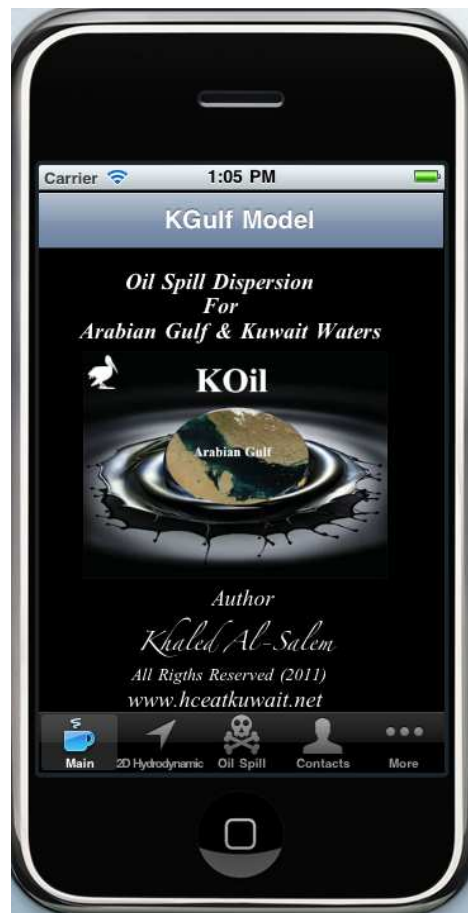




iPhone App for



**Numerical Prediction of Oil Slick Movement in Arabian Gulf and  
Kuwait Waters  
For  
iPhone Mobile**

**KOIl Apps**

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2011

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Oil spills frequently occur in the marine environment causing pollution to the marine environment, thus endangering the marine resources and life. A contingency plan should be setup by every State to be prepared to deal with any accidental oil spill in their marine environment. The prediction of the fate and transport of an oil spill is an important tool for decision makers in such cases. Numerical models are widely used for that purpose. Such models require accurate data on the marine currents which are usually provided from a separate hydrodynamic model (KGulf Model developed by k. Al-Salem 2005 for more Information as

[www.hceatkuwait.net/web\\_pas/web-KGulf/KGulfmain.aspx](http://www.hceatkuwait.net/web_pas/web-KGulf/KGulfmain.aspx)

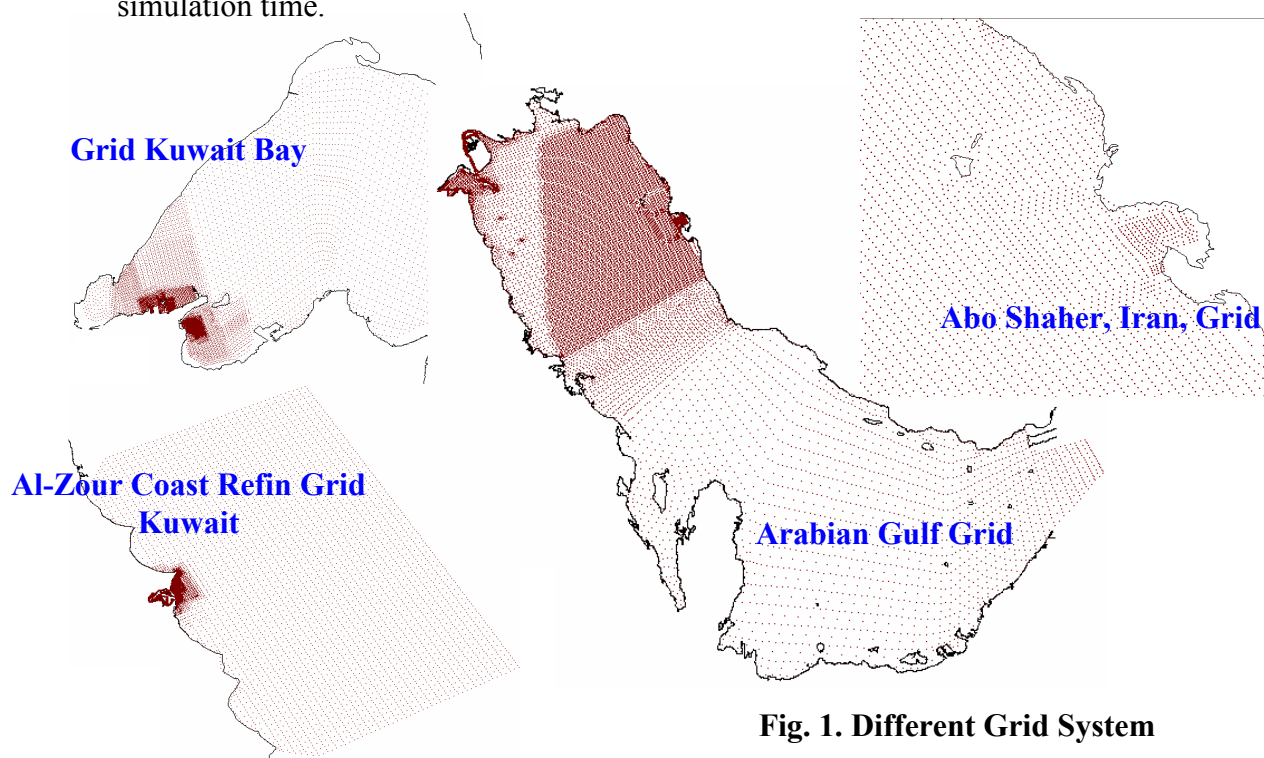
In this work I will Present KGulf Model 2D Hydrodynamic Model Coupled with oil spill fate prediction to oil spill trajectory model (KOil model).

