middle of the anus to the genitalia). In human prospective cohort studies, reduced sperm quality was observed in men.

<sup>4</sup> See the section on toxicology in this advisory report for a more detailed explanation of the term toxic equivalency (TEQ).

WHO<sub>2005</sub>-TEQ/kg body weight per week, which is seven times lower than that of the SCF.

- Given that dioxins and dioxin-like PCBs can have a negative effect on the health of the consumer after long-term exposure and the consumption of mitten crab is seasonal, the exposure is averaged over an entire year in this advisory report. The total exposure (including the background exposure) may not exceed 52 times the TWI ( $= 52 * 14 = 728$  pg TEQ/kg body weight per year or  $= 52 * 2 = 104$  pg TEQ/kg body weight per year, depending on the assumed TWI), which is then expressed as TYI (tolerable yearly intake).
- The concentration of dioxins and dioxin-like PCBs in the meat from the body is higher than the meat from the legs and claws (see the Substantiation).
- Based on a TWI of 14 pg TEQ/kg body weight (SCF, 2001), the TYI (728 pg TEQ/kg body weight) is not exceeded when the adult mitten crab consumer is exposed to dioxins and dioxin-like PCBs from normal consumption of the meat from all consumable parts of the mitten crab (legs, claws and body). With respect to the exposure of children and crab-lovers to dioxins and dioxin-like PCBs from consumption of the meat from all consumable parts of the mitten crab (legs, claws and body), the TWI is exceeded and its health effects cannot be ruled out (see Table 2 in the Substantiation).
- Based on a TWI of 14 pg TEQ/kg body weight (SCF, 2001) and the consumption data presented in this advisory report, the level of dioxins and dioxin-like PCBs that the meat from all consumable parts of the mitten crab (legs, claws and body) can contain before the TWI is exceeded appears to be (very) low. The levels of dioxins and dioxin-like PCBs range between 0.76 and 26.9 pg TEQ/gram of meat (see Table 3 in the Substantiation).
- Based on a TWI of 14 pg TEQ/kg body weight (SCF, 2001) and the consumption data presented in this advisory report, the level of dioxins and dioxin-like PCBs that the meat from the body of the mitten crab can contain before the TWI is exceeded appears to be very low. The levels of dioxins and dioxin-like PCBs range between 0.12 and 0.21 pg TEQ/g of meat (see Table 4 in the Substantiation). The dioxin and dioxin-like PCB levels were higher in the meat from the body of mitten crabs from open and closed catch areas that RIKILT investigated in 2016 and 2017.
- The TWI (2 pg TEQ/kg body weight per week) derived from EFSA is seven times lower than the TWI (14 pg TEQ/kg body weight) established by SCF. Because the background exposure remains the same, the margin available for being filled by dioxins and dioxin-like PCBs from mitten crab meat drops before the TWI is exceeded. With a TWI of 2 pg TEQ/kg body weight and the same background exposure (3.5 pg TEQ/kg body weight), there is no space left to be filled ( $2 - 3.5 = -1.5$ ). In this case, the background exposure is already higher than the TWI, meaning that health effects to the consumer cannot be excluded.

**Office for Risk Assessment & Research**

**Date**

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### Answers to the question

*What health risks are posed to the Dutch consumer from the consumption of the Chinese mitten crab?*

The level of dioxins and dioxin-like PCBs that can be present in the meat from all consumable parts of the mitten crab (legs, claws and body) before the TWI of 14 pg TEQ/kg body weight (SCF, 2001) is exceeded appears to be (very) low (i.e. levels between 0.76 and 26.9 TEQ/g of meat). The same applies to the level of dioxins and dioxin-like PCBs that can be present in the meat from the body of the mitten crab (i.e. levels between 0.12 and 0.21 TEQ/g of meat). The dioxin and dioxin-like PCB levels were higher (i.e. levels between 28.4 and 82.1 pg TEQ/g of meat) in the meat from the body of mitten crabs from open and closed catch areas that RIKILT investigated in 2016 and 2017.

When the assessment is not made based on the TWI set by SCF but the TWI of EFSA (seven times lower), the existing background exposure to dioxins and dioxin-like PCBs of the mitten crab is already enough to exceed the TWI.

When the TWI is exceeded, health effects to the consumer cannot be excluded.

### BuRO recommendation

The calculated levels of dioxins and dioxin-like PCBs in the meat of the mitten crab before the TWI is exceeded are (very) low. This applies to both the meat from all consumable parts of the mitten crab (legs, claws and body) and the meat from the body. When mitten crab is consumed at a level of dioxins and dioxin-like PCBs that is higher than these calculated levels, health effects<sup>5</sup> to the mitten crab consumer<sup>6</sup> cannot be excluded. For this reason, BuRO recommends the following:

*To the Minister for Medical Care*

Take a combination of the following measures:

- Prevent the placement on the market of Chinese mitten crab intended for human consumption.
- Inform the mitten crab consumer that consumption of the mitten crab can possibly lead to adverse health effects.
- Make a plea for a maximum dioxins and dioxin-like PCB's concentration of 0.12 pg TEQ/gram of meat from the body of the Chinese mitten crab at the European level.
- Make a plea for replacing the current maximum concentration of dioxins and dioxin-like PCB's mentioned in Regulation (EC) No 1881/2006 to a maximum dioxins and dioxin-like PCB's concentration of 0.76 pg TEQ/gram of meat from all consumable parts of the Chinese mitten crab on a European level.

*Yours faithfully,*

*Prof Dr Antoon Opperhuizen*

*Director of the NVWA Office for Risk Assessment and Research (BuRO)*

<sup>5</sup> Dioxins and dioxin-like PCBs have effects on one's offspring.

<sup>6</sup> The mitten crab is primarily consumed by people of Asian origin, mostly Chinese or those of Chinese origin.

## SUBSTANTIATION

### Background

The Chinese mitten crab (*Eriocheir sinensis*, hereinafter referred to as 'mitten crab') is an invasive species that has been present in Dutch surface waters since the 1930s. The mitten crab can also be found in Belgium, Germany, Spain, France and the United Kingdom (Herborg *et al.*, 2003). In the Netherlands, the mitten crab is commercially fished and primarily consumed by people of Asian origin, especially those of Chinese origin (van Leeuwen *et al.*, 2013b; Zaalmlink & Rijk, 2018).

The mitten crab in the Netherlands contains high levels of dioxins<sup>7</sup> and dioxin-like PCBs (polychlorinated biphenyls) in comparison to other food (Kotterman & Lee, 2011; van der Lee *et al.*, 2012; van Hattum *et al.*, 2013; van Leeuwen *et al.*, 2013a). For this reason, a ban on catching mitten crabs has been in effect for specific catch areas in the Netherlands since 1 April 2011 (Bleker, 2011).

The consumable parts of the mitten crab consist of white and brown meat. Clark and colleagues define brown meat as the total of the hepatopancreas and gonads. The same authors define white meat as the muscle tissue from the legs and claws, as well as the body (Clark *et al.*, 2009). The European Commission (EC) defines brown meat as the meat from the body (cephalothorax), which includes the hepatopancreas, among other things. The EC defines the meat in the legs and claws of crabs (the "appendages") as white meat (EC, 2011). Researchers from RIKILT define "meat from the body" as the total of the soft parts from the body, excluding the gills. This includes white muscle tissue (for moving the legs) and the other organs such as the hepatopancreas and gonads (van der Lee *et al.*, 2012; van Leeuwen *et al.*, 2013a).

In Regulation (EC) No 1881/2006<sup>8</sup>, maximum levels are established for the muscle tissue of the legs and claws (the "appendages") (per gram of fresh weight), namely 3.5 pg TEQ for the sum of dioxins and furans, 6.5 pg TEQ for the sum of dioxins, furans and dioxin-like PCBs and 75 ng for six non-dioxin-like PCBs (ICES). The regulation does not contain maximum levels for meat from the body of the crab.

In recent years, the Office for Risk Assessment & Research (BuRO) has issued various recommendations regarding the mitten crab. In September 2011, BuRO concluded that the ban on catching mitten crabs protects consumers against an inadmissible intake of dioxins, dioxin-like PCBs and cadmium (BuRO, 2011). In addition to this, BuRO concluded in 2013 that the concentrations of dioxins and dioxin-like PCBs in the white meat of mitten crabs, from both open and closed catch areas, meet the EU norm. The concentrations of dioxins and dioxin-like PCBs in the brown meat of these crabs was 40 to 100 times higher than in the white meat. This meant that, despite the fact that the white meat met the statutory norm, the crabs were not suitable for consumption due to the high concentrations of dioxins and dioxin-like PCBs in the brown meat (BuRO, 2013; BuRO, 2014).

Because the terms white meat and brown meat are confusing, this BuRO advisory report refers to meat from the legs and claws (the "appendages") and meat from the body of the crab. The meat from the legs and claws is white meat. The meat from the body is primarily brown meat, though it also contains a little bit of white

<sup>7</sup> In this report, the term dioxins is used to refer to polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans.

<sup>8</sup> Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs.

meat. However, no distinction is made in this regard when it comes to consumption of the body of the crab.

### **Trade flows**

The mitten crab was initially viewed as a nuisance by fishermen and water boards. The crabs cut nets and snares open with their claws, which allowed the fish that were caught to escape (Bakker & Zaalmink, 2012). Starting in 2000, a number of fishing operations discovered that there was a market for the mitten crab. Since 2011, specific areas (mainly the drainage basins of the big rivers) were closed to the catching of eel and mitten crab due to the excessive concentrations of dioxins and dioxin-like PCBs contained by these eels and crabs. The amount of mitten crab that is caught varies from year to year. This depends on whether or not the conditions are favourable for the crabs during their growing season. This is mainly determined by the amount of too cold or too warm water (Zaalmink & Rijk, 2018).

The mitten crab brings in a lot of money between the months of September and November. The period from October to January is the best time to fish for mitten crab. The demand – and thus also the price – is the highest around the Chinese New Year (late January – early February), when the mitten crab fetches €17 per kg, on average (Zaalmink & Rijk, 2018).

In 2017, almost 114 tonnes of mitten crab were hauled in by the Dutch inland fisheries. Most mitten crabs (53%) are sold directly to fish wholesalers and a few Chinese traders. Another 39% is sold at the fish auction and 8% is sold directly to end users (e.g. shops, restaurants and consumers) (Zaalmink & Rijk, 2018).

The vast majority (85%) of Dutch mitten crab is exported to Chinese communities and restaurants in both the EU and China (especially Hong Kong). The mitten crab that remains in the Netherlands is intended for the Chinese communities and Chinese restaurants (Zaalmink & Rijk, 2018).

### **Toxicology**

Dioxins consist of a group of persistent organic chlorinated compounds that are found throughout the environment and accumulate in the food chain. Dioxins can be formed through the burning of chlorine-containing materials and produced as a side product of various industrial processes (e.g. the bleaching of paper with chlorine gas). Because a number of dioxins are poorly metabolised and are highly soluble in fat, they accumulate in the bodies of animals and humans (EFSA, 2015).

Dioxins and dioxin-like PCBs consist of several congeners that occur in various combinations and, as such, exhibit mixed toxicity. Because the potential of the various dioxins and dioxin-like PCBs differs, Toxic Equivalency Factors (TEFs) have been developed for the congeners that accumulate in humans. A TEF describes a conversion factor that is used to relate the concentration of other dioxins to the most toxic dioxin 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). This dioxin has been extensively studied and as such toxicological and epidemiological data are available. Much less is known about other congeners. The sum of the weighed concentrations of dioxins is a Toxic Equivalent (TEQ) (EFSA, 2015). For example, an analysis result of a mitten crab is made up of a combination of three dioxins (A, B and C). Dioxin A is TCDD and has a TEF of 1, which is multiplied by the amount of A that is present. Dioxin congeners B and C have a TEF of 0.1 (B) and 0.01 (C) (less potent than TCDD), which are multiplied by the amount of B and C that is present. The levels of A, B and C are then added together and expressed in 'x unit' TEQ in order to make it possible to evaluate the toxicity of the mixture as though it only contains TCDD.

The TEFs and the resulting TEQs that are used by EFSA and other authorities in European legislation have been established under the coordination of the World Health Organisation (WHO). That is why reference is made to WHO-TEQs, with a specific year. TEFs are regularly revised and updated based on new information about the potency of congeners (EFSA, 2015). However, it can be the case that the WHO has revised the TEFs, but that this revision has not yet been incorporated into the current European legislation.

