Queensland University of Technology
School of Mathematical Sciences
MXB332 Operations Research 2
2016 Semester 1

Assignment 1
due date: 4PM Friday 22nd April 2016
weight 20%

This assignment can be done individually, or in groups of 2 or 3. Each group must choose a group name and notify me via email (p.corry@qut.edu.au) of the group name and members, no later than the Easter break. All members of a group will be graded equally.

THIS ASSIGNMENT MUST BE SUBMITTED IN HARD COPY INTO THE ASSIGNMENT BOX ON LEVEL 6 IN O-BLOCK. THE COVER SHEET MUST SPECIFY THE GROUP NAME, AND A LIST OF THE GROUP MEMBERS. IF YOU ARE DOING THIS ASSIGNMENT INDIVIDUALLY, YOUR GROUP NAME IS JUST YOUR SURNAME AND FIRST INITIAL.

ALL MODEL FILES (INPUTS/OPL/OUTPUTS) MUST BE SUBMITTED ELECTRONICALLY WITHIN A SINGLE ZIP FILE (file name: "<Group name> assignment 1.zip", e.g. "Mathemagicians assignment 1.zip"), AND SUBMITTED VIA EMAIL TO p.corry@qut.edu.au.

BACKGROUND

You have been appointed by Deluxe Seafoods Ltd to optimise their 5 year harvest plan for honey-prawns. The project brief is given below.

PROJECT BRIEF

Deluxe Seafoods Ltd specialises in harvesting high value seafood products supplying to top restaurants around the world. Currently, Deluxe Seafoods is the sole supplier of the highly sought after honey-prawn. The habitat of the honey-prawn is within the vicinity of the remote Haruchai Islands, and is naturally divided into 5 independent sub-habitats (or zones).

Haruchai Government requires Deluxe Seafoods to submit a plan for the next 5 years of honey-prawn harvesting. For each of the 5 years, Deluxe Seafoods must nominate the quantity of honey-prawns (in kg) to be harvested in each zone. The government charges an annual harvest fee of $100,000 for each zone harvested during a year, regardless of quantity harvested (zones not harvested during a given year will not incur a fee for that year). Each kilogram of prawns harvested from any zone earns Deluxe Seafoods revenue of $80.

The Haruchai Department of Primary Industries (HDPI) has conducted extensive surveys and analysis to map the honey-prawn stocks and model its population dynamics. HDPI have validated a simple model of population dynamics where the honey-prawn stocks in a given zone grows at a fixed rate until it reaches the maximum sustainable limit for the zone, at which point the population stabilises. For a given annual growth factor (>1), the following difference equation describes the population dynamics.

$$\text{stock in year } t+1 = \min[\text{sustainable limit}, (\text{stock in year } t - \text{harvest in year } t) \times \text{growth factor}]$$

HDPI have also determined that zone stocks falling below 40% of the sustainable limit are at risk of crashing, and have specified that the Deluxe Seafoods harvest plan must not result in any zone stocks falling below this limit.

The following table provides the parameters for modelling honey-prawn stocks in each zone:

Table 1 Honey-prawn population dynamics parameters.

	zone 1	zone 2	zone 3	zone 4	zone 5
current stocks (kg)	200,000	210,000	150,000	160,000	110,000
annual growth factor	1.09	1.10	1.09	1.10	1.11
max sustainable stock level (kg)	240,000	240,000	180,000	180,000	120,000

Deluxe Seafoods operates a vessel base within Haruchai Islands, with a fleet of 10 vessels. When operating at full capacity, each vessel will harvest a maximum 9000 kg of honey-prawns in one year. It is permitted to operate some vessels at less than full capacity within a year if it is beneficial for management of honey-prawn stocks. Also, in any given year it is

permitted to rest some (or all) of the vessels in the fleet to allow for recovery of honey-prawn stocks. HDPI regulations require that a given vessel cannot operate within multiple zones in a single year.

For any given year, each utilised vessel will incur fixed operating expenditure (OPEX) (regardless of harvest quantity). Resting vessels do not incur OPEX. Due to varying proximity of zones to the vessel base, OPEX varies across the zones.