### **Model Description**

The present oil transport model is coupled with 2D hydrodynamic model for Kuwait Waters and Arabian Gulf (KGulf model). This model gives the velocity distribution on the surface of water body. In the transient case, the velocity distribution is calculated at each time step and is taken as an input for the oil transport simulation model (KOil model).

#### **2D Hydrodynamic Model for Arabian Gulf (KGulf Model)**

Hydrodynamic models (HD) represent the core of any simulation for water quality, siltation, and morphology studies. In this study a KGulf model was developed and setup for the Arabian Gulf to predict the 2D tidal currents field. A grid constituents values was setup for Arabian Gulf waters and refined grids inside Kuwaiti territorial Waters. The model was setup in two dimensional mode with an element size varying from 11 km within the Arabian Gulf to less than 50 m inside the Kuwaiti territorial waters for refined grid as shown in fig.1. The model was shown to provide good results for the water level variations and the tidal currents with very short computer simulation time.



**Fig. 1. Different Grid System**

## Oil Spill Tracking and Weathering Processes Model (KOil Model)

Models to predict the behavior of the oil spill include the calculation of the spreading, the displacement and the mass/volume balance over the different compartments (air, water surface) of a released substance. The variables that mainly influence the dispersion and evaporation are the wind speed, currents, time, density of the oil and the amount of the oil released. In the present study, a Lagrangian discrete-parcel algorithm is used. In this algorithm, the oil slick is viewed as a large ensemble of small parcels. The movement of each parcel is followed and recorded as functions of time relative to a reference grid system fixed in space. In the Lagrangian discrete-parcel algorithm, the oil slick is divided into a large number of equal masses. These parcels are introduced into the system in case of instantaneous spill at the spill site at the same time. Each parcel is then allowed to move with the drift velocity. The drift velocity is computed as the weighted velocity of current and wind. The component of velocity due to diffusion of oil slick is calculated by random walk analysis. The computation for oil parcels calculated numerically by integrating the drift velocity in each time interval. After the advection and diffusion calculations are completed for the current time step, oil parcels in the slick are further spread according to the spreading laws. The mass in each parcel is also reduced by an equal amount determined from evaporation rate.

### Conclusions

The development of iPhone APPs application for oil spill cases was the added ability of the 2D KGulf model to resolve complex geometry and topography makes it suitable for such practical coastal and estuarine applications as the dispersion of immiscible pollutants.

### KOil Model Apps StepUp (for iPhone Operation system)

To Start Koil Apps application as shown in fig.2. user must follow the next steps as:

#### Section.1

User should generate 2D hydrodynamic field by running the KGulf model . Click on **2D hydrodynamics** if fig.2. Fig.3 will display for user to input information for hydrodynamic's Prediction.