### Health-based limit value

#### SCF

In 2001, the Scientific Committee on Food (SCF) established a tolerable weekly intake (TWI) for dioxins and dioxin-like PCBs of 14 pg WHO-TEQ (World Health Organisation toxic equivalency) per kg body weight (SCF, 2001). A TWI is an estimate of the amount of a substance that can be ingested on a weekly basis over a lifetime without it having a noticeable effect on one's health. In various animal studies involving rats (which were exposed to TCDD orally or through the skin), effects on male offspring were observed, including reduced sperm concentration, altered sexual behaviour or reduced anogenital distance (i.e. the distance from the middle of the anus to the genitalia). Based on the lowest "no observed adverse effect level" (NOAEL) and the "lowest observed adverse effect level" (LOAEL) in these studies, SCF has calculated an "estimated maternal steady state body burden" and a corresponding "estimated human daily intakes" (EHDI). Based on the NOAEL in one study, this corresponds to an EDHI of 10 pg/kg body weight. If we then take into account a safety factor of 3.2 due to the difference between people with respect to toxicokinetics, this results in a "tolerable intake" of 3 pg/kg body weight. Based on the LOAEL from the other study, the EDHI is 20 pg/kg body weight. If we then take into account a safety factor of 9.6 (3.2 due to the difference between people in terms of toxicokinetics times 3 for the use of LOAEL instead of the NOAEL), this results in a "tolerable intake" of 2 pg/kg body weight. Because substances like TCDD remain in the human body for a long time, SCF finds that the tolerable intake should be expressed per week instead of per day ( $7 \times 2 = 14$  pg/kg body weight).

#### EFSA

The Panel on Contaminants in the Food Chain (CONTAM) of EFSA has established a tolerable weekly intake (TWI) of 2 pg WHO<sub>2005</sub>-TEQ/kg body weight per week (EFSA, 2018). The TWI is based on studies in humans into the effects of dioxins and dioxin-like PCBs. Information from animals studies is considered to be supporting evidence. Effects were observed, such as reduced sperm counts in men, in three prospective cohort studies (two in response to the Seveso disaster and the Russian Children's Study). The Russian Children's Study was used by the panel as a point of departure, with an NOAEL of 7.0 pg WHO<sub>2005</sub>-TEQ/gram of fat for the sum of dioxins and dioxin-like PCBs (levels measured in the blood of 9-year-old boys). The panel then used a toxicokinetic model to estimate what the daily intake of TCDD (as a measure for dioxins and dioxin-like PCBs) must be to result in an exposure at the level of the NOAEL in 9-year-old boys. In doing so, the panel assumed that these children were breastfed for the entire first year of their lives. If this is the case, the model indicates that the daily intake by adults may not exceed 0.25 pg WHO<sub>2005</sub>-TEQ/kg body weight per day. This corresponds to an exposure of 1.75 WHO<sub>2005</sub>-TEQ/kg body weight per week. EFSA has rounded this value up to 2 pg WHO<sub>2005</sub>-TEQ/kg body weight per week (TWI).

Various European Union member states, including the Netherlands, had scientific concerns about the EFSA opinion (EFSA, 2018) prior to its publication. EFSA therefore organised an information meeting in order to explain how they arrived at their opinion and what choices were made. The member states also explained their concerns during this meeting. All presentations and accompanying

documents can be viewed at  
<https://www.efsa.europa.eu/en/events/event/181113>.

In brief, the Netherlands has the following concerns (NL, 2018):

- The choice of the Russian Children's Study as the key study, despite the study results being influenced by confounders (e.g. the presence of high concentrations of hexachlorobenzene).
- The derivation of the TWI
- The interpretation of the TWI
- The exposure assessment
- Overall uncertainty in the opinion

The primary concern is the choice of the underlying epidemiological study (the Russian Children's Study) as the key study for the derivation of the TWI.

Now that the EFSA opinion has been published it will be discussed by the European Commission, which will discuss the further implications of lowering the health-based limit value for the laws and regulations. The present advisory report includes both health-based limit values (SCF and EFSA) in the risk assessment.

### **Concentrations of dioxins and dioxin-like PCBs in the mitten crab**

In 2016 and 2017, RIKILT examined the meat from the body of the mitten crab for the presence of dioxins and dioxin-like PCBs (N=11). The mitten crabs that were examined had been caught at various locations around the Netherlands, in both open (N=1) and closed (N=10) catch areas. The levels of dioxins and dioxin-like PCBs ranged between 28.4 and 82.1 TEQ/g of meat from the body (Brust *et al.*, 2018). The lowest level (28.4 pg TEQ/g of meat from the body) was measured in an open catch area. This provides an indication of the level of dioxins and dioxin-like PCBs in mitten crabs that are sold as food.

### **Consumption data**

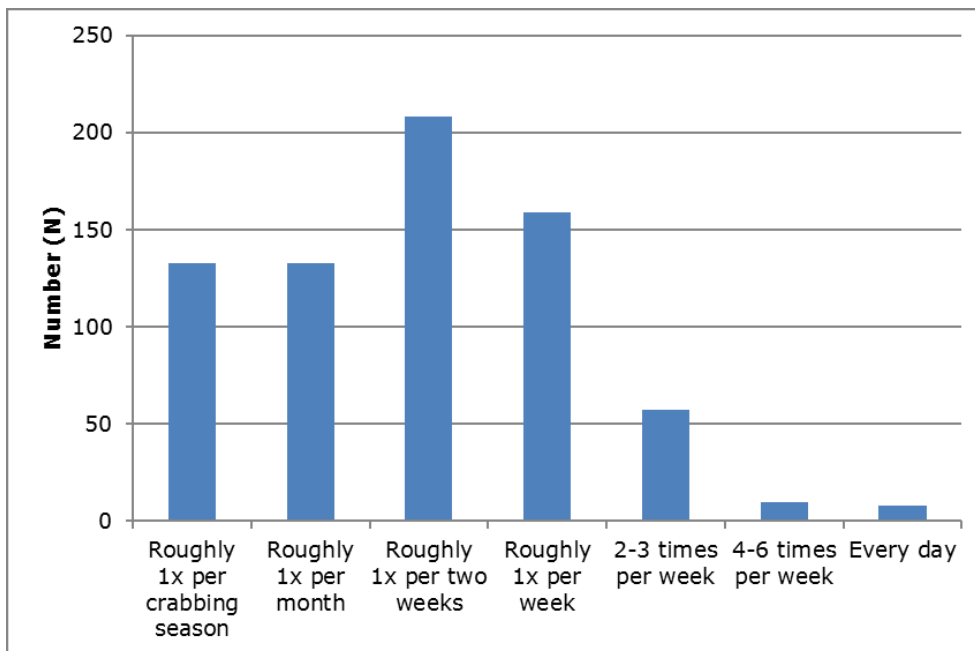
Consumption data on mitten crab are limited. In 2013, RIKILT Wageningen UR (RIKILT) conducted a small-scale survey of the consumption of the mitten crab (van Leeuwen *et al.*, 2013b). BuRO asked market research agency Motivaction to repeat the same consumption survey on a larger scale. Previous research found that primarily individuals of Chinese, Japanese or Korean origin consume mitten crab with some regularity (Bakker & Zaalmink, 2012; van Leeuwen *et al.*, 2013b). In an earlier survey, interviewed Chinese restaurant owners (N=10) did not have mitten crab on the menu. Upon request, however, it was possible to order mitten crab from half of them. According to the restaurant owners, the Dutch do not eat mitten crab because it would involve too much work to eat it and it is an unknown dish to them (Zaalmink & Rijk, 2018). Of the 17 million people who live in the Netherlands, roughly four million have an immigrant background. When we specifically look at individuals of Chinese, Japanese or Korean origin, those of Chinese origin are the largest group (0.4% of the Dutch population)<sup>9</sup>. For this reason, the mitten crab consumption survey targeted people of Chinese origin. To conduct the survey, Motivaction used an online questionnaire (in Dutch and simplified Chinese) and face-to-face research. A summary of the results is shown below. The full results appear in Appendix I.

In total, 990 people (365 men and 625 women) participated in the consumption survey. Of the participants, 72% ( $= (708/990) * 100\%$ ) eat Chinese mitten crab. Most of the mitten crab consumers were born in China (54%). Of the mitten crab consumers who were born in the Netherlands, of 69% both the parents came from China. Of the other 31%, one of the two parents came from China.

<sup>9</sup> The Netherlands has approximately 74,000 residents of Chinese origin, 8,600 residents of Korean origin (South Korea) and 8,500 residents of Japanese origin. <https://opendata.cbs.nl/statline/#/CBS/nl/>



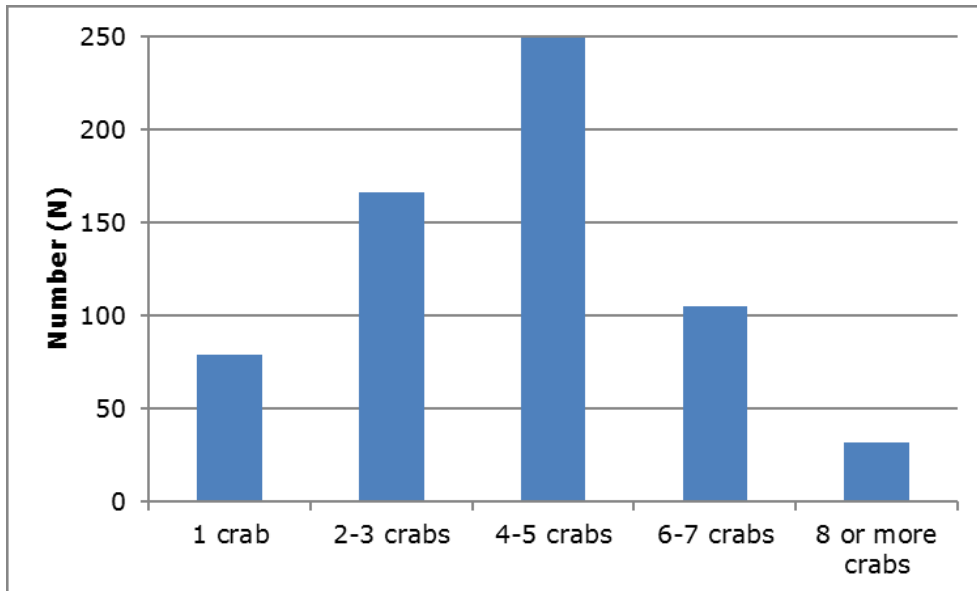
Figure 1 provides an overview of the frequency with which mitten crab is consumed during crabbing season (i.e. September through November). Median mitten crab consumption is “roughly once every two weeks”. The 95<sup>th</sup> percentile is “2 to 3 times a week”.



**Figure 1.** A frequency overview of the consumption of the mitten crab by mitten crab consumers during crabbing season (September through November); roughly 1x per crabbing season (N=133), roughly 1x per month (N=133), roughly 1x per two weeks (N=208), roughly 1x per week (N=159), 2-3 times per week (N=57), 4-6 times per week (N=10), every day (N=8).

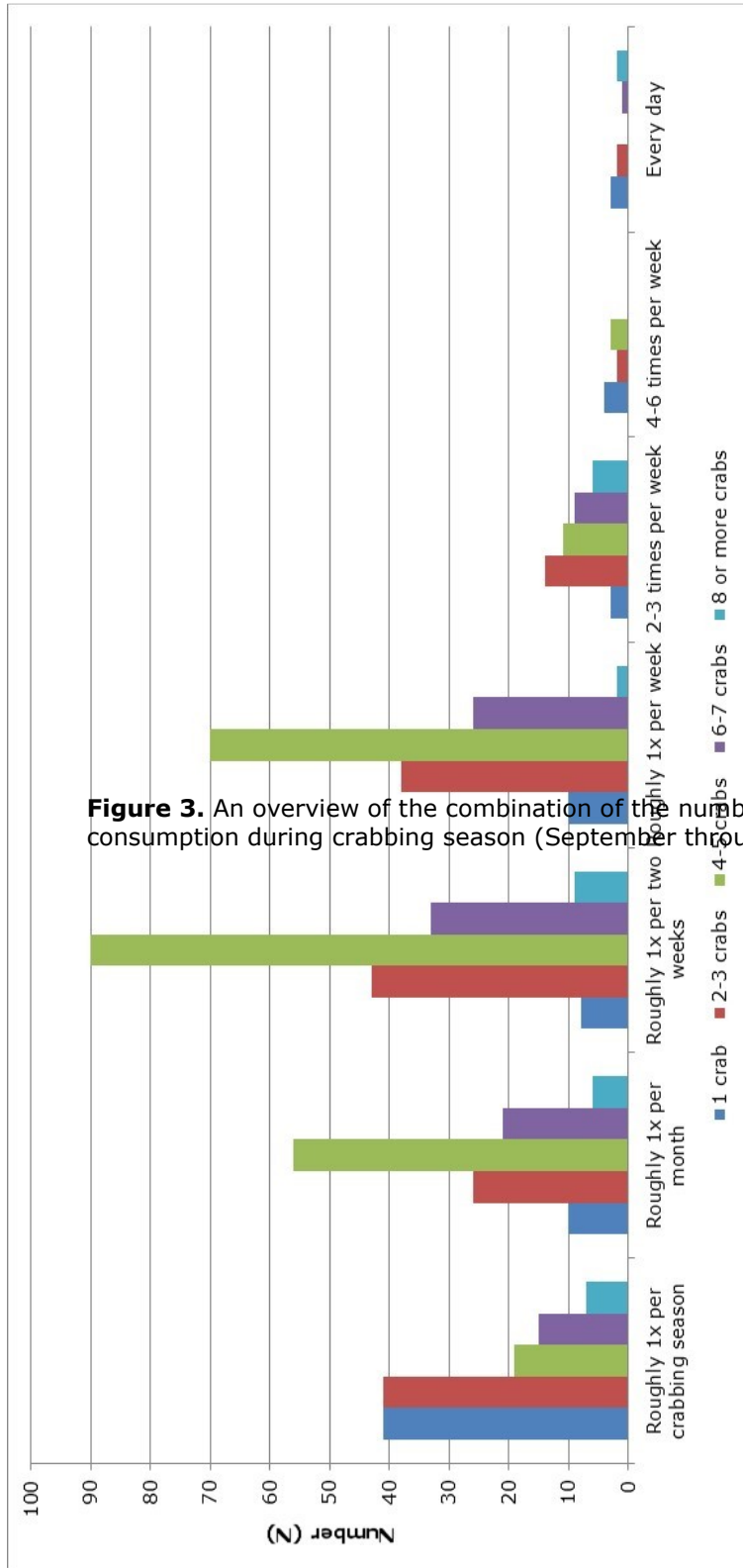
Eighteen percent  $(=(129/708)*100\%)$  of the consumers also eat mitten crab outside of crabbing season (December through August). The other consumers report that they do not eat mitten crab outside of crabbing season.