Table 2 Fixed operating expenditure per vessel within each zone ($/vessel/year)

zone 1	zone 2	zone 3	zone 4	zone 5
102,000	105,000	100,000	80,000	85,000

SCOPE OF WORKS

Deluxe Seafoods requires a 5 year harvest plan to be developed. The harvest plan must consider the initial honey-prawn stocks and apply the HDPI population dynamics model to predict annual changes in honey-prawn stocks in each zone across the 5 years.

Within any given zone, the honey-prawn stocks are not permitted to fall below 40% of the maximum sustainable limit (see Table 1).

HDPI have specified that the total honey-prawn stocks across all zones must be fully replenished by the end of the 5 year plan (ie beginning of the 6^{th} year). That is, the total stock (summed across all zones) at the beginning of year 6 must be at least equal to the total current stocks.

The harvest plan consists of a harvest quantity allocation and stock level prediction for each zone across each of the 5 years. The plan should also specify the number of vessels allocated to each zone in each year.

Deluxe Seafoods require this plan to be optimal with respect to the Net Present Value (NPV) of the operation. An interest rate of 8%pa is to be assumed for the NPV calculations. For the purposes of NPV calculations, it should also be assumed that the profit for any given year is recognised at the end of the year. Therefore, if the harvest profit in year t is P, then the contribution of year t to overall NPV is $(1.08)^{-t}P$, where t=1 for the first year.

In addition to the base harvest plan, Deluxe Seafoods is considering the procurement of an 11^{th} vessel incurring a one-off capital expenditure (CAPEX) of $95,000. This CAPEX would be incurred at time 0 for the purposes of NPV calculations. It is required to devise an alternative NPV-optimal harvest plan for a fleet of 11 vessels.

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DELIVERABLES

Deliverable 1: Report

1A: Specification of *generalised* mixed integer programming model for determining NPV-optimal harvest plan (NOTE: all inputs to be parameterised including number of zones, periods and vessels). Description of Notation

- indices
- parameters
- main decision variables and supporting variables

Generalised Model

- objective function
- constraints (with descriptions)

1B: Specify NPV-optimal harvest plans for the base case (10 vessels) and the alternative case (11 vessels). Both plans must be specified using the following template:

NPV ($)	X					
Vessel Allocation	**year 1**	**2**	**3**	**4**	**5**	
zone 1	*X*	*X*	*X*	*X*	*X*	
2	*X*	*X*	*X*	*X*	*X*	
3	*X*	*X*	*X*	*X*	*X*	
4	*X*	*X*	*X*	*X*	*X*	
5	*X*	*X*	*X*	*X*	*X*	
Harvest Quantities (kg)	**year 1**	**2**	**3**	**4**	**5**	
zone 1	*X*	*X*	*X*	*X*	*X*	
2	*X*	*X*	*X*	*X*	*X*	
3	*X*	*X*	*X*	*X*	*X*	
4	*X*	*X*	*X*	*X*	*X*	
5	*X*	*X*	*X*	*X*	*X*	
Zone Population Stocks (kg)	**start of year 1**	**2**	**3**	**4**	**5**	**6**
zone 1	200000	*X*	*X*	*X*	*X*	*X*
2	210000	*X*	*X*	*X*	*X*	*X*
3	150000	*X*	*X*	*X*	*X*	*X*
4	160000	*X*	*X*	*X*	*X*	*X*
5	110000	*X*	*X*	*X*	*X*	*X*
Stocks Totals (kg)	830000	*X*	*X*	*X*	*X*	830000
NPV Breakdown	**year 1**	**2**	**3**	**4**	**5**	
zone 1	*X*	*X*	*X*	*X*	*X*	
2	*X*	*X*	*X*	*X*	*X*	
3	*X*	*X*	*X*	*X*	*X*	
4	*X*	*X*	*X*	*X*	*X*	
5	*X*	*X*	*X*	*X*	*X*	
Annual NPV totals ($)	*X*	*X*	*X*	*X*	*X*	

1C: State a business case for approving or rejecting the proposal to purchase the 11th vessel.

Deliverable 2: Model Files (see assignment header for submission instructions)

- data input files for optimisation model
- .mod OPL file (model parameters to be read from data input file)
- raw data output files from CPLEX