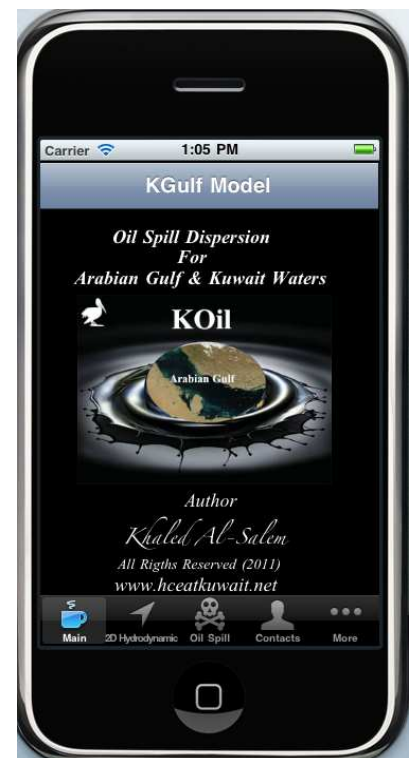


Fig. 2. Apps Main Page

## 1- Date Selection

In Fig. 3 Date Picker display to select the starting time and Ending Time.



Fig. 3. 2D Hydrodynamic's Page

## 2- Grid Domain Selection

If grid domain selected from fig.3. Fig. 4 will display the description for different type of grid system.

In text box enter the grid system number (1 to 5).

To see the type grid selected user must select (**Grid Map** button) in fig. 3. Fig 5 displays a Different type of grid system map.



Fig. 4. Grid Domains Description

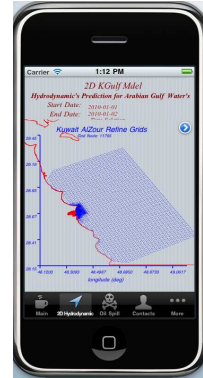
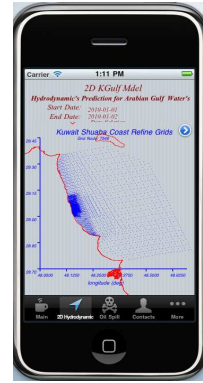
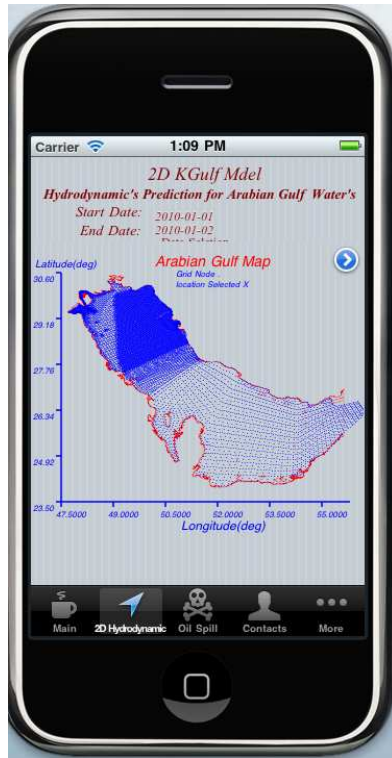
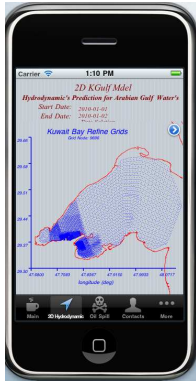


Fig. 5. Different Grid System Map

### 3- Start 2D HD Simulation

When user entered the information required for the date and grid system data, the apps ready to run the simulation show in fig 6 by touching on image