Figure 2 provides an overview of the number of mitten crabs consumed per meal, per person. In total, 77 consumers indicate that they do not know how many crabs they eat per meal. As such, the consumption amounts of these individuals were not included when calculating the median and the 95<sup>th</sup> percentile. The median mitten crab consumption per person is “4 to 5 crabs” per meal. The 95<sup>th</sup> percentile is “8 or more crabs” per meal.



**Figure 2.** The number of mitten crabs that are consumed per meal, per person; 1 crab (N=79), 2-3 crabs (N=166), 4-5 crabs (N=249), 6-7 crabs (N=105), 8 or more crabs (N=32).

Figure 3 provides an overview of the combination of the number of mitten crabs consumed per meal, per person and the frequency of consumption during crabbing season.



**Figure 3.** An overview of the combination of the number of mitten crabs consumed per meal, per person a consumption during crabbing season (September through November).

Of mitten crab consumers, 79% ( $= (560/708) * 100\%$ ) eat all parts of the crab. In contrast, 21% ( $= (148/708) * 100\%$ ) of mitten crab consumers eat only specific parts of the mitten crab. When these consumers were asked whether they do not eat specific parts of the crab, however, it turns out that 38% ( $= (56/148) * 100\%$ ) of them eat all parts of the mitten crab after all.

Furthermore, it was found that children and adults eat mitten crab equally often, with children eating portions that are equal to or smaller than those of the adults.

### **Exposure to dioxins and dioxin-like PCBs via the mitten crab**

#### *Background exposure*

The mitten crab is not the only source of dioxins and dioxin-like PCBs to which consumers can be exposed. Due to environmental pollution, other food (e.g. eggs, fish) can also contain dioxins and dioxin-like PCBs. Ingestion of these foods leads to an exposure which we refer to as 'background exposure' in this report. Specific information relating to the background exposure of the interviewed mitten crab consumers is not available. However, Front Office has information about the background exposure of the general population to dioxins and dioxin-like PCBs (Boon et al., 2014). For children (2-6 years old), the median background exposure ranges between 0.8-1 pg TEQ/kg body weight per day and the 95<sup>th</sup> percentile ranges between 1.2-1.6 pg TEQ/kg body weight per day. For children aged seven years and older and adults (7-69 years old), the median background exposure is 0.5 pg TEQ/kg body weight per day and the 95<sup>th</sup> percentile is 1.0 pg TEQ/kg body weight per day.

#### *Amount of meat in the legs, claws and body of the mitten crab*

Front Office has estimated the amount of meat in the legs, claws and body of the mitten crab based on a review of the literature (van der Lee *et al.*, 2012). Depending on the size of the crab, the total amount of crab meat ranges from 24 to 40 grams per crab. Most mitten crabs weigh between 100 and 150 grams (shell weight + meat weight), with an average of 21.7% meat (van der Lee *et al.*, 2012; Zaalmlink & Rijk, 2018). This corresponds to 21.7 to 32.6 gram of fresh meat weight. The average ratio of the meat from the body to the meat from the legs and claws is 2.8 (van der Lee *et al.*, 2012). Of the total fresh meat weight, 26.3% ( $= (1/3,8) * 100$ ) is from meat from the legs and 73.7% ( $= (2.8/3.8) * 100$ ) is from meat from the body. Because it is not possible to further distinguish between the white meat and brown meat from the body, Front Office assumes the meat from the body is brown meat.

#### *Weekly exposure versus yearly exposure*

Most mitten crab consumers eat mitten crab during crabbing season (i.e. September through November). Based on the consumption survey, 82% of the mitten crab consumers only eat mitten crab during this season (September through November). The other 18% of the mitten crab consumers also eat mitten crab outside of crabbing season. In this advisory report, this information has been translated into two scenarios, namely:

1. A mitten crab consumer eats mitten crab during crabbing season (12 weeks) and not during the other weeks of the year.
2. A mitten crab consumer eats mitten crab during crabbing season (12 weeks) and eats mitten crab once a month outside of crabbing season ( $= \frac{1}{4} * 40 = 10$  weeks). In total, this mitten crab consumer eats mitten crab 22 weeks a year.

Given that dioxins and dioxin-like PCBs can have a negative effect on health after long-term exposure, the exposure is averaged over an entire year. The total exposure (including the background exposure) may not exceed 52 times the TWI.

*Exposure to dioxins and dioxin-like PCBs through consumption of all consumable parts of the mitten crab*

First of all, BuRO used the current monitoring data to calculate the total exposure of the consumer to dioxins and dioxin-like PCBs. The total exposure is determined by the background exposure and the consumption of the meat from all consumable parts of the mitten crab. This can be calculated as follows (see Table 1 for further explanation):

$$EXP = \frac{BE + (CA * FMP * MCW * CF)}{BW}$$

EXP = exposure; BE = background exposure; CA = consumption amount; FMP = fresh meat percentage; MCW = mitten crab weight; CF = consumption frequency; BW = body weight

**Table 1.** Overview of the various parameter values that are used to calculate the level of dioxins and dioxin-like PCBs in the meat of the mitten crab (total) and the meat from the body.

Parameter	Value(s)	Source
TWI	14 pg TEQ/kg body weight per week 2 pg WHO <sub>2005</sub> -TEQ/kg body weight per week	SCF, 2001 EFSA, 2018
TYI	728 pg TEQ/kg body weight per year (based on SCF, 2001) 104 pg TEQ/kg body weight per year (based on EFSA, 2018)	Current advice
Background exposure (BE)	P50: 0.5 pg TEQ/kg body weight per day P95: 1.0 pg TEQ/kg body weight per day	Boon <i>et al.</i> , 2014
Body weight (BW)	37.6 kg (10-year-old child) 65 kg (adults, 7-69 years old)	Ocké <i>et al.</i> , 2008; van Rossum <i>et al.</i> , 2011
Consumption frequency (CF)	P50: 0.5 meals per week P95: 2.5 meals per week	Consumption survey
Consumption amount (CA)	P50: 4.5 crabs per meal P95: 10 crabs per meal	Consumption survey
Fresh meat percentage (FMP)	21.7% (total); of which 26.4% from the legs and claws and 73.6% from the body	van der Lee <i>et al.</i> , 2012; Zaalmink & Rijk, 2018
Mitten crab weight (MCW)	100 - 150 grams	Zaalmink & Rijk, 2018

Based on a worst-case approach, BuRO assumed a 15:1 ratio between the concentration of dioxins and dioxin-like PCBs in the meat of the body and the concentration in the meat from the legs and claws (Hoogenboom *et al.*, 2015). BuRO also assumed a background exposure of 1 pg TEQ/kg body weight per day (95<sup>th</sup> percentile) and a crab weight of 150 grams. BuRO based its calculations on the lowest level (28.4 pg TEQ/g of meat from the body) that was found during monitoring because this value came from a mitten crab that was caught in an open catch area. Mitten crabs with such concentrations can be sold and then consumed. See Appendix IV for more detailed calculations. Table 2 presents the results.

**Table 2.** The total exposure to dioxins and dioxin-like PCBs (pg TEQ/kg body weight) per week and per year, consisting of the background exposure and the consumption of meat from all consumable parts of the mitten crab (legs, claws and body).

Exposure period	Consumption frequency	Consumption amount	Consumer	Exposure (pg TEQ/kg BW <sup>***</sup> )
Week	P50	P50	Child*	48.6
	P50	P50	Adult**	31.1
	P95	P95	Child	469.7
	P95	P95	Adult	274.7
Year (consumption only during crabbing season)	P50	P50	Child	863.7
	P50	P50	Adult	653.1
	P95	P95	Child	5916.6
	P95	P95	Adult	3575.9
Year (consumption during and outside of crabbing season)	P50	P50	Child	1280.2
	P50	P50	Adult	894
	P95	P95	Child	10543.7
	P95	P95	Adult	6252.6

\*A ten-year-old child with a body weight of 37.6 kg.

\*\*An adult (7-69 years old) with a body weight of 65 kg.

\*\*\*BW = body weight

*Level of dioxins and dioxin-like PCBs at which the TWI or TYI is reached*

Meat from all consumable parts of the mitten crab (legs, claws and body)

Front Office and BuRO then calculated the level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) at which the TWI (based on exposure during one week) or the TYI (based on exposure during one year) is reached. The point at which the TWI and the TYI is met depends on both the background exposure and the consumption of the mitten crab. This can be calculated as follows (see Table 1 for further explanation):

$$DC = \frac{(TWI - BE) * BW}{CA * FMP * MCW * CF}$$

DC = dioxin concentration in mitten crab meat; TWI = tolerable weekly intake; BE = background exposure; CA = consumption amount; FMP = fresh meat percentage; MCW = mitten crab weight; CF = consumption frequency; BW = body weight

See Appendix V of this advisory report and page 12 of the Front Office recommendation (Appendix II) for more detailed calculations. Table 3 presents the results, based on a TWI of 14 pg TEQ/kg body weight, a background exposure of 1 pg TEQ/kg body weight per day (95<sup>th</sup> percentile) and a crab weight of 150 grams.

**Table 3.** The level of dioxins and dioxin-like PCBs (pg TEQ/g of meat) in the meat of all consumable parts of the mitten crab (legs, claws and body) at which the TWI (based on exposure during one week; 14 pg TEQ/kg body weight) or the TYI (based on exposure during one year; 728 pg TEQ/kg body weight) is reached, taking into account the background exposure.

Exposure period	Consumption frequency	Consumption amount	Consumer	Level of dioxins and dioxin-like PCBs (pg TEQ/g of meat)
Week	P50	P50	Child*	3.6
	P50	P50	Adult**	6.2
	P95	P95	Child	0.32
	P95	P95	Adult	0.56
Year (consumption only during crabbing season)	P50	P50	Child	15.6
	P50	P50	Adult	26.9
	P95	P95	Child	1.4
	P95	P95	Adult	2.4
Year (consumption during and outside of crabbing season)	P50	P50	Child	8.5
	P50	P50	Adult	14.7
	P95	P95	Child	0.76
	P95	P95	Adult	1.3

\*A ten-year-old child with a body weight of 37.6 kg.

\*\*An adult (7-69 years old) with a body weight of 65 kg.

The level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) is zero when calculated using the TWI proposed by EFSA (2 pg TEQ/kg body weight). The background exposure (P95) of the Dutch population to dioxins and dioxin-like PCBs, which is 3.5 and 7 pg TEQ/kg body weight per week for children (ages 2-6) and adults (ages 7-69), respectively, is higher than the TWI. The TWI has been reached due to the background exposure.

#### Meat from the body

Front Office and BuRO then calculated the level of dioxins and dioxin-like PCBs in the meat from the body of the mitten crab at which the TWI (based on exposure during one week) or the TYI (based on exposure during one year) is reached. This was done using the formula from the previous page, with the exception that the exposure to dioxins in the meat from the legs and claws was also included in addition to the background exposure. For the ratios of the concentration of dioxins and dioxin-like PCBs in the meat of the body to the concentration in the meat from the legs and claws, Front Office assumed the ratios of 15:1 (lower limit), 49:1 (median) and 120:1 (upper limit) (Hoogenboom *et al.*, 2015).

Table 4 presents the level of dioxins and dioxin-like PCBs in the meat from the body of the mitten crab at which the TWI (based on exposure during one week) or the TYI (based on exposure during one year) is reached, based on a TWI of 14 pg TEQ/kg body weight and the 95<sup>th</sup> percentile for all parameters (including a crab weight of 150 grams) and the most conservative ratio between the dioxin concentration in the meat from the body and the dioxin concentration in the legs and claws (15:1).

**Table 4.** The level of dioxins and dioxin-like PCBs in the meat from the body of the mitten crab at which the TWI (based on exposure during one week; 14 pg TEQ/kg body weight) or the TYI (based on exposure during one year; 728 pg TEQ/kg body weight) is reached, based on the 95<sup>th</sup> percentile for all parameters (including a crab weight of 150 grams) and the most conservative ratio between the dioxin concentration in the meat from the body and the dioxin concentration in the legs and claws (15:1).

Exposure period	Consumption frequency	Consumption amount	Consumer	Level of dioxins and dioxin-like PCBs (pg TEQ/g of meat)
Week	P95	P95	Child*	0.43
	P95	P95	Adult**	0.74
Year (consumption only during crabbing season)	P95	P95	Child	0.12
	P95	P95	Adult	0.21
Year (consumption during and outside of crabbing season)	P95	P95	Child	0.14
	P95	P95	Adult	0.16

\*A ten-year-old child with a body weight of 37.6 kg.

\*\*An adult (7-69 years old) with a body weight of 65 kg.

### Risk assessment

Given that dioxins and dioxin-like PCBs can have a negative effect on health after long-term exposure and the mitten crab is a seasonal product, the exposure is averaged over an entire year. The total exposure (including the background exposure) may not exceed 52 times the TWI, which is then expressed as TYI (tolerable yearly intake). Both the TWI and the TYI are for lifetime exposure. However, no short-term effects are expected from exposure to dioxins and dioxin-like PCBs. For this reason, the health risks posed to the consumer can only be assessed on the basis of a yearly exposure.

#### **Based on a TWI of 14 pg TEQ/kg body weight (SCF, 2001)**

##### *Consumption of all consumable parts of the mitten crab*

The exposure to dioxins and dioxin-like PCBs through the consumption of meat from all consumable parts of the mitten crab (legs, claws and body) with a level of 28.4 pg TEQ/g of meat from the body is 863.7 pg TEQ/kg body weight per year (at median consumption during crabbing season) or 5,916.6 pg TEQ/kg body weight per year (at consumption above the 95<sup>th</sup> percentile during crabbing season) for a ten-year-old child and 653.1 pg TEQ/kg body weight per year (at median consumption during crabbing season) or 3,575.9 pg TEQ/kg body weight per year (at consumption above the 95<sup>th</sup> percentile during crabbing season) for adults. Only at median consumption by adults is the TYI (728 pg/TEQ kg body weight) not exceeded. The TYI is exceeded in all other scenarios, meaning that health effects to the consumer cannot be excluded.

The exposure to dioxins and dioxin-like PCBs through the consumption of meat from all consumable parts of the mitten crab (legs, claws and body) with a level of 28.4 pg TEQ/g of meat from the body is 1,280.2 pg TEQ/kg body weight per year



(at median consumption during and outside of crabbing season) or 10,543.7 pg TEQ/kg body weight per year (at consumption above the 95<sup>th</sup> percentile during and outside of crabbing season) for a ten-year-old child and 894 pg TEQ/kg body weight per year (at median consumption during and outside of crabbing season) or 6,252.6 pg TEQ/kg body weight per year (at consumption above the 95<sup>th</sup> percentile during and outside of crabbing season) for adults. The TYI (728 pg/TEQ kg body weight) is exceeded in all scenarios, meaning that health effects to the consumer cannot be excluded.

The level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) at which the TYI is reached is 15.6 pg TEQ/g of meat for consumption during crabbing season or 8.5 pg TEQ/g of meat for consumption during and outside of crabbing season. These levels provide sufficient protection for both children aged 10 and older and adults who consume average amounts of mitten crab. With respect to mitten crab lovers, the level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) at which the TYI is reached is 1.4 pg TEQ/g of meat for consumption during crabbing season or 0.76 pg TEQ/g of meat for consumption during and outside of crabbing season. These levels provide sufficient protection for both children aged 10 and older and adults who are mitten crab lovers.

#### *Consumption of meat from the body of the mitten crab*

With respect to mitten crab lovers, the level of dioxins and dioxin-like PCBs in the meat from the body of the mitten crab at which the TYI is reached is 0.12 pg TEQ/g of meat for consumption during crabbing season or 0.14 pg TEQ/g of meat for consumption during and outside of crabbing season. These levels provide sufficient protection for both children aged 10 and older and adults who are mitten crab lovers.

#### **Based on a TWI of 2 pg TEQ/kg body weight (EFSA, 2018)**

The level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) is zero when calculated using the TWI proposed by EFSA (2 pg TEQ/kg body weight). The background exposure (P95) of the Dutch population to dioxins and dioxin-like PCBs, which is 3.5 and 7 pg TEQ/kg body weight per week for children (ages 2-6) and adults (ages 7-69), respectively, is higher than the TWI. The TWI has been reached due to the background exposure, meaning that health effects to the mitten crab consumer cannot be excluded.

#### Discussion

In their calculations, Front Office and BuRO made assumptions that possibly overestimate the allowable level of dioxins and dioxin-like PCBs.

The first pertains to the background exposure. In its calculations, Front Office assumed the background exposure of the general population to dioxins and dioxin-like PCBs. If, however, the mitten crab consumer regularly eats more fish, for example, the background exposure for this group of consumers can be higher, given the relatively high levels of dioxins and dioxin-like PCBs in fish. A higher background exposure would entail less of a protective margin for exposure to dioxins and dioxin-like PCBs in meat from the body of the mitten crab.

The second assumption pertains to body weight. Front Office based the body weight on the reported weights in the food consumption surveys that are also used to calculate the background exposure. Because mitten crab consumers are not represented in these food consumption surveys and the surveyed population consisting primarily of the general Dutch population, the body weight may be overestimated. The Asian – more specifically, Chinese – consumer is very likely lighter than the average Dutch consumer. Dutch data are lacking in this respect, but data from the United States indicate that adult white Americans (men and

women) are roughly 1.3 heavier than Asian Americans (Fryar *et al.*, 2016). A lower body weight would entail less of a protective margin for exposure to dioxins and dioxin-like PCBs in meat from the body of the mitten crab.

In this advisory report, exposure is averaged over an entire year because dioxins and dioxin-like PCBs can have a negative effect on the health of the consumer after long-term exposure and the consumption of mitten crab is seasonal. It is still unclear as to what time or during which period negative health effects occur due to exposure to dioxins and dioxin-like PCBs. Averaging the exposure can lower the exposure at a critical point from a mathematical perspective, such that a health-based limit value is not exceeded, while in reality an exposure during the critical period certainly poses risks. Averaging the exposure over a year may lead to an underestimation of that critical period.

### Conclusion

The Chinese mitten crab is an invasive species that is commercially fished in Dutch waters. The vast majority of the Dutch mitten crab is exported to Chinese communities and restaurants in the EU and China. The mitten crab that remains in the Netherlands is intended for the Chinese communities and Chinese restaurants. In principle, the mitten crab is thus primarily consumed by people of Asian origin, especially those of Chinese origin.

The mitten crab in the Netherlands contains high levels of dioxins and dioxin-like PCBs, and as such consumption of the mitten crab entails possible health effects. Regulation (EC) No 1881/2006 establishes a statutory maximum for the presence of dioxins and dioxin-like PCBs in the white meat of the crab, but a statutory maximum for brown meat (meat from the body) is lacking.

*Based on a TWI of 14 pg TEQ/kg body weight (SCF, 2001)*

In general, the meat of all consumable parts of the mitten crab is eaten, meaning both the meat from the legs/claws and the meat from the body. The maximum exposure to dioxins and dioxin-like PCBs from the consumption of meat of all consumable parts of the mitten crab, with a level of 28.4 pg TEQ/g meat from the body, does not exceed the TYI at median consumption of an adult during crabbing season. In the other scenarios (median consumption and a crab-lover's consumption by a ten-year-old child; a crab-lover's consumption by an adult; consumption only during crabbing season and consumption during and outside of crabbing season), the TYI is exceeded.

The level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) at which the TYI is reached is 15.6 pg TEQ/g of meat for consumption during crabbing season or 8.5 pg TEQ/g of meat for consumption during and outside of crabbing season (at median consumption). With respect to mitten crab lovers, the level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) at which the TYI is reached is 1.4 pg TEQ/g of meat for consumption during crabbing season or 0.76 pg TEQ/g of meat for consumption during and outside of crabbing season. These levels provide sufficient protection for both children and adults.

With respect to mitten crab lovers, the level of dioxins and dioxin-like PCBs in the meat from the body of the mitten crab at which the TYI is reached is 0.12 pg TEQ/g of meat for consumption during crabbing season or 0.14 pg TEQ/g of meat for consumption during and outside of crabbing season. These levels provide sufficient protection for both children aged 10 and older and adults who are mitten crab lovers.

With respect to level of dioxins and dioxin-like PCBs in either the meat from all consumable parts of the mitten crab or the meat from the body of the mitten crab, it has been found that at median consumption there is still room left before

reaching the TYI. When it comes to genuine crab-lovers, however, the tolerable level of dioxins and dioxin-like PCBs in either the meat from all consumable parts of the mitten crab or the meat from the body of the mitten crab is almost zero. The background exposure and the exposure via meat from the legs/claws is all it takes to reach the TYI. There is no protective margin left to allow for additional exposure via meat from the body.

*Based on a TWI of 2 pg TEQ/kg body weight (EFSA, 2018)*

The level of dioxins and dioxin-like PCBs in the meat of all consumable parts of the mitten crab (legs, claws and body) is zero when calculated using the TWI proposed by EFSA (2 pg TEQ/kg body weight). The background exposure (P95) of the Dutch population to dioxins and dioxin-like PCBs, which is 3.5 and 7 pg TEQ/kg body weight per week for children (ages 2-6) and adults (ages 7-69), respectively, is higher than the TWI. The TWI has been reached due to the background exposure,

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## Appendix I: Consumption survey

Exact consumption data on the mitten crab are limited. In 2013, RIKILT Wageningen UR conducted a small-scale survey of the consumption of the mitten crab (van Leeuwen *et al.*, 2013b). Market research agency Motivaction was commissioned by BuRO to repeat the same consumption survey on a larger scale.

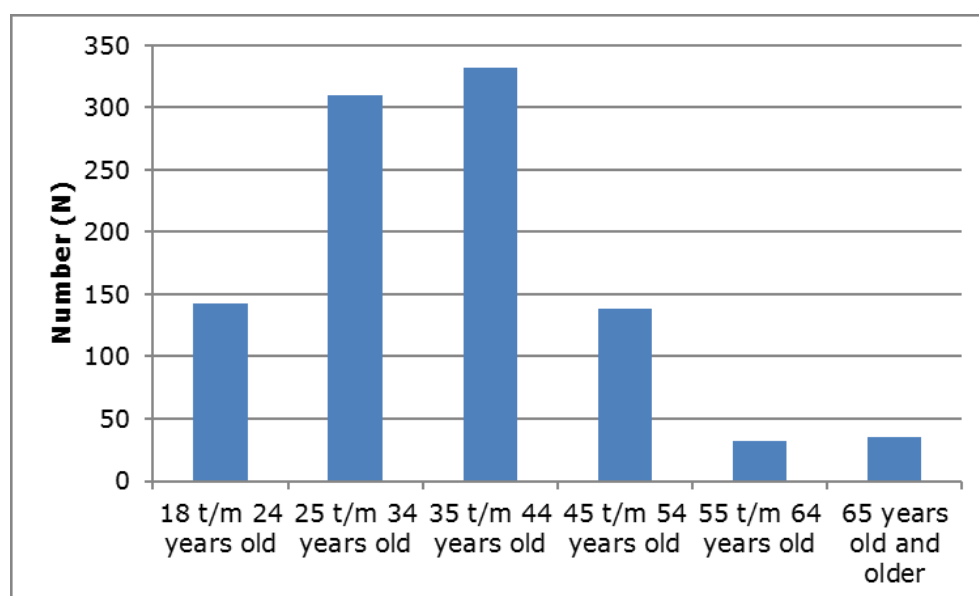
### Method

Previous research found that primarily individuals of Chinese, Japanese or Korean origin consume mitten crab with some regularity (Bakker & Zaalmink, 2012; van Leeuwen *et al.*, 2013b). Of the 17 million people who live in the Netherlands, roughly four million have an immigrant background. When we specifically look at individuals of Chinese, Japanese or Korean origin, those of Chinese origin are the largest group (0.4% of the Dutch population). For this reason, the mitten crab consumption survey targeted people of Chinese origin. To conduct the survey, Motivaction used an online questionnaire (in Dutch and simplified Chinese) and face-to-face research in Amsterdam, Rotterdam and The Hague.

The source document, supplied by Motivaction, was analysed by BuRO in Microsoft Excel 2010. Frequency tables were made for all variables, and the median and the 95<sup>th</sup> percentile were calculated for the consumption amount (the number of crabs eaten per meal) and the consumption frequency (the number of times crab is eaten per crabbing season).