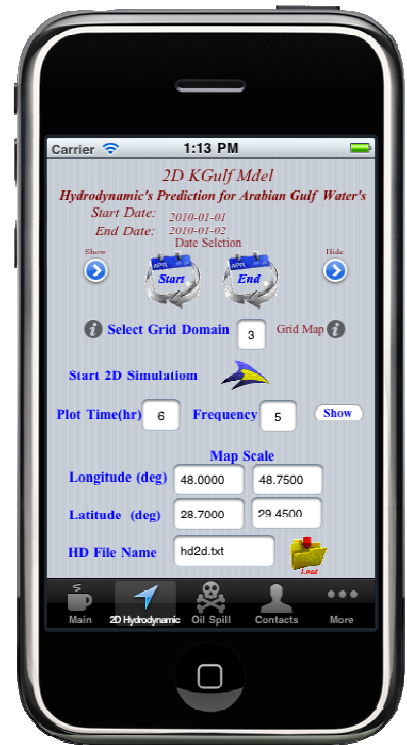


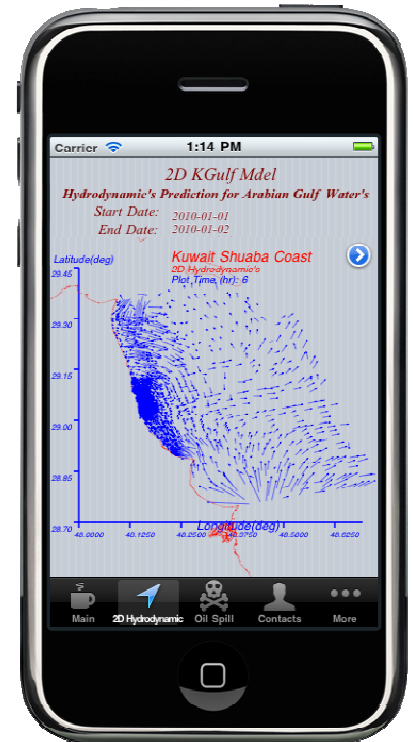
Fig. 6. End Simulation Option

To display simulated 2D hydrodynamics Results user must select input data as shown in fig. 6 as follow:

- Input **Plot Time** (selected hours of the simulated time )
- Input **Frequency** of Tidal Current Plot on map.

To display 2D hydrodynamic map

Press **Show** Button in fig 6. Fig 7 will display the select time map plot.



**Fig. 7. Tidal Current Vectors Map**

#### 4- To Export simulated 2D hydrodynamic's data

There are two ways to export or extract the results from the apps which are:

- 1- Send SMS. Short summary information
- 2- Send E-mail . Short summary information with and attachment text file for 2D tidal Current (cm/sec) and Tidal Current Direction (deg) for 24 hours shown in fig 8.

#### **Example:**

If user select (fig. 2)

**Start date** 1/1/2010

**Ending date** 5/1/2010

Total simulated time is 119 hrs

If user enter **Plot Time**=11 hr (1/1/2010 At 11:00 Am)

Data Will Export (1/1/2010 From 0:00 to 23:00 hr)

If user enter **Plot Time**=45 hr (2/1/2010 At 9:00 Pm)

Data Will Export (2/1/2010 From 0:00 to 23:00 hr)

If user enter **Plot Time**=110 hr (2/1/2010 At 2:00 Pm)

Data Will Export (5/1/2010 From 0:00 to 23:00 hr)



**Fig. 8. Data Export (E-mail Page)**

Sample list of Export 2D hydrodynamic's file from E-mailed from Koil Model App.

```

<?xml version="1.0" encoding="UTF-8"?>
<DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0/EN" "http://www.apple.com/DTDs/PropertyList-1.0.dtd">
<plist version="1.0">
<array>
<string>-----K Gulf Model-----</string>
<string>2D Hydrodynamic's Prediction for Arabian Gulf Water's</string>
<string>Developed By: Khaled Al-Salem (2005)</string>
<string>website address: www.hceadkwait.net</string>
<string>Starting Date for the Requested Data :1/1/2010</string>
<string>Total Simulation time 23 hours</string>
<string>Start Selected Simulation time at 0 hours</string>
<string>Tidal Direction Calculated from X-Axis Counter Clockwise</string>

<string>2D Tidal Current From 0hr to 23hr in (cm/sec)</string>
<string>Longitude(deg) Latitude(deg) 0hr 1hr 2hr 3hr 4hr 5hr 6hr 7hr 8hr 9hr 10hr 11hr 12hr 13hr 14hr 15hr 16hr 17hr 18hr 19hr 20hr 21hr 22hr 23hr</string>
<string>48.1077 29.3544 75.16 113.41 132.54 122.98 90.44 43.47 13.84 66.08 101.47 112.39 102.83 77.33 37.69 12.97 46.92 59.77 50.56 26.46 781 43.99 67.42 68.24 49.15
17.46</string>
<string>48.1501 29.0948 3.09 2.84 1.87 0.41 1.17 2.45 3.11 2.97 2.07 0.64 0.97 2.33 3.10 3.08 2.27 0.87 0.76 2.19 3.07 3.17 2.45 1.10 0.54 2.04</string>
<string>48.1501 29.0940 4.15 3.89 2.64 0.71 1.41 3.18 4.14 4.06 2.94 1.06 1.09 2.97 4.10 4.19 3.21 1.40 0.76 2.74 4.02 4.28 3.45 1.74 0.42 2.48</string>
....
....
....
To end of Grid node