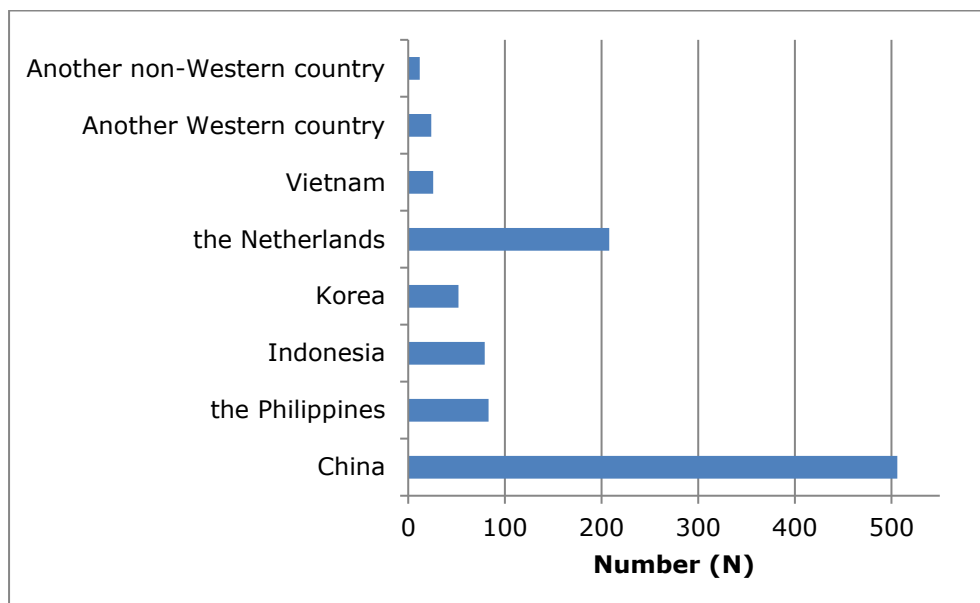
### Results

In total, 990 respondents (365 men and 625 women) participated in the consumption survey. Figure 1 provides an overview of the age distribution of the respondents.



**Figure 1.** An overview of the number of respondents per age category; 18-24 years old (N=143), 25-34 years old (N=310), 35-44 years old (N=332), 45-54 years old (N=138), 55-64 years old (N=32), 65 years old and older (N=35).

Most of the respondents were born in China (51%) or in the Netherlands (21%) (Figure 2). Of the respondents who were born in the Netherlands, the parents of 67% came both from China. Of the other 33%, one of the two parents came from China.



**Figure 2.** An overview of the country of birth of the respondents; China (N=506), the Philippines (N=83), Indonesia (N=79), Korea (N=52), the Netherlands (N=208), Vietnam (26), another Western country (N=24), another non-Western country (N=12).

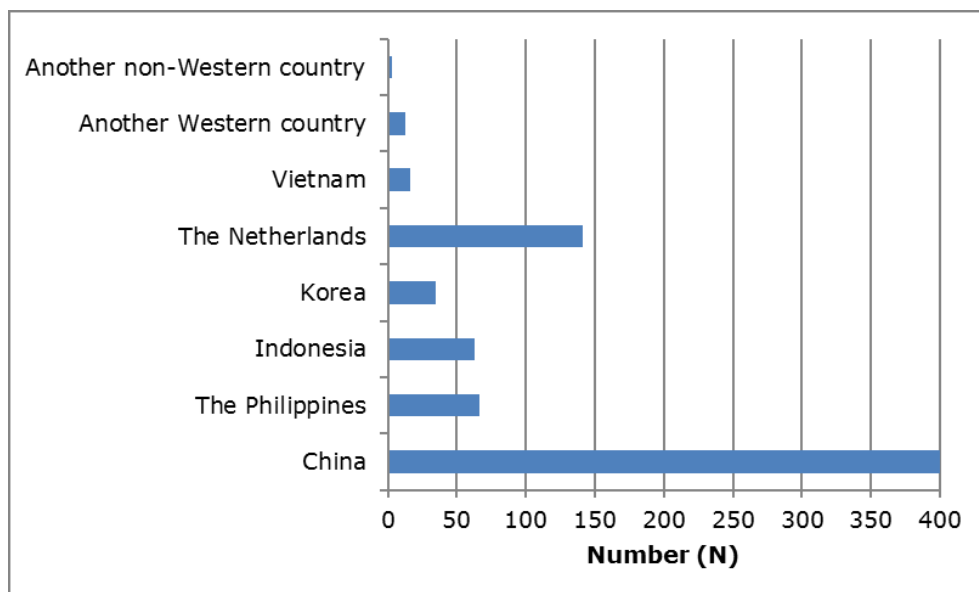
#### *Crab consumers*

Eighty three percent ( $=\frac{821}{990} \times 100\%$ ) of all respondents eat crab. When these respondents were asked whether they were familiar with the Chinese mitten crab, 79% ( $=\frac{650}{821} \times 100\%$ ) recognised the mitten crab in an image. Of the respondents who did not recognise the mitten crab (N=171), 51% ( $=\frac{87}{171} \times 100\%$ ) recognised the Chinese mitten crab by name after it was indicated that the crab in the image was the Chinese mitten crab. Therefore, a total of 737 ( $=650+87$ ) crab consumers are familiar with the mitten crab.

#### *Chinese mitten crab consumers*

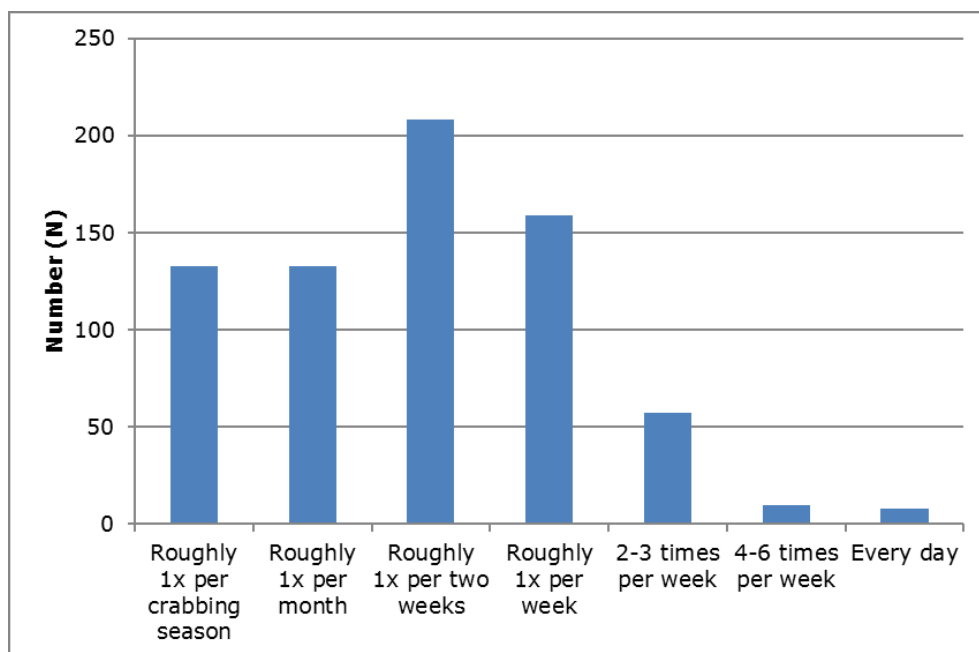
Of the 737 crab consumers who are familiar with the mitten crab, 29 consumers reported that they never eat mitten crab. Accordingly, this results in 708 ( $=737-29$ ) mitten crab consumers.

Most of the mitten crab consumers were born in China (54%) or in the Netherlands (19%) (Figure 3). Of the mitten crab consumers who were born in the Netherlands, the parents of 69% came both from China. Of the other 31%, one of the two parents came from China.



**Figure 3.** An overview of the country of birth of the mitten crab consumers; China (N=400), the Philippines (N=66), Indonesia (N=63), Korea (N=35), the Netherlands (N=141), Vietnam (16), another Western country (N=13), another non-Western country (N=3).

Figure 4 provides an overview of the frequency with which mitten crab is consumed during crabbing season (i.e. September through November). Median mitten crab consumption is “roughly once every two weeks”. The 95<sup>th</sup> percentile is “2 to 3 times a week”.

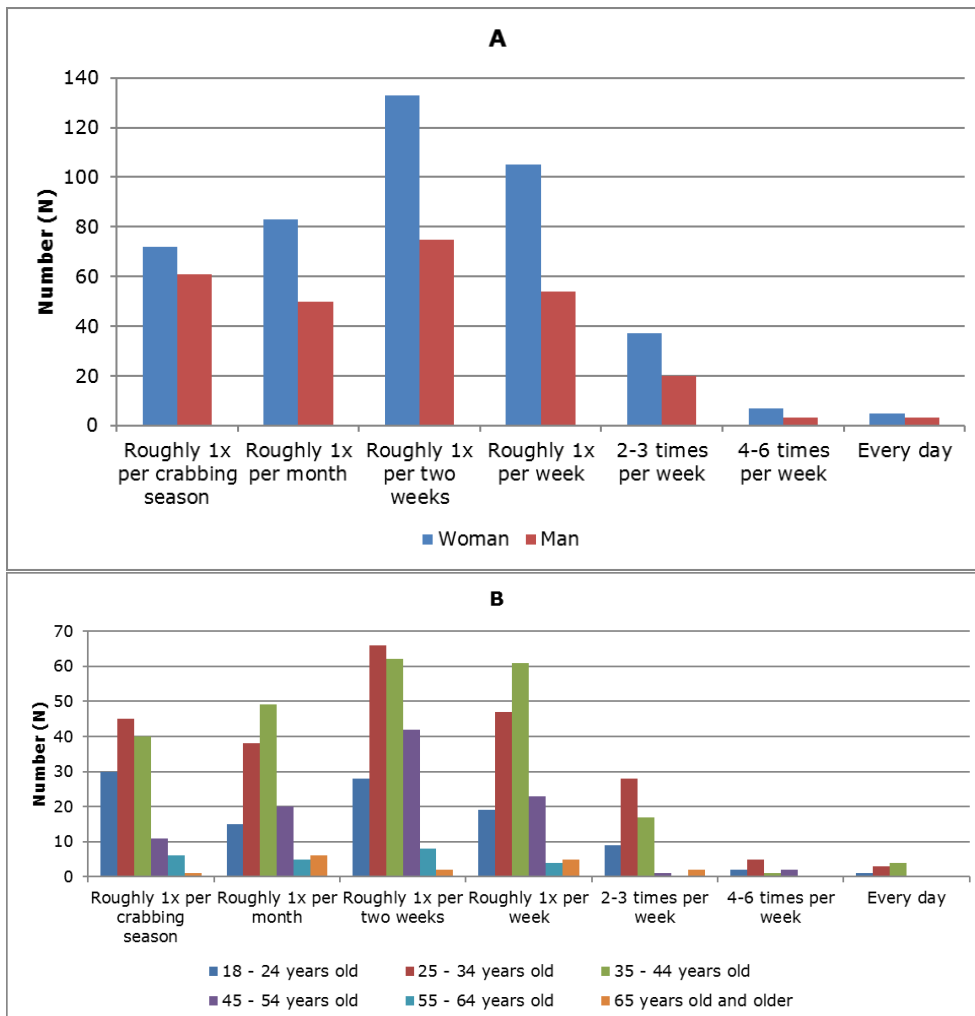


**Figure 4.** A frequency overview of the consumption of the mitten crab by mitten crab consumers during crabbing season (September through November); roughly 1x per crabbing season (N=133), roughly 1x per month (N=133), roughly 1x per two weeks (N=208), roughly 1x per week (N=159), 2-3 times per week (N=57), 4-6 times per week (N=10), every day (N=8).



Eighteen percent  $(=(129/708)*100\%)$  of the consumers also eat mitten crab outside of crabbing season (December through August). The other consumers report that they do not eat mitten crab outside of crabbing season.

Figure 5 provides an overview of the frequency with which mitten crab is consumed during crabbing season, subdivided according to gender (A) and age (B).



**Figure 5.** A frequency overview of the consumption of the mitten crab during crabbing season (September through November) by mitten crab consumers, subdivided according to gender (A) and age (B).

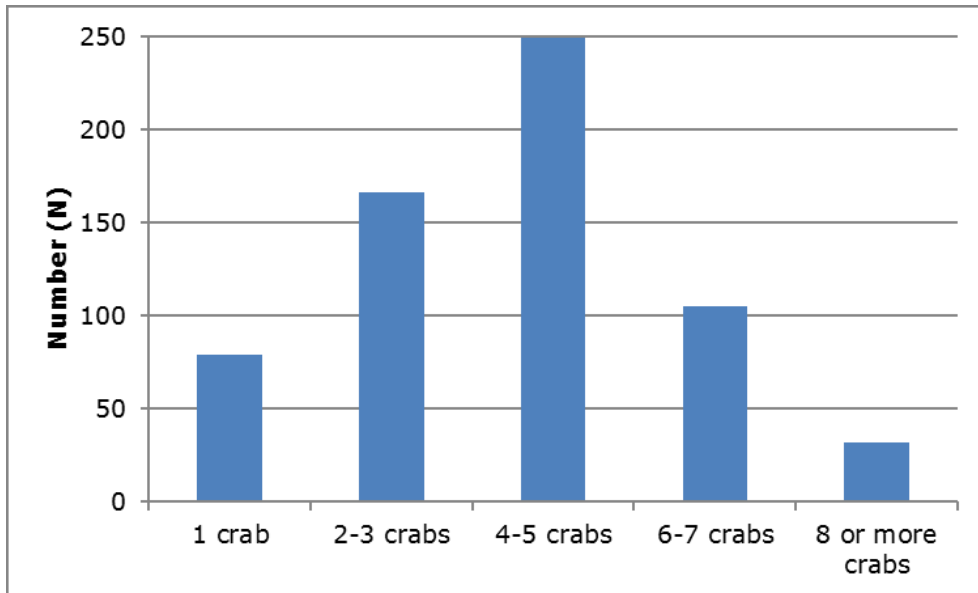
Figure 6 provides an overview of the number of mitten crabs consumed per meal, per person. Seventy-seven consumers report not knowing how many crabs they eat per meal. As such, their data were not included in calculating the median and the 95<sup>th</sup> percentile. The median mitten crab consumption per person is "4 to 5 crabs per meal". The 95<sup>th</sup> percentile is "8 or more crabs" per meal.

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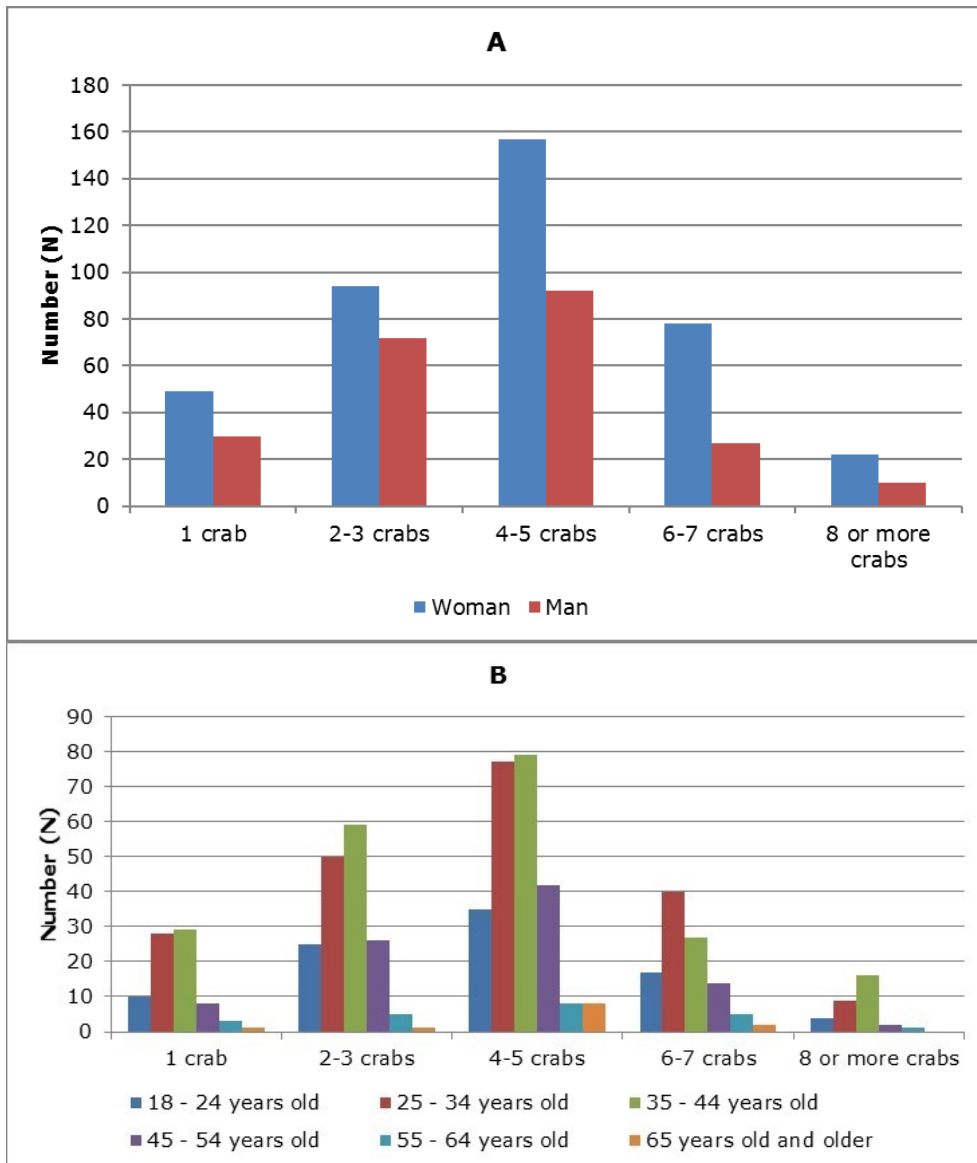
**Our reference**

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**Figure 6.** An overview of the number of mitten crabs that are consumed per meal, per person; 1 crab (N=79), 2-3 crabs (N=166), 4-5 crabs (N=249), 6-7 crabs (N=105), 8 or more crabs (N=32).

Figure 7 provides an overview of the number of mitten crabs consumed per meal, per person, subdivided according to gender (A) and age (B). This graphic also does not include data from those who did not know how many mitten crabs they ate per meal.



**Figure 7.** An overview of the number of mitten crabs consumed per meal, per person, subdivided according to gender (A) and age (B).

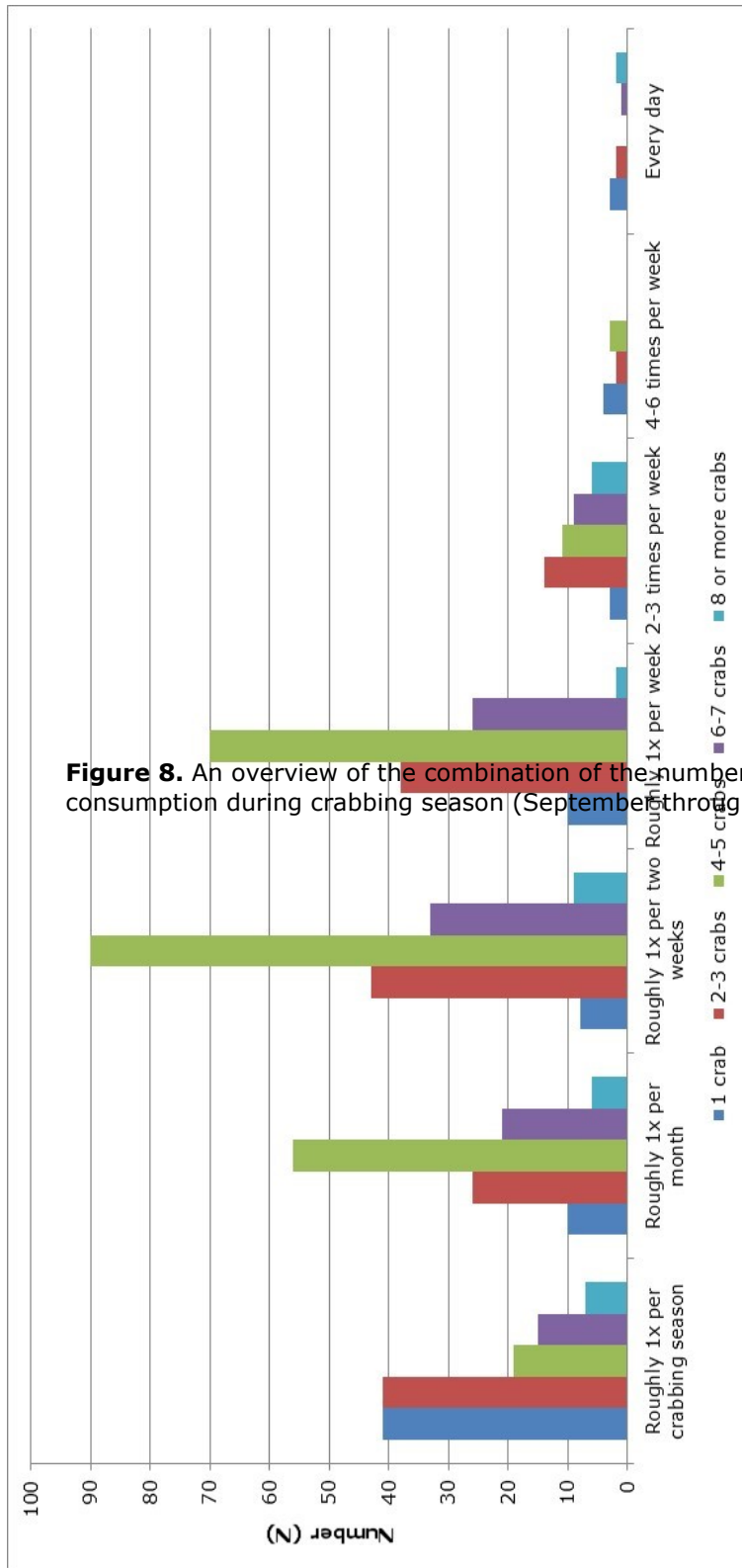
Figure 8 provides an overview of the combination of the number of mitten crabs consumed per meal, per person and the frequency of consumption during crabbing season.

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**Figure 8.** An overview of the combination of the number of mitten crabs consumed per meal, per person and consumption during crabbing season (September through November).

Seventy-nine percent  $(=(560/708)*100\%)$  of mitten crab consumers eat all parts of the crab (Table 1). In contrast, 21%  $(=(148/708)*100\%)$  of the consumers report eating only specific parts of the mitten crab. When these consumers were asked whether they do not eat specific parts of the crab, however, it turns out that 38%  $(=(56/148)*100\%)$  indicate that there are no specific parts of the mitten crab that they do not eat.

**Table 1.** Overview of specific parts of the mitten crab that are eaten by mitten crab consumers (N=708).

Description	Number (N)	Percentage (%)
All parts (entire crab)	560	79
Legs	40	6
Claws	15	2
Contents of the body	20	3
Gill/lung	13	2
Heart/stomach	11	2
Yellow organ	8	1
Ovaries and eggs	3	0
A combination of the above parts	38	5

Furthermore, it was found that children and adults eat mitten crab equally often, with children eating portions that are equal to or smaller than those of the adults.

The mitten crab is eaten in the domestic sphere with family, friends and acquaintances as well as in restaurants. Its consumption is not limited to the Netherlands (Table 2).

**Table 2.** An overview of the various locations or social settings in which mitten crab consumers (N=708) eat mitten crab.

Description	Number (N)	Percentage (%)
Home	32	5
At family	48	7
At friends	134	19
At acquaintances	227	32
In a restaurant	136	19
Abroad	35	5
I don't know	5	1
A combination of the above answers	91	13

Most mitten crab consumers (98%) report that the mitten crab is part of a regular meal. The other consumers report that the mitten crab is eaten on special occasions, such as Chinese New Year, weddings and birthdays.