```



## Section 2.

### **Oil Spill Tracking**

To predict the behavior of the oil spill include the calculation of the spreading, the displacement and the mass/volume balance over the different compartments (air, water surface) of a released oil substance from fig 2 user must Select **Oil Spill** option. Fig. 9 will display for user start input requested data

User must check in fig. 9 the following:

If Total HD Hours = 0 user must select **Reload Button**

To start Oil Spill Tracking and Weathering Processes user must select the following:

#### 1-Oil Map Scale & Extract 1D touch Button

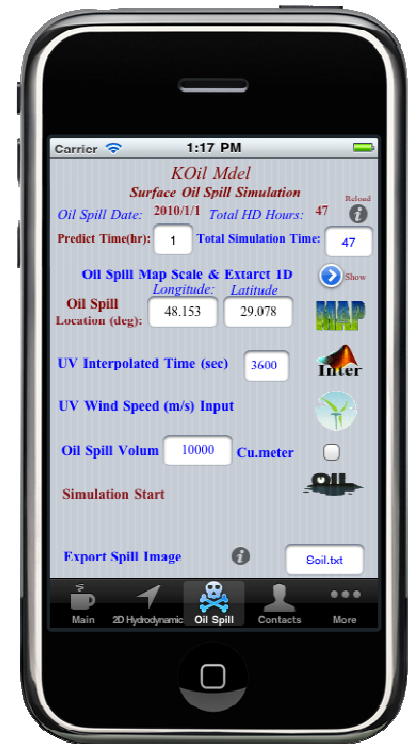
User must select oil spill setup parameters as scale map of the spill location as in fig. 10.

Fig. 10 has several input option as:

**Option 1.** Enter manual Map scale as longitude/latitude (deg).And save in text file.

**Option 2.** Load Existing map Scale File.

**Option 3.** If user want the results of the oil spill simulation to be posted on a satellite Image map user must select (**Image Superimpose Check**) fig 11 will display with new input Box For Image Reference number.



**Fig. 9. Oil Spill Page**



**Fig. 10. Oil Spill Setup Map Scale**



Image Reference number is the number for satellite Image for user to select .

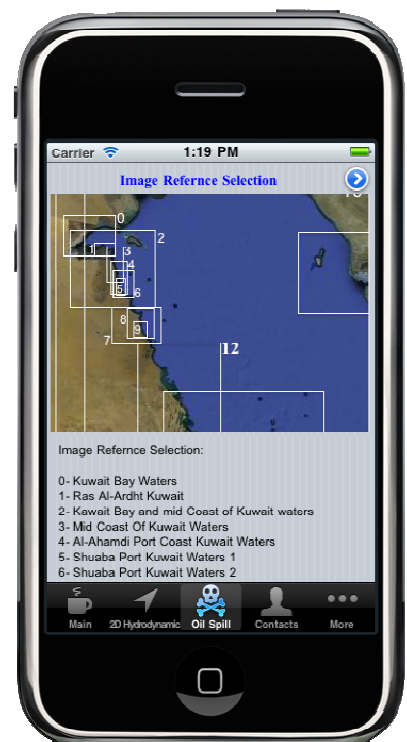
For Help on selected the image satellites reference number, user must select (**Info. Button**) fig 12 will show 16 satellites image reference number.



**Fig. 11. Image Reference**

Fig 12 displays the map name for each Satellite image and their referenced number for user to select.

From fig. 11 user selected the Image Reference number then click **Folder Button** to load image map scale the click in **Disk Button** to save data in the text file.



**Fig. 12. Image Reference Number and names**

## 2-Oil Spill Location.

From fig.9 user must select the oil spill location as in longitude/latitude (deg).

Then from **Map Button** in fig.9 

User can post the spill location on the selected Satellite map or a map as shown in fig. 13.