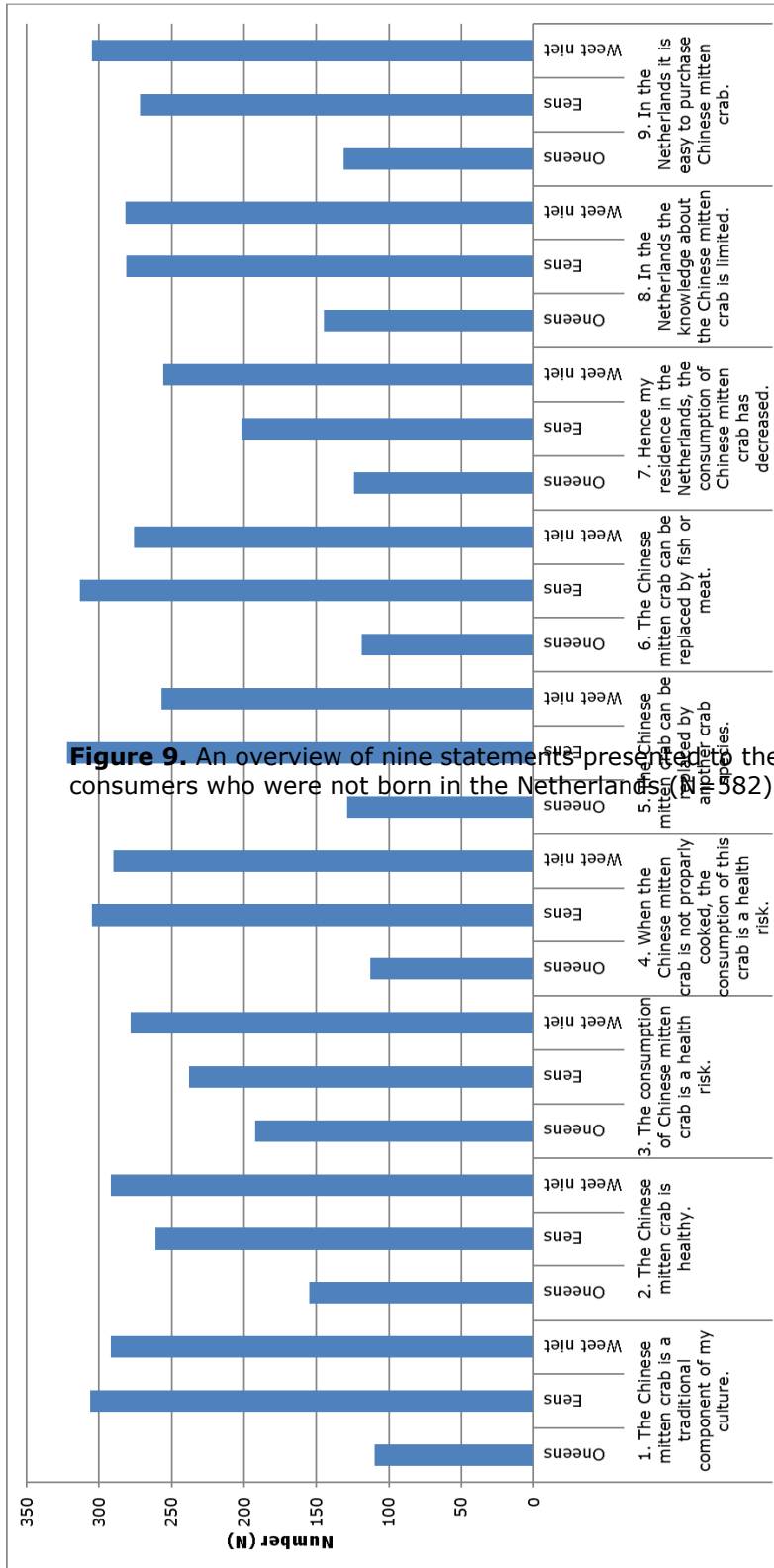
Half of mitten crab consumers (50%) cannot indicate where they purchase the mitten crab they eat. The other consumers report purchasing mitten crab at a Chinese supermarket, at the market, in a fish shop, at a supermarket or at a fish trader. There are also consumers who catch mitten crab themselves (Table 3).

**Table 3.** An overview of the places where mitten crab consumers (N=708) purchase mitten crab.

Description	Number (N)	Percentage (%)
Chinese supermarket	47	7
Market	28	4
Fish shop	55	8
Supermarket	63	9
I catch my own mitten crab	66	9
Fish trader	32	5
I don't know	353	50
A combination of the above answers	64	9

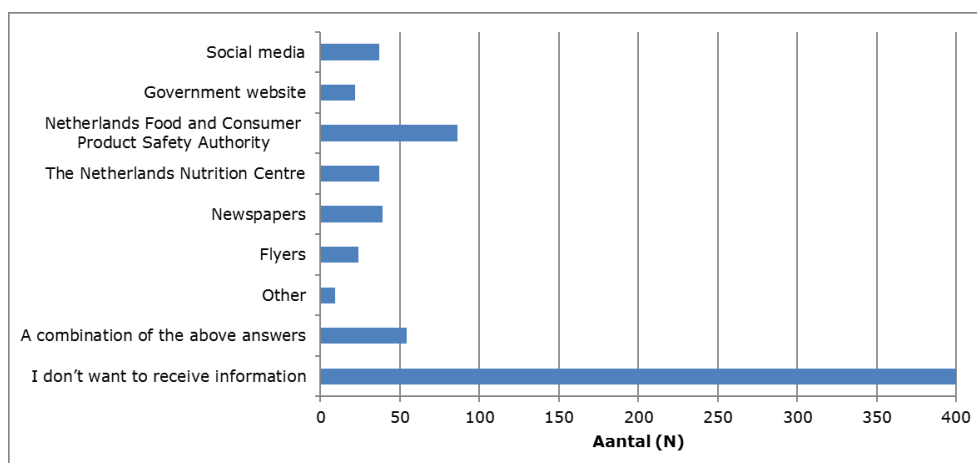
Figure 9 provides an overview of nine statements presented to the mitten crab consumer. These statements pertain to various aspects relating to the consumption of mitten crab. Statement #7 was only presented to consumers who were not born in the Netherlands (N=582). For each statement, roughly 30% to 40% of the mitten crab consumers answered "I don't know".

Thirty-four percent ( $(=238/708)*100\%$ ) of the consumers agree with the statement that mitten crab poses a health risk. The mitten crab is seen as a traditional part of the consumer's culture (43% agree). Since moving to the Netherlands, the consumer has begun to eat less mitten crab (35% agree). The mitten crab can easily be replaced by other types of crabs (45% agree) or meat or fish (44% agree). In the Netherlands, little is known about the mitten crab (40% agree), but it is easy to acquire mitten crab (38% agree).



**Figure 9.** An overview of nine statements presented to the mitten crab consumers (N=708). Statement #7 consumers who were not born in the Netherlands (N=582).

Lastly, the mitten crab consumers were asked in what way(s) they would like to receive information about food from the Dutch government (Figure 10). The majority (56%) of the consumers would not like to receive information about food. Those who do want to receive information mention NVWA, the Netherlands Nutrition Centre, newspapers, social media (e.g. Facebook), flyers and the government website as options.



**Figure 10.** Overview of the possible ways in which mitten crab consumers would like to receive information about food from the government; Social media (N=37), Government website (N=22), NVWA (N=86), The Netherlands Nutrition Centre (N=37), Newspapers (N=39), flyers (N=24), Other (N=9), A combination of the above answers (N=54), I don't want to receive information (N=400).



**Appendix II: Estimate of the maximum tolerable level of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and dioxin-like polychlorinated biphenyls in the brown meat of the Chinese mitten crab (RIVM/RIKILT Front Office report)**

**Office for Risk Assessment & Research**

**Date**

June 11, 2019

**Our reference**

TRCNVWA/2019/3583

**Appendix III: The catching, trading and consumption of mitten crab in the Netherlands (Zaalmink and Rijk, 2018).**

**Office for Risk Assessment & Research**

**Date**

June 11, 2019

**Our reference**

TRCNVWA/2019/3583

#### Appendix IV: Detailed calculations by BuRO on exceeding the TWI or TYI

Because the terms white meat and brown meat are confusing, the BuRO advisory report refers to meat from the legs and claws (the “appendages”) and meat from the body of the crab. The meat from the legs and claws is white meat. The meat from the body is primarily brown meat, though it also contains a little bit of white meat. No distinction is made between white and brown meat when it comes to consumption of meat from the body.

In 2016 and 2017, RIKILT examined the meat from the body of the mitten crab for the presence of dioxins and dioxin-like PCBs. The levels ranged between 28.4 and 82.1 TEQ/g of meat from the body. The lowest level was found in a mitten crab caught in an open catching area. Because mitten crabs can only be caught in open catching area, the lowest level found was used in the calculation. This provides an indication of the level of dioxins and dioxin-like PCBs in mitten crabs that are sold as food.

From the monitoring, the lowest found concentration of dioxins and dioxin-like PCBs is 28.4 pg TEQ/g of meat from the body (i.e. brown meat with a small amount of white meat). This means that the white meat from the legs/claws contains 1.8 pg TEQ/g ( $= (1/16) * 28.4$ ). Based on a worst-case scenario, a 1:15 ratio was assumed between the concentration of dioxins and dioxin-like PCBs in white meat compared to brown meat.

A mitten crab consists of 21.7% fresh meat weight. The total fresh meat weight can be subdivided into brown meat (73.6%) and white meat (26.4%).

At a total weight of 150 grams, this corresponds to a total fresh meat weight of 32.55 grams ( $= 150 * 0.217$ ). When subdivided into brown and white meat, this corresponds to 23.96 gram ( $= 32.55 * 0.736$ ) (brown meat) and 8.59 gram ( $= 32.55 * 0.264$ ) (white meat).

The meat from the body of the mitten crab contains 680.46 ( $= 28.4 * 23.96$ ) pg TEQ.

The meat from the legs/claws of the mitten crab contains 15.46 ( $= 1.8 * 8.59$ ) pg TEQ.

In total, a mitten hand crab contains 150 grams, which translates into 695.92 ( $= 680.46 + 15.46$ ) pg TEQ.

#### Is the TWI or TYI exceeded at the current concentration of dioxins and dioxin-like PCBs found during the 2016/2017 monitoring?

Two scenarios have been worked out below: a realistic scenario (based on a median consumption amount; 4.5 crabs per meal and a median consumption frequency; 0.5 meals per week) and a worst-case scenario (based on the 95<sup>th</sup> percentile for the consumption amount; 10 crabs per meal and the 95<sup>th</sup> percentile for the consumption frequency; 2.5 meals per week). The other parameters for calculating both scenarios are the same, i.e. the 95<sup>th</sup> percentile for the background exposure (1 pg TEQ/kg body weight per day) and a crab weight of 150 grams.

The below calculations assumed a body weight of 37.6 kg for a ten-year-old child and 65 kg for an adult (7-69 years old). These were the weights reported in the food consumption survey on which the background exposure was based (see also FO recommendation on page 7).

##### *Weekly exposure*

##### *Realistic scenario*

##### Child (37.6 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

A child eats 4.5 crabs per meal and has 0.5 meals per week.

In total, this child is exposed to 1,565.8 pg TEQ ( $=695.92 * 4.5 * 0.5$ ). This corresponds to an exposure of 41.6 TEQ/kg body weight per ( $=1,565.8/37.6$ ) week.

The background exposure is 7 pg TEQ/kg body weight per week ( $=1*7$ ).

**The total exposure per week is 48.6 TEQ/kg body weight ( $=41.6+7$ ).**

Adult (65 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

An adult eats 4.5 crabs per meal and has 0.5 meals per week.

In total, an adult is exposed to 1,565.8 pg TEQ ( $=695.92 * 4.5 * 0.5$ ). This corresponds to 24.1 TEQ/kg body weight ( $=1,565.8/65$ ).

The background exposure is 7 pg TEQ/kg body weight per week ( $=1*7$ ).

**The total exposure per week is 31.1 TEQ/kg body weight ( $=24.1+7$ ).**

*Worst-case scenario*

Child (37.6 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

A child eats 10 crabs per meal and has 2.5 meals per week.

In total, this child is exposed to 17,398 pg TEQ ( $=695.92 * 10 * 2.5$ ). This corresponds to 462.7 TEQ/kg body weight ( $=17,398/37.6$ ).

The background exposure is 7 pg TEQ/kg body weight per week ( $=1*7$ ).

**The total exposure per week is 469.7 TEQ/kg body weight ( $=462.7+7$ ).**

Adult (65 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

An adult eats 10 crabs per meal and has 2.5 meals per week.

In total, an adult is exposed to 17,398 pg TEQ ( $=695.92 * 10 * 2.5$ ). This corresponds to 267.7 TEQ/kg body weight ( $=17,398/65$ ).

The background exposure is 7 pg TEQ/kg body weight per week ( $=1*7$ ).

**The total exposure per week is 274.7 TEQ/kg body weight ( $=267.7+7$ ).**

*Yearly exposure*

The scenarios below assume that exposure only occurs during a few months per year and, as such, the TWI is converted into a value per year. The TYI (Tolerable Yearly Intake) is therefore 104 pg WHO<sub>2005</sub>-TEQ/kg body weight per year ( $52 * 2$  pg).

Based on the consumption survey, 82% of the mitten crab consumers only eat mitten crab during crabbing season (September through November). The other 18% of the mitten crab consumers also eat mitten crab outside of crabbing season. For the yearly exposure, two scenarios have been calculated:

1. A scenario in which a mitten crab consumer eats mitten crab during crabbing season (12 weeks) and not during the other weeks of the year.
2. A scenario in which a mitten crab consumer eats mitten crab during crabbing season (12 weeks) and once a month outside of crabbing season ( $= \frac{1}{4} * 40 = 10$  weeks). In total, this mitten crab consumer eats mitten crab 22 weeks a year.

*Realistic scenario*

Child (37.6 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

A child eats 4.5 crabs per meal and has 0.5 meals per week, 12 weeks per year (only during the mitten crab crabbing season and not during the other weeks of the year). In total, this child is exposed to 18,789.8 pg TEQ ( $=695.92 * 4.5 * 0.5$

\* 12) per year. This corresponds to 499.7 TEQ/kg body weight (=18,789/37.6) per year.

The background exposure is 364 pg TEQ/kg body weight per year (=1\*7\*52).

**The total exposure per year is 863.7 TEQ/kg body weight (=499.7+364).**

Adult (65 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

An adult eats 4.5 crabs per meal and has 0.5 meals per week, 12 weeks per year (only during the mitten crab crabbing season and not during the other weeks of the year).

In total, an adult is exposed to 18,789.8 pg TEQ (=695.92 \* 4.5 \* 0.5 \* 12). This corresponds to 289.1 TEQ/kg body weight (=18,789.8/65).

The background exposure is 364 pg TEQ/kg body weight per year (=1\*7\*52).