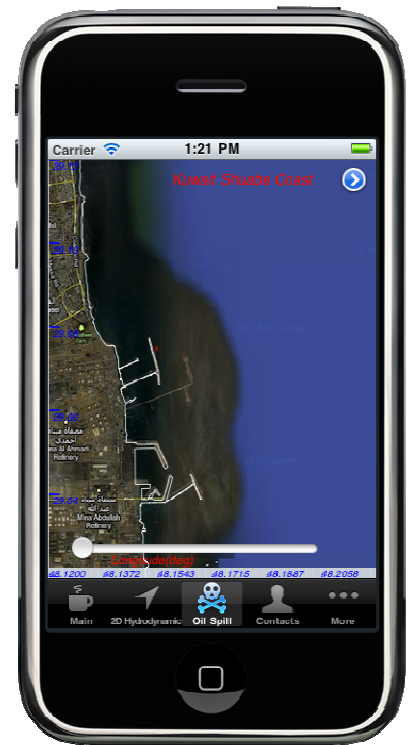


Fig. 13. Satellite Image

## 3-UV Interpolation Time (sec)

From fig.9 User Must setup the time step for the 2d hydrodynamic's information that predicted from KGulf Model. For Minimum time step is 600 sec.

To UV interpolation user must

Touch on **INTER Image**



Fig.14 will display the superimposed tidal current data line time step (3600 sec) with the interpolated line based on the selected time step for interpolation check.

Then the hydrodynamic's data are ready and linked for oil spill model (KOil model)



Fig. 14. UV tidal Current Interpolated Plot

#### 4-UV Wind Speed Input (m/sec)

From fig.9 user has an option to inter Wind speed data link to KOil model simulation by select image as follow:



- Option 1. For Wind Speed not included Case user must Select **Image Wind Button** from fig.9. Fig 15 will display to user check that wind speed box has zero value.
- Option 2. for Wind Speed Included case user must Select **Image Wind Button** from fig.9. Fig 15 will display to user. Fig 15 has different type of input wind speed case as:



**Fig. 15. UV Interpolated Plot**

- 1-For Constant Wind speed (m/sec) and Direction (deg) as in fig 16. To Simulate the Oil spill model with constant wind speed effect



**Fig. 16. Constant Wind Speed (m/sec)**

2-For Variables Wind Speed (m/sec) and Direction (deg) as shown in fig.17. For Different Options to enter wind speed data as

- Load Existing data file.
- Manual Enter wind speed and direction(hr) As time serious data. And save as text file.

When wind speed data finished entry, user must Start **Wind Speed Interpolation Button** based On the hydrodynamic's time Step as in fig.9.



**Fig. 17. Option of Wind Speed Entry**

Fig.18 will display the superimposed Wind Speed data line time step (3600 sec) with the interpolated line based on the selected time step for interpolation check.

Then the hydrodynamic's data and wind speed data are ready for simulation oil spill model (KOil model)



**Fig. 18. UV Wind Speed Interpolated Plot**

From fig.17 user can get some help in wind data entry by Select (**Info Button**).

Fig 19 will display Wind Speed Entry Description for user to get help in set wind speed data for the KOil model.



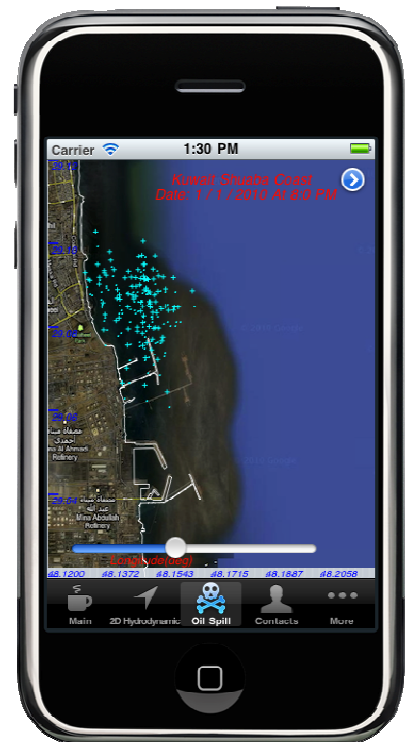
**Fig. 19. Wind Entry Help page**

In fig.9 Touch in **Oil Image** to start simulate oil spill case. Fig.20 will display with new **SHOW button** for user to start run Slid Animation.



**Fig. 20. Show Animation Button.**

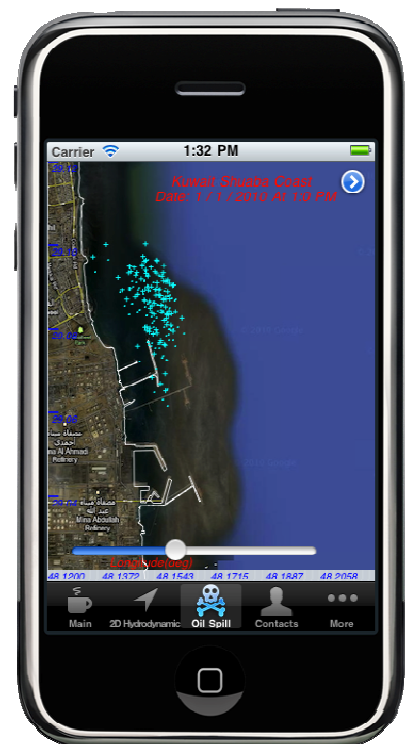
Fig 21 Display the Slid Animation for oil spill drifting. By a Lagrangian discrete-parcel algorithm is represent the oil spill parcels.



**Fig. 21. Show Animation Page.**

#### 5- To Export simulated oil Spill Information

User can extract Spill data at a select time (hour)  
From fig.9 user can input the **Predicted Time (hr)** for which image and the corresponding data will be stored for export by touch on **Export Spill Image** Info Button. Fig.22 will display for the selected time image.



**Fig. 22. Selected Image for Export.**



There are two ways to export or extract the results from the apps which are:

- 1-Send SMS. Short summary information
- 2-Send E-mail . Short summary information with and attachment text file for oil Weathering Processes and Oil Spill particles Tracking location as in fig 23.



Fig. 23. Export data.

Sample list of Export Oil Spill simulation results at selected time file and the corresponding image E-mailed from Koil Model App.

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0/EN"
"http://www.apple.com/DTDs/PropertyList-1.0.dtd">
<plist version="1.0">
<array>
  <string>-----KGulf Model-----</string>
  <string>2D Hydrodynamic's Prediction and Oil Spill Dispersion for Arabian
  Gulf Water's</string>
  <string>Developed By: Khaled Al-Salem (2005)</string>
  <string>website address: www.hceatkuwait.net</string>
  <string>Starting Date for the Requested Data :1/1/2010</string>
  <string>Oil Spill location at Longitude:48.6800 deg Latitude:28.1800 deg</string>
  <string>Total Simulation time Listed:47 hours and Initial Spill volume 10000.000000 Cu.meter</string>
  <string>Oil Spill Particles location at hours: 26.00</string>
  <string>Spill Area (Sq-m): 9299.47 Weathered Oil Spill Volume (Cu-m): 6449.12</string>
  <string>Oil Spill Weathering Process Components Percent</string>
  <string>Oil Type: Frankenfeld's Oil Sample</string>
  <string>Paraffin(C6-C12) :0.00/10 Density=710 kg/cum</string>
  <string>Paraffin(C13-C25) :7.73/25 Density=770 kg/cum</string>
  <string>Cycloparaffin(C6-13) :0.00/10 Density=810 kg/cum</string>
  <string>Cycloparaffin(C13-23) :19.65/12 Density=900 kg/cum</string>
  <string>Aromatic(mono- and di-Cyclic)(C6-C11) :0.00/15 Density=940 kg/cum </string>
  <string>Aromatic(Poly-Cyclic)(C12-C18) :1.56/8 Density=1000 kg/cum</string>
  <string>Naphtheno-aromatic(C9-C25) :10.54/20 Density=980 kg/cum</string>
  <string>Residual(including heterocycles) :25.00/00 Density=000 kg/cum</string>
  <string>Oil Spill Particles location</string>
  <string> Longitude(Deg) Latitude(Deg)</string>
  <string>48.684505 28.223824</string>
  <string>48.709549 28.211826</string>
  <string>48.683411 28.221285</string>
  <string>48.712719 28.212229</string>
  <string>48.703896 28.214977</string>
  <string>48.682350 28.221146</string>
  <string>48.690983 28.222794</string>
  <string>48.700428 28.217331</string>
  ....
  ....
  Until end of Particles
</array>
</plist>
```



## 1D Hydrodynamic's data extracting at Oil Spill Location

From fig.9 user should select **Oil Spill Map Scale & Extracting 1D Info. Button.**

Fig. 24 will display for user. Then user must selected the

**Extract 1D hydrodynamic's at Spill Location (Disk Image)**

To extract the data for the total hydrodynamic's simulation time

As shown in fig. 25.

To Export the data by email as shown in fig 26. Thet user can email the data file and the corresponding tidal current plot.



Fig. 24.

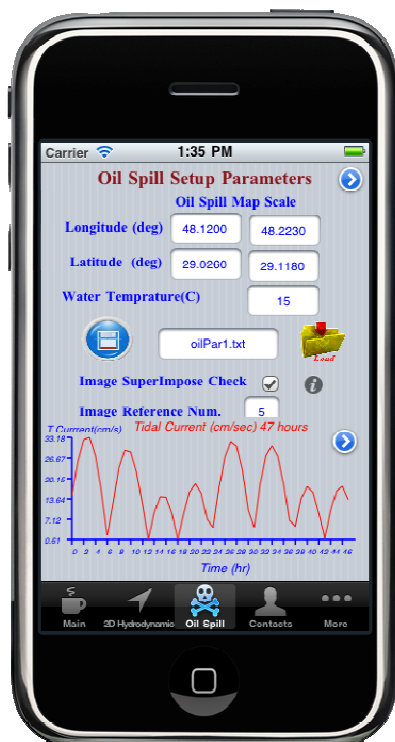


Fig. 25. Extract 1D tidal current data.

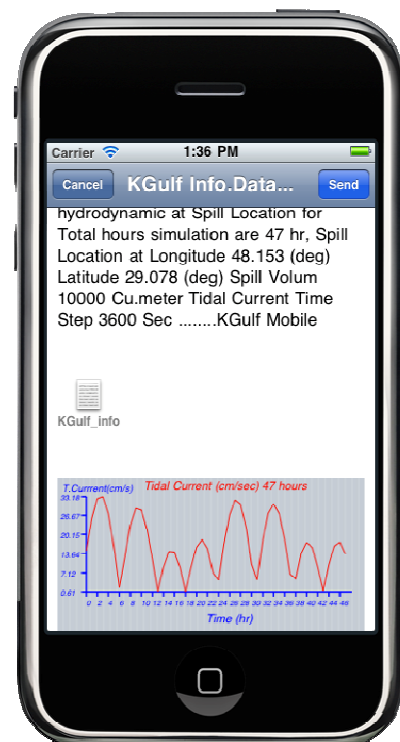


Fig. 26. Export data.

## Sample list of Export 1D Hydrodynamic's results at spill location and the corresponding image E-mailed from Koil Model App.