**The total exposure per year is 653.1 TEQ/kg body weight (=289.1+364).**

*Worst-case scenario*

Child (37.6 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

A child eats 10 crabs per meal and has 2.5 meals per week, 12 weeks per year (only during the mitten crab crabbing season and not during the other weeks of the year).

In total, this child is exposed to 208,776 pg TEQ (=695.92 \* 10 \* 2.5 \* 12). This corresponds to 5,552.6 TEQ/kg body weight (=208,776/37.6).

The background exposure is 364 pg TEQ/kg body weight per year (=1\*7\*52).

**The total exposure per year is 5,916.6 TEQ/kg body weight (=5,552.6+364).**

Adult (65 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

An adult eats 10 crabs per meal and has 2.5 meals per week, 12 weeks per year (only during the mitten crab crabbing season and not during the other weeks of the year).

In total, an adult is exposed to 208,776 pg TEQ (=695.92 \* 10 \* 2.5 \* 12). This corresponds to 3,211.9 TEQ/kg body weight (=208,776/65).

The background exposure is 364 pg TEQ/kg body weight per year (=1\*7\*52).

**The total exposure per year is 3,575.9 TEQ/kg body weight (=3,211.9+364).**

*Realistic scenario*

Child (37.6 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

A child eats 4.5 crabs per meal and has 0.5 meals per week, 22 weeks per year (both during and outside of crabbing season). In total, this child is exposed to 34,448 pg TEQ ( $=695.92 * 4.5 * 0.5 * 22$ ) per year. This corresponds to 916.2 TEQ/kg body weight ( $=34,448/37.6$ ) per year.

The background exposure is 364 pg TEQ/kg body weight per year ( $=1*7*52$ ).

**The total exposure per year is 1,280.2 TEQ/kg body weight (=916.2+364).**

Adult (65 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

An adult eats 4.5 crabs per meal and has 0.5 meals per week, 22 weeks per year (both during and outside of crabbing season). In total, an adult is exposed to 34,448 pg TEQ ( $=695.92 * 4.5 * 0.5 * 22$ ) per year. This corresponds to 530 TEQ/kg body weight ( $=34,448/65$ ).

The background exposure is 364 pg TEQ/kg body weight per year ( $=1*7*52$ ).

**The total exposure per year is 894 TEQ/kg body weight (=530+364).**

*Worst-case scenario*

Child (37.6 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

A child eats 10 crabs per meal and has 2.5 meals per week, 22 weeks per year (both during and outside of crabbing season). In total, this child is exposed to 382,756 pg TEQ ( $=695.92 * 10 * 2.5 * 22$ ). This corresponds to 10,179.7 TEQ/kg body weight ( $=382,756/37.6$ ).

The background exposure is 364 pg TEQ/kg body weight per year ( $=1*7*52$ ).

**The total exposure per year is 10,543.7 TEQ/kg body weight (=10,179.7+364).**

Adult (65 kg)

A 150-gram mitten hand crab contains 695.92 pg TEQ (see above).

An adult eats 10 crabs per meal and has 2.5 meals per week, 22 weeks per year (both during and outside of crabbing season). In total, an adult is exposed to 382,756 pg TEQ ( $=695.92 * 10 * 2.5 * 22$ ). This corresponds to 5,888.6 TEQ/kg body weight ( $=382,756/65$ ).

The background exposure is 364 pg TEQ/kg body weight per year ( $=1*7*52$ ).

**The total exposure per year is 6,252.6 TEQ/kg body weight (=5,888.6+364).**

## Appendix V: Detailed calculations by BuRO on reaching the TWI or TYI

Because the terms white meat and brown meat are confusing, the BuRO advisory report refers to meat from the legs and claws (the “appendages”) and meat from the body of the crab. The meat from the legs and claws is white meat. The meat from the body is primarily brown meat, though it also contains a little bit of white meat. No distinction is made between white and brown meat when it comes to consumption of meat from the body.

A mitten crab consists of 21.7% fresh meat weight. The total fresh meat weight can be subdivided into brown meat (73.6%) and white meat (26.4%).

### What is the level of dioxins and dioxin-like PCBs that all consumable parts of the mitten crab (legs, claws and body) can contain before the TWI or the TYI is reached?

Two scenarios have been worked out below: a realistic scenario (based on a median consumption amount; 4.5 crabs per meal and a median consumption frequency; 0.5 meals per week) and a worst-case scenario (based on the 95<sup>th</sup> percentile for the consumption amount; 10 crabs per meal and the 95<sup>th</sup> percentile for the consumption frequency; 2.5 meals per week). The other parameters for calculating both scenarios are the same, i.e. the 95<sup>th</sup> percentile for the background exposure (1 pg TEQ/kg body weight per day) and a crab weight of 150 grams.

The below calculations assumed a body weight of 37.6 kg for a ten-year-old child and 65 kg for an adult (7-69 years old). These were the weights reported in the food consumption survey on which the background exposure was based (see also FO recommendation on page 7).

These calculations were based on the calculation made by Front Office, page 12 of the FO recommendation.

#### *Weekly exposure*

##### *Realistic scenario*

###### Child (37.6 kg)

The TWI is 14 pg TEQ/kg body weight. The background exposure ( $=1 \times 7 = 7$  pg TEQ/kg body weight) must be subtracted from this. This means that a child may be exposed to 7 pg TEQ/kg body weight  $= 7 \times 37.6 = 263.2$  pg TEQ per mitten crab.

A child eats 4.5 crabs per meal and has 0.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, a child consumes 73.2 grams of mitten crab ( $=4.5 \times 0.217 \times 150 \times 0.5$ ). **The TWI is reached at a level of 3.6 pg TEQ/g of meat (=263.2/73.2).**

###### Adult (65 kg)

The TWI is 14 pg TEQ/kg body weight. The background exposure ( $=1 \times 7 = 7$  pg TEQ/kg body weight) must be subtracted from this. This means that an adult may be exposed to 7 pg TEQ/kg body weight per week  $= 7 \times 65 = 455$  pg TEQ per mitten crab.

An adult eats 4.5 crabs per meal and has 0.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, an adult consumes 73.2 grams of mitten crab ( $=4.5 \times 0.5 \times 0.217 \times 150$ ). **The TWI is reached at a level of 6.2 pg TEQ/g of meat (=455/73.2).**

*Worst-case scenario*

Child (37.6 kg)

The TWI is 14 pg TEQ/kg body weight. The background exposure ( $=1*7=7$  pg TEQ/kg body weight) must be subtracted from this. This means that a child may be exposed to 7 pg TEQ/kg body weight  $= 7 * 37.6 = 263.2$  pg TEQ per mitten crab.

A child eats 10 crabs per meal and has 2.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, a child consumes 813.8 grams of mitten crab ( $=10 * 2.5 * 0.217 * 150$ ). **The TWI is reached at a level of 0.32 pg TEQ/g of meat (=263.2/813.8).**

Adult (65 kg)

The TWI is 14 pg TEQ/kg body weight. The background exposure ( $=1*7=7$  pg TEQ/kg body weight) must be subtracted from this. This means that an adult may be exposed to 7 pg TEQ/kg body weight per week  $= 7 * 65 = 455$  pg TEQ per mitten crab.

An adult eats 10 crabs per meal and has 2.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, an adult consumes 813.8 grams of mitten crab ( $=10 * 2.5 * 0.217 * 150$ ). **The TWI is reached at a level of 0.56 pg TEQ/g of meat (=455/813.8).**

*Yearly exposure*

The scenarios below assume that exposure only occurs during a few months per year and, as such, the TWI is converted into a value per year. The TYI (Tolerable Yearly Intake) is then 728 TEQ/kg body weight per year ( $52 * 14$  pg).

Based on the consumption survey, 82% of the mitten crab consumers only eat mitten crab during crabbing season (September through November). The other 18% of the mitten crab consumers also eat mitten crab outside of crabbing season. For the yearly exposure, two scenarios have been calculated:

1. A scenario in which a mitten crab consumer eats mitten crab during crabbing season (12 weeks) and not during the other weeks of the year.
2. A scenario in which a mitten crab consumer eats mitten crab during crabbing season (12 weeks) and once a month outside of crabbing season ( $= \frac{1}{4} * 40 = 10$  weeks). In total, this mitten crab consumer eats mitten crab 22 weeks a year.

*Realistic scenario*

Child (37.6 kg)

The TYI is 728 pg TEQ/kg body weight per year. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that a child may be exposed to 364 pg TEQ/kg body weight  $= 364 * 37.6 = 13,686.4$  pg TEQ per mitten crab.

A child eats 4.5 crabs per meal and has 0.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, a child consumes 73.2 grams of mitten crab ( $=4.5 * 0.217 * 150 * 0.5$ ). Per year, this corresponds to  $73.2 * 12 = 878.9$  grams. **The TYI is reached at a level of 15.6 pg TEQ/g of meat (=13,686.4/878.9).**

Adult (65 kg)

The TYI is 728 pg TEQ/kg body weight. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that an adult may be exposed to 364 pg TEQ/kg body weight per week  $= 364 * 65 = 23,660$  pg TEQ per mitten crab.



An adult eats 4.5 crabs per meal and has 0.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, an adult consumes 73.2 grams of mitten crab ( $=4.5 * 0.5 * 0.217 * 150$ ). Per year, this corresponds to  $73.2 * 12 = 878.9$  grams. **The TYI is reached at a level of 26.9 pg TEQ/g of meat (=23,660/878.9).**

*Worst-case scenario*

Child (37.6 kg)

The TYI is 728 pg TEQ/kg body weight. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that a child may be exposed to 364 pg TEQ/kg body weight =  $364 * 37.6 = 13,686.4$  pg TEQ per mitten crab.

A child eats 10 crabs per meal and has 2.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, a child consumes 813.8 grams of mitten crab ( $=10 * 2.5 * 0.217 * 150$ ). Per year, this corresponds to  $813.8 * 12 = 9,765.6$  grams. **The TYI is reached at a level of 1.4 pg TEQ/g of meat (=13,686.4/9,765.6).**

Adult (65 kg)

The TYI is 728 pg TEQ/kg body weight. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that an adult may be exposed to 364 pg TEQ/kg body weight per week =  $364 * 65 = 23,660$  pg TEQ per mitten crab.

An adult eats 10 crabs per meal and has 2.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, an adult consumes 813.75 grams of mitten crab ( $=10 * 2.5 * 0.217 * 150$ ). Per year, this corresponds to  $813.75 * 12 = 9,765$  grams. **The TYI is reached at a level of 2.4 pg TEQ/g of meat (=23,660/9,765).**

*Realistic scenario*

Child (37.6 kg)

The TYI is 728 pg TEQ/kg body weight per year. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that a child may be exposed to 364 pg TEQ/kg body weight =  $364 * 37.6 = 13,686.4$  pg TEQ per mitten crab.

A child eats 4.5 crabs per meal and has 0.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, a child consumes 73.2 grams of mitten crab ( $=4.5 * 0.217 * 150 * 0.5$ ). Per year, this corresponds to  $73.2 * 22 = 1,610.4$  grams. **The TYI is reached at a level of 8.5 pg TEQ/g of meat (=13,686.4/1,610.4).**

Adult (65 kg)

The TYI is 728 pg TEQ/kg body weight. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that an adult may be exposed to 364 pg TEQ/kg body weight per week =  $546 * 65 = 23,660$  pg TEQ per mitten crab.

An adult eats 4.5 crabs per meal and has 0.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, an adult consumes 73.2 grams of mitten crab ( $=4.5 * 0.5 * 0.217 * 150$ ). Per year, this corresponds to  $73.2 * 22 = 1,610.4$  grams. **The TYI is reached at a level of 14.7 pg TEQ/g of meat (=23,660/1,610.4).**

*Worst-case scenario*

Child (37.6 kg)

The TYI is 728 pg TEQ/kg body weight. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that a child may be exposed to 364 pg TEQ/kg body weight  $= 364 * 37.6 = 13,686.4$  pg TEQ per mitten crab.

A child eats 10 crabs per meal and has 2.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, a child consumes 813.8 grams of mitten crab ( $=10 * 2.5 * 0.217 * 150$ ). Per year, this corresponds to  $813.8 * 22 = 17,903.6$  grams. **The TYI is reached at a level of 0.76 pg TEQ/g of meat (=13,686.4/17,903.6).**

Adult (65 kg)

The TYI is 728 pg TEQ/kg body weight. The background exposure ( $=1*7*52=364$  pg TEQ/kg body weight) must be subtracted from this. This means that an adult may be exposed to 364 pg TEQ/kg body weight per week  $= 364 * 65 = 23,660$  pg TEQ per mitten crab.

An adult eats 10 crabs per meal and has 2.5 meals per week. Based on a crab weight of 150 grams, of which 21.7% is the fresh meat weight, an adult consumes 813.75 grams of mitten crab ( $=10 * 2.5 * 0.217 * 150$ ). Per year, this corresponds to  $813.75 * 22 = 17,903.6$  grams. **The TYI is reached at a level of 1.3 pg TEQ/g of meat (=23,660/17,903.6).**