```

<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0//EN" "http://www.apple.com/DTDs/PropertyList-1.0.dtd">
<plist version="1.0">
<array>
<string>-----KGulf Model-----</string>
<string>2D Hydrodynamic's Prediction and Oil Spill Dispersion for Arabian Gulf Water's</string>
<string>Developed By: Khaled Al-Salem (2005)</string>
<string>website address: www.hceatkuwait.net</string>
<string>Starting Date for the Requested Data :1/1/2010</string>
<string>Oil Spill location at Longitude:48.1530 deg Latitude:29.0780 deg</string>
<string>Total Simulation time Listed:23 hours</string>
<string>1D Hydrodynamic's info. for Spill location</string>
<string>Time(hr)    Ux (cm/s)    Vy (cm/s)    Tidal Current(cm/s)    Tidal Direction(deg)</string>
<string>0        13.78        -4.74        14.57        341.0</string>
<string>1        24.27        -8.36        25.66        341.0</string>
<string>2        30.52        -11.11       32.48        340.0</string>
<string>3        31.18        -11.35       33.18        340.0</string>
<string>4        25.54        -9.80        27.36        339.0</string>
<string>5        14.94        -6.04        16.11        338.0</string>
<string>6        1.47         -1.27        1.94         319.0</string>
<string>7        -3.43        11.97        12.45        106.0</string>
<string>8        -6.88        22.51        23.54        107.0</string>
<string>9        -9.03        27.80        29.23        108.0</string>
<string>10       -8.82        27.15        28.54        108.0</string>
<string>11       -7.18        20.86        22.06        109.0</string>
<string>12       -4.01        11.03        11.74        110.0</string>
<string>13       -0.59        0.18         0.62         163.0</string>
<string>14       8.76         -2.51        9.11         344.0</string>
<string>15       13.69        -4.19        14.32        343.0</string>
<string>16       13.53        -4.14        14.15        343.0</string>

